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FINAL REPORT

Combined Heat and Power Technologies for Distributed Energy Systems

APEC Energy Working Group

November 2012

PROJECT PROFILE

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INTRODUCTION.

Energy security and climate change mitigation are among the top current priorities of the global development. Finding affordable solutions to these challenges is crucial during an economically unstable situation.

CHP (cogeneration) is a proven cost-effective energy-efficient technology which could be used for increasing energy efficiency in APEC economies in the short and middle terms. The Canada, China, Japan, Russia and the USA and other APEC economies already have experience in using CHP technologies for distributed energy generation. Researching this experience will allow organising the available material in a systematic way for the benefit of all APEC economies. The fact that such APEC economies as Canada, Russia and the USA have considerable cold climate territories and many APEC economies are either located on archipelagos (Indonesia, Japan, Malaysia, the Philippines) or have islands within their territories (Australia, Canada, New Zealand Russia, the USA,, etc.) adds practical value to the project.

CHP benefits among others include:

- Possibility to deliver hot water, space heating, hot air/steam for industrial heat processes, space cooling (using an absorption chiller), dry air generation (with the use of desiccant) in addition to electricity and heat;
- Considerable increase in energy efficiency. Cogeneration's simultaneous generation of electrical power and thermal energy ensures greater energy efficiency (70-90%) in comparison with conventional systems producing power and heat separately (35%). Less fuel is required to produce a given amount of energy because the conversion and transmission losses associated with the separate production of power and heat are also avoided.
- Greenhouse gas reduction. Emissions from cogeneration plants are considerably lower than emissions from conventional power plants.

Cogeneration technologies also have significant advantages in the distributed energy generation systems. Cogeneration provides distributed power generation at or near the point of consumption which lessens the need for significant investments in the expansion of the central grid. Thus transmission losses are reduced, the electricity grid is stabilized and the impact of rising electricity prices may be decreased.

Cogeneration technologies are particularly suitable for rapidly developing APEC economies because efficiency of heat and power production in densely populated areas can be doubled by means of such technologies.

In 2011 the International Energy Agency in the report "Cogeneration and Renewables" once again underlined the value and importance of CHP technologies which can help dramatically increase energy efficiency to achieve low-carbon goals.

The EU is working on a new CHP strategy and since European countries are leading in using CHP in residential and industrial sectors it is the right time to study their strategies, understand the situation in APEC and prepare practical recommendations to promote CHP technologies.

The proposed project is expected to contribute to the APEC Green Growth agenda to move APEC economies to a clean energy future. It is widely recognized that modernization of the economies depends to a significant degree on the countries' ability to provide reliable and clean energy. For Russia's 2012 chairmanship in APEC modernization and innovative growth have been announced among key priorities, so the proposed project will contribute to the practical implementation of these priorities.

The main objectives are:

- To survey the current APEC economies' priorities, strategies and plans for the CHP application in distributed energy generation and also to study the European initiatives, strategies and legislation in this area;
- To study and share best practices and experiences of practical projects in which CHP technologies are applied for distributed energy generation in cold climate and/or on islands;
- To develop recommendations for promoting use of CHP in distributed energy generation in specific conditions (islands and cold climate territories) including measures aimed at overcoming barriers (including significant upfront capital investment) identified during the project.

The project foresees surveys of many of the APEC economies, state strategies and measures related to CHP.

The project aims to best practices in the area of policy development, financial and marketing arrangements and, to a lesser extent on the technological aspects. Such an approach would ensure the collection of the most relevant common mechanisms that apply in different circumstances.

The project is aligned with current APEC and EWG priorities.

According to the APEC Leaders' Declaration on Climate Change, Energy Security and Clean Development endorsed in Sydney, Australia on 9 September 2007: "improving energy efficiency is a cost-effective way to enhance energy security and address greenhouse gas emissions while promoting economic growth and development".

The APEC Growth Strategy announced in 2010 defines sustainability as one of the five critical growth attributes. This Growth Strategy includes enhancing energy security and promotion of energy-efficiency and low-carbon policies as an important action within the sustainable growth agenda.

The Fukui Declaration of APEC Energy Ministers of 2010 also states that "improving energy efficiency is one of the quickest, greenest and most cost-effective ways to address energy security, economic growth and climate change challenges at the same time". At this meeting the APEC Energy Ministers also directed the EWG to develop APEC Technology Development Roadmaps for key energy technologies to accelerate collective efforts to deploy such technologies in APEC.

At the 19th APEC Leaders' Meeting in November 2011 the following instruction was made: "We instruct officials to undertake capacity-building activities…including exchanging views, experiences and best practices to promote trade and investment in environmental goods and services". CHP equipment represents technologies with high potential for improving the environment. Preceding the Leaders' Meeting at the 42th Energy Working Group it was stated that "APEC members have agreed to work toward a more ambitious, visionary/aspirational goal of a 45 percent reduction in APEC-wide energy intensity by 2035 (with 2005 as the base year)".

The proposed project is also in line with the APEC "Energy Smart Communities Initiative" supporting development of the energy-efficient buildings, transport, and electric power grids.

The project foresees studying implemented projects and compiling recommendations for the future. Preliminary analysis showed that the experience gained by different countries in distributed energy generation is already considerable and may be catalogued in a systematic way to simplify future projects particularly in the territories where distributed energy has the most benefits (islands, cold climate territories)

Work plan

A. Overview of the current situation with CHP in APEC

The main part of the stage will be research of APEC economies' strategies, plans and practical experience in applying CHP for distributed energy generation. The research will consist of:

- desk research based on already available APEC publications (e.g. Compendium of Energy Efficiency Policies of APEC Economies 2010, APEC Energy Overview 2010, etc.);
- questionnaires sent to identified contacts with specific questions on applying CHP technologies in distributed energy systems in specific conditions (islands, cold climate territories), barriers to further development of CHP, the questionnaires will be used to collect more detailed and/or missing information on CHP in APEC economies;
- skype interviews with relevant experts from APEC economies (China, Indonesia/Philippines, Japan, the USA) and non-APEC economies (tentatively – Denmark) to collect successful case studies of CHP technologies in distributed energy systems and determine the success factors and barriers.

Interviews allow the collection and cataloging of all the factors that have influenced the reviews practical projects: legislation, the specific conditions in the territory, the economic basis for decisions, barriers and how they were overcome. In an interview with the project owners and project study will be to identify the most important factors in the decision making process. The information obtained will enable the appropriate results of desk research with practical experience of projects to enhance the relevance of the project for the industry.

Outputs: a research project reviewing the APEC economies' policies in the field of CHP existing base in this area, several studies have been applied to the case of CHP technologies in distributed energy systems, review of the main barriers to the further promotion of CHP.

B. Recommendations on wider use of CHP in APEC

This phase includes the work on preparation of recommendations for the development of CHP in distributed power systems with an emphasis on the island and cold climate areas. The recommendations will be primarily aimed at overcoming the identified barriers, and to provide information on existing mechanisms for promotion. It is planned to hold a series of consultations with outside APEC fora such as the International Energy Agency, COGEN Europe, the U.S. EPA CHP Partnership, possibly, other organizations identified in the previous step.

After preparing the recommendations, they were sent to the relevant APEC contacts to get your feedback and comments, which are also included in the report.

Attend the workshop

Participated in the seminar, which will take place in Vladivostok in November 2012 to discuss the details with the research seminar attendies.

Workshop for combined heat and power (CHP) technology for distributed power systems, organized in Vladivostok (Russia), in November 2012 with 5 ~ 6 of the countries concerned.

Conclusion: The study design document containing recommendations for a wider application of CHP in APEC economies, with an emphasis on the use of CHP for distributed energy systems in specific circumstances (the islands, cold climate areas).

C. Prepare the reports

In accordance with established procedures of the projects, the Russian Foundation for educational programs "Economics and Management" in the course of preparation of the project was implemented following set of measures:

#	Stage	Note	Liability
1	Formation of project team activities	Formed the project team consisting of: Project team leading, 1 person. Academic advisor, one people. Deputy Project team leading, 1 person. Project coordinator, 1 person. Project Manager, 2 pers. In addition, at some point in the provision of services to the project team included other specialists for additional functions (office manager, operator, lawyer, etc.)	Head of the company
2.	Conducting preliminary communications and workshops	Basis for specifying implementation details of activities, coordination of milestones and project schedule	Project team leading
3.	Conducting preliminary communications and meetings with relevant federal executive body, Project Overseer	Basis for specifying implementation details of activities, suggestions for activities, coordination of the milestones and the project schedule	Project team leading
4.	Project planning	Carried out detailed planning stages and timing of their implementation for the event, concept development, turn-based program activities, responsible persons are appointed stages, confirmed the list of borrowed funds and resources for the project	Project team leading, Deputy Project team leading
5.	Formation of the research group	Carry out the formation of the research group for the collection, analysis, and the formation of scientific information on the subject of the project	Project team leading, academic advisor
6.	Support for the operation of the research group	Non note	Project team leading, academic advisor
7.	Working meetings and communications with project overseer and	Non note	Project team leading, academic advisor

#	Stage	Note	Liability
	relevant federal executive body on the harmonization of project implementation plan		

Opportunities and Problems Addressed in This Report

Energy security and climate change mitigation are among the top current priorities of the global development. Finding affordable solutions to these challenges is crucial during an economically unstable situation. It is widely recognized that modernization of the economies depends to a significant degree on the countries' ability to provide reliable and clean energy. For Russia's 2012 chairmanship in APEC modernization and innovative growth have been announced among key priorities, thus our report hopefully will contribute to the practical implementation of these priorities. We also hope that this report will contribute to the APEC Green Growth agenda to move APEC economies to a clean energy future.

In this report the available on-line material is organised in a systematic way with references to the original research teams for the benefit of all APEC economies.

Combined Heat and Power generation/ CHP (cogeneration) is a proven cost-effective energy-efficient technology which could be used for increasing energy efficiency in APEC economies in the short and middle terms. Canada, China, Japan, Russia, the USA,and other APEC economies already have experience in using CHP technologies for distributed energy generation.

CHP benefits among others include:

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Cogeneration technologies also have significant advantages in the distributed energy generation systems. Cogeneration provides distributed power generation at or near the point of consumption which lessens the need for significant investments in the expansion of the central grid. Thus transmission losses are reduced, the electricity grid is stabilized and the impact of rising electricity prices may be decreased.

Cogeneration technologies are particularly suitable for rapidly developing APEC economies because efficiency of heat and power production in densely populated areas can be doubled by means of such technologies. In 2011 the International Energy Agency in the report "Cogeneration and Renewables" once again underlined the value and importance of CHP technologies which can help dramatically increase energy efficiency to achieve low-carbon goals.

Approach

The report is focusing on best practices in the areas of policy design, financial and promotional mechanisms and to some degree on technological aspects. Studying the European initiatives, strategies and legislation in this area is one of key objectives of this report.

European countries are leading in using CHP in residential and industrial sectors it is the right time to study their strategies and based on their experience find practical recommendations to promote CHP technologies. The European Union's new flagship energy strategy 'Energy 2020', adopted by the European Council on 17 June, 2010, reflects the priority of energy policy in overall EU policy and incorporates the EU's energy and climate goals - a 20% cut in carbon dioxide emissions, 20% of end-use energy from renewables, and a 20% drop in primary energy use by 2020. As part of this strategy, the flagship initiative 'Resource-efficient Europe' aims, among other things, to decouple economic growth from the use of resources[1]. The energy and climate objectives for 2020 now form an integral part of this strategy.

The Cogeneration Directive[2] of EU offers a clear way forward for Member States in improving energy-efficiency performance. Based on an agreed primary energy savings methodology, a cogeneration installation will bring the Member State a minimum of 10% primary energy saving over separate production of heat and electricity on the same fuel. Where a suitable national political focus and leadership is in place and proportionate support mechanisms have been developed, growth in the sector can be stimulated rapidly. Hence action now will produce a result for 2020.

Germany set a national target to double cogeneration by 2020 and has seen a jump in projects within the first 12 months of the new Cogeneration Law. Belgium, which set a target to double CHP to 2 GWe installed capacity by 2012, has already achieved this in 2010 through a very successful green certificate scheme.

The Cogeneration Directive introduced a measurement and analysis process to the world of cogeneration that the EU hoped would stimulate 27 Member States to promote cogeneration by the pure logic of the process. As a result, Europe now knows from its Member States' own assessment that there is an additional economic potential of 120 GWe of cogeneration in Europe today, which is achievable by 2020. Moreover, the barriers are to achieving the potential are known and there is a structure of Guarantees of Origins and a legal provision for support mechanisms that allows some supervision and quality assurance for any promotional programme.

The Cogeneration Directive covers the full supply chain from generation through to end-use applications, bridging into activities under the ETS sector. Hence, EU Member States seeking to win efficiency gains in the transformation sector already possess the legislative structure with which to proceed. There are still large structural and market barriers to cogeneration around connection to the electricity grid, development of the role of cogeneration services within a supply mix heavy with intermittent sources, and rewarding the cogeneration operator for emissions offset

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[1] Cogeneration and the new EU energy strategy, *Fiona Riddoch is the managing director of COGEN Europe, based in Brussels, Belgium. Email: Fiona.riddoch@cogeneurope.eu*, 01.01.2011, Cogeneration & On-site Power Production, http://www.cospp.com/articles/print/volume-12/issue-1/features/cogeneration-and-the-new-eu-energy-strategy.html

[2] *COGEN Europe report, 'Cogeneration as the foundation of Europe's 2050 low carbon energy policy'*

somewhere else in the generating system. COGEN Europe's Director suggests that removal of these market barriers, re-addressed for renewables in the new Renewables Directive, must be part of any new provisions. Additionally there must be a trigger for the Member States to take action on the identified potential and this should logically be linked to Europe's energy efficiency target. This could come from a range of different approaches. There are several market approaches which should be considered first.

A cogeneration plant has specific generating characteristics as do traditional condensing plants, nuclear power or renewables. For cogeneration the defining characteristic is that it should follow the heat load which it serves if it is to deliver the energy efficiency savings it is required to deliver. Different sizes of cogeneration plants manage this requirement in different ways but - through the use of variable operation and short term thermal storage, and depending on the fuel used - there are several interesting new services which the sector can sell to the electricity market. If these are recognized through reasonable dispatch rules for cogenerated electricity and cogenerators are also rewarded for their services in lowering transmission and distribution losses, their characteristic of consistent availability and also being reasonably responsive to variations in electricity demand, a new economic model for cogeneration could be created which would increase the commercial attractiveness of the sector.

Taking a classic policy approach to stimulating the market requirements to improve the efficiency of processes, including the use of heat, and to discourage the wholesale dumping of heat from condensing power plants, industry and other processes would create renewed interest in cogeneration. Targets on energy efficiency in general, or efficiency improvements in the generation sector, would also stimulate cogeneration. All of these, supported with some market-based mechanism to do with maximizing the utility of CHP in the overall system so that it can sell services and be rewarded for consistency of supply and responsiveness of small systems, to certificate trading schemes coupled with targets and caps, would stimulate cogeneration.

Organization of Report

The chapter on CHP technologies will give a general view on the range of technologies based on the efficient, integrated system that combines electricity production and heat recovery system, describe main benefits of utilising CHP as well as advantages of district heating and opportunities it opens. Investors in new power plants as well as political decision makers face huge challenges with respect to attaining a secure, affordable and clean energy supply. There are many uncertainties about fuel availability, emissions limits and economic developments. There is competition in open energy markets and it is not clear what the best market model for a commodity such as electricity is[3]. This makes it very difficult to decide which generating technology is the optimum. A large scale introduction of renewable energy sources tends to disturb the delicate balancing of power production and power demand. This chapter gives examples of how renewables and co-generation can be combined, leading to the solution of smart power generation.

The chapter on State Support for Cogeneration Development: Policies, Instruments, Case Studies is dedicated to the state policies and

[3] Smart power generation-The road to the goal, The future of electricity production, Jacob Klimstra and Markus Hotakainen &Wärtsilä Finland Oy, 2011

instruments elaborated for development of cogeneration technologies and covers the main barriers to the development of CHP technologies and how state policies address those barriers; models of state policies that different countries use in order to promote the idea of cogeneration and its benefits to foster the development of cogeneration technologies on the national level; factors influencing the choice of a certain model and instruments of implementation of the state policy; and finally, discusses the practice of implementation of the state policies in different countries and their success factors, including utility supply obligations and local planning practice.

At the 19th APEC Leaders' Meeting in November 2011 the following instruction was made: "We instruct officials to undertake capacity-building activities...including exchanging views, experiences and best practices to promote trade and investment in environmental goods and services". CHP equipment represents technologies with high potential for improving the environment. Preceding the Leaders' Meeting at the 42th Energy Working Group it was stated that "APEC members have agreed to work toward a more ambitious, visionary/aspirational goal of a 45 percent reduction in APEC-wide energy intensity by 2035 (with 2005 as the base year)".

It was important to note in the chapter **State Support for Cogeneration Development: Policies, Instruments, Case Studies** the ways of climate change mitigation and the role capacity building plays in raising the awareness for CHP, informing the potential users about the benefits of CHP and the types of sites particularly suited to CHP. It also demonstrates countries' case studies where the CHP market share is considerable.

According to the APEC Leaders' Declaration on Climate Change, Energy Security and Clean Development endorsed in Sydney, Australia on 9 September 2007: "improving energy efficiency is a cost-effective way to enhance energy security and address greenhouse gas emissions while promoting economic growth and development". The APEC Growth Strategy announced in 2010 defines sustainability as one of the five critical growth attributes. This Growth Strategy includes enhancing energy security and promotion of energy-efficient technologies and low-carbon policies as an important action within the sustainable growth agenda. The Fukui Declaration of APEC Energy Ministers of 2010 also states that "improving energy efficiency is one of the quickest, greenest and most cost-effective ways to address energy security, economic growth and climate change challenges at the same time". At this meeting the APEC Energy Ministers also directed the EWG to develop APEC Technology Development Roadmaps for key energy technologies to accelerate collective efforts to deploy such technologies in APEC.

In the chapter **Experience with CHP Project Implementation in the APEC Region** the attention was paid to analysing the implemented projects and the experience gained by different countries in distributed energy generation, which is already considerable and may be catalogued in a systematic way to simplify future projects particularly in the territories where distributed energy has the most benefits (islands, cold climate territories). It aimed to review the experience with CHP pilot project implementation in the APEC region, and to elaborate a set of practical recommendations to APEC policymakers on how to overcome the existing barriers to the wider use of CHP systems in the major APEC economies and on how to enhance the CHP investment attractiveness in the region.

Several case-studies were analysed in this chapter. For example, on November 11, 2010 in Tokyo Kawasaki Heavy Industries Ltd. and Sojitz Corporation announced that they have reached an agreement with the Far Eastern Center for Strategic Research on Fuel and Energy Complex Development (FEC), the Russian government affiliate, to proceed jointly with cogeneration projects for the Russian Far East. Kawasaki and Sojitz were to sign contracts to supply cogeneration systems for pilot plants as well as a framework contract for the first phase with the Vladivostok city based above mentioned company at the Fourth Japan-Russian Investment Forum[4]. As a key component in Russia's energy and environmental strategy, the cogeneration project was designed to bring highly efficient cogeneration systems to municipalities located along a 1,800-kilometer-long natural gas pipeline. The cogeneration systems replaces aging coal-fired boilers currently being operated in the Russian Far East. These energy efficient systems will provide a steady supply of electricity and hot water while significantly cutting carbon dioxide emissions.

According to IEA[5], the easiest and most attractive strategy for improving energy supply efficiency is to increase investment in highly efficient CHP and district heating and cooling (DHC) systems. Investments in new power plants imply high investment costs and long payback periods, and thus bear significant risks for the investing utility. The risk exposure depends on the development of commodity prices in liberalized energy markets as well as on political and regulatory uncertainties, and hence has serious impact on the investment decision. The chapter on CHP Financing discusses options for investors, which can be divided into two key groups – those that appear on the company's balance sheet and those that do not. It also lists major multilateral and bilateral organizations that provide financing or technical assistance for district heating projects. It was imperative to compile a clear message on risk allocation and mitigation, i.e. measures that could be possibly undertaken to mitigate possible risks at different stages of the project, such as hazards associated with fuel, sales or off-takers, technology and operating as well as environment, country and politics.

[4] http://www.sojitz.com/en/news/2010/20101111_2.html, 11.11.2010

[5] Investing in CHP and district energy - international collaboration to advance near-term low-carbon energy solutions, Tom Kerr is with the IEA Secretariat in Paris, France. E-mail: tom.kerr@iea.org, http://www.cospp.com/articles/print/volume-8/issue-5/features/investing-in-chp-and-district-energy-international-collaboration-to-advance-near-term-low-carbon-energy-solutions.html, 01.09.2007, Cogeneration & On-Site Power Production

CHAPTER 1. CHP TECHNOLOGIES

Cogeneration (CHP or Combined Heat and Power) is defined as the sequential generation of two different forms of useful energy (electricity and heat) from a single primary energy source in a single, integrated system.

CHP systems are much more efficient than separate generation of thermal energy and electricity because heat that is normally wasted in conventional power generation is recovered to meet existing thermal demands. CHP systems range in size from tens of kilowatts for single buildings powered by biomass or fuel cells, up to hundreds of megawatts for large industrial or commercial facilities powered by natural gas.

CHP encompasses the range of technologies, but always is based on the efficient, integrated system that combines electricity production and heat recovery system. By using the heat output from the electricity production for heating or industrial applications, CHP plants generally convert 75-80% of the fuel source into useful energy, while the most modern CHP plants reach efficiencies of 90% or more. CHP plants also reduce transmission and distribution losses as they are sited near the end user.

To compare, the efficiency of traditional fossil-fuelled power generation is 35-37%[6].

Selecting a CHP technology for a specific application depends on many factors, including the amount of power needed, the duty cycle, space constraints, thermal needs, emission regulations, fuel availability, utility prices and interconnection issues.

Successful place for application of cogeneration technologies should meet the following criteria[7]:

- a reliable power requirement;
- relatively steady electrical and thermal demand patterns;
- higher thermal energy demand than electricity;
- long operating hours in the year;
- inaccessibility to the grid or high price of grid electricity.

The main benefits of CHP

Cogeneration offers a range of benefits in economic and environmental spheres. Cogeneration is an attractive alternative to the conventional power and heat generating options due to its low capital investment, shorter pay-back period, reduced fuel consumption and environmental benefits.

The efforts to reduce greenhouse gas emissions and the use fossil fuels and, concerns over security of supply on a way to low-carbon economy has led to great attention to development of renewables and energy efficient technologies.

However, fossil and other alternative fuels will still take a major share in national energy supply. For that reason, it is important to use these fuels as efficiently as possible. In this respect cogeneration

[6] *Co-generation and District Energy: Sustainable energy Technologies for Today and Tomorrow*. IEA, 2009 // http://www.iea.org/media/files/chp/CHPbrochure09.pdf. P. 13.

[7] *Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia.* The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf. P. 5.

is a proven energy-efficient technology.

can accelerate the integration of renewable energy technologies.

The average global efficiency of fossil-fuelled power generation has remained stagnant for decades at 35% to 37%. The two-thirds of input energy lost globally in traditional power generation. Technologies already exist today to bring the generation fleet closer to 45% efficiency. Co-generation allows 75% to 80% of fuel inputs, and up to 90% in the most efficient plants. By making more efficient use of fuel inputs, co-generation allows the same level of end-use energy demand to be met with fewer energy inputs[8].

Benefits of CHP are obvious to both – system owners and utilities. Benefits to owners include lower overall energy costs, improved reliability and reduced thermal energy consumption.

Benefits to utilities and the electric system include reduced system energy consumption and overall emissions, reduced demand and grid congestion, deferred or avoided investments in generation and distribution infrastructure, improved system reliability and diversity, and enhanced energy security.

The main rationale beyond CHP is that cogeneration offers a variety of benefits to a range of stakeholders:

- Reduced reliance on imported fossil fuels.
- Beneficial use of local energy resources.
- Increased fuel efficiency and overall energy efficiency.
- Reduced CO2 emissions and other pollutants.
- Cost saving for energy consumers.
- Reduced need for transmission and distribution networks.
- Reduced transmission losses.
- Improved network stability.

Where cogeneration technologies are deployed?

There can be two main options for deployment of cogeneration technologies: integration of CHP into the existing system of district heating and cooling (DHC) or installation of CHP capacities in the remote areas that are not connected to the grid and, therefore, require an autonomous heat and energy supply.

In terms of economic spheres, typical cogeneration applications may be in three distinct areas:

- Utility cogeneration: in district heating and cooling.
- Industrial cogeneration: applicable mainly to two types of industries, some requiring thermal energy at high temperatures (refineries, fertilizer plants, steel, cement, ceramic and glass industries), and others at low temperatures (pulp and paper factories, textile mills, food and beverage plants, etc.).
- Commercial/institutional cogeneration: specifically applicable to establishments having round-the-clock operation, such as hotels, hospitals and university campuses.

[8] *Co-generation and Renewables: Solutions for a Low-carbon Energy Future*. IEA, 2011 // http://www.iea.org/Textbase/npsum/CHP_RenewablesSUM.pdf. P. 6.

CHP and DHC

With an appropriate regulation DHC provides a major opportunity and a flexible platform for CHP deployment. DHC with CHP can provide the double benefit of reducing costs and impacts of both – electricity generation and heat supply.

While DHC network development requires an initial investment, it provides a long term asset that enables a transition to a law-carbon energy system. It can take heat from any source, and so can recycle “waste” heat streams that are difficult to use otherwise, and it can change to renewable heat sources over time as new technologies become available. Combined with CHP, these networks can therefore create a bridge to la-carbon energy supply system[9].

Cogeneration and Renewables

Biomass[10] co-generation is a prime example of how renewables and co-generation can be combined.

The biomass resource can take a variety of forms and shapes. It can be in solid form such as agricultural residues, wood wastes from forestry and industry, residues from food and paper industries, green municipal solid waste (MSW), and reclaimed wood. Biomass can be in gas form including in the form of landfill gas, manure biogas and wastewater treatment biogas. Alternatively, it can also be fed indirectly to generating plants through gasification of solid biomass or production of liquid biofuel.

Geothermal cogeneration11

Thermal sources are actively used for cogeneration. There are three types of geothermal power plants, each one differing because of the composition of the geothermal resource and the temperature level of the resource: steam only, steam in combination with water and water only. High temperature reservoirs consisting of steam only can be used directly to drive steam turbines in dry steam power plants. High temperature geothermal resources consisting of both water and steam are first processing so that the mixture is converted to steam: the steam is then used to drive a turbine. In the third type of plant (binary plants), geothermal resources are fed to a heat exchanger to produce steam indirectly. These typically operate with lower temperature geothermal resources in water form, with temperatures varying from as low as 70°C to 180°C.

Concentrating solar power12

Concentrating solar power (CSP) converts solar energy into thermal energy which is then converted into electricity. The second process is achieved most often through a steam turbine as in most conventional power plants that rely on the steam cycle to drive an electric generator.

As with any technology that generates power through prior heat generation, CSP has scope for the application of co-generation. Isolated locations receiving large

[9] Ibid. P.13.

[10] Ibid. P.13

[11] Ibid. P.15.

[12] Ibid. P.17.

amounts of direct sunshine such as deserts are particularly suitable for solar CSP plants, but located far from energy demand and must deal with transmission issues.

With proper planning, heat derived from CSP can be used gainfully to dramatically increase the overall efficiency of energy system.

Classification by technology13

- Steam turbine cogeneration systems

The two types of steam turbines most widely used are the backpressure and the extraction condensing types. The choice between backpressure turbine and extraction condensing turbine depends mainly on the quantities of power and heat, quality of heat, and economic factors. The extraction points of steam from the turbine could be more than one, depending on the temperature levels of heat required by the processes.

Another variation of the steam turbine topping cycle cogeneration system is the extraction back pressure turbine that can be employed where the end-user needs thermal energy at two different temperature levels. The full-condensing steam turbines are usually incorporated at sites where heat rejected from the process is used to generate power.

The specific advantage of using steam turbines in comparison with the other prime movers is the option for using a wide variety of conventional as well as alternative fuels such as coal, natural gas, fuel oil and biomass. The power generation efficiency of the cycle may be sacrificed to some extent in order to optimize heat supply. In backpressure cogeneration plants, there is no need for large cooling towers. Steam turbines are mostly used where the demand for electricity is greater than one MW up to a few hundreds of MW. Their operation is not suitable for sites with intermittent energy demand.

- Gas turbine cogeneration systems

Gas turbine cogeneration systems can produce all or a part of the energy requirement of the site, and the energy released at high temperature in the exhaust stack can be recovered for various heating and cooling applications. Though natural gas is most commonly used, other fuels such as light fuel oil or diesel can also be employed. The typical range of gas turbines varies from a fraction of a MW to around 100 MW.

Gas turbine cogeneration has probably experienced the most rapid development in the recent years due to the greater availability of natural gas, rapid progress in the technology, significant reduction in installation costs, and better environmental performance.

Furthermore, the gestation period for developing a project is shorter and the equipment can be delivered in a modular manner. Gas turbine has a short start-up time and provides the flexibility of intermittent operation. Though it has a low heat to power conversion efficiency, more heat can be recovered at higher temperatures. If the heat output is less than that required by the user, it is possible to have supplementary natural gas firing by mixing additional fuel to the oxygen-rich exhaust gas to boost the thermal

[13] - *Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia*. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf;

- *Review of Combined Heat and Power Technologies*. US DOE, 1999 // http://www.distributed-generation.com/Library/CHP.pdf.

output more efficiently. On the other hand, if more power is required at the site, it is possible to adopt a combined cycle that is a combination of gas turbine and steam turbine cogeneration.

- Reciprocating engine cogeneration systems

Also known as internal combustion engines these cogeneration systems have high power generation efficiencies in comparison with other prime movers. There are two sources of heat for recovery: exhaust gas at high temperature and engine jacket cooling water system at low temperature. As heat recovery can be quite efficient for smaller systems, these systems are more popular with smaller energy consuming facilities, particularly those having a greater need for electricity than thermal energy and where the quality of heat required is not high, for example low pressure steam or hot water.

Though diesel has been the most common fuel in the past, the prime movers can also operate with heavy fuel oil or natural gas. In urban areas where natural gas distribution network is in place, gas engines are finding wider application due to the ease of fuel handling and cleaner emissions from the engine exhaust.

This technology is ideal for intermittent operation and their performance is not as sensitive to the changes in ambient temperatures as the gas turbines. Though the initial investment on these machines is low, their operating and maintenance costs are high due to high wear and tear.

- Microturbines

A new class of small gas turbines called microturbines (25- 250 kW range), is emerging for the distributed resource market. Multiple units can be integrated to produce higher electrical output while providing additional reliability. Most manufacturers are pursuing a single shaft design wherein the compressor, turbine and permanent-magnet generator are mounted on a single shaft supported on lubrication-free air bearings. These turbines are powered by natural gas, gasoline, diesel, and alcohol.

The operating process of the microturbine is similar to the gas turbine, except that most designs incorporate a recuperator to recover part of the exhaust heat for preheating the combustion air.

- Fuel Cells

Fuel cells offer the potential for clean, quiet, and very efficient power generation. The fuel sell at the moment is not the most competitive technology for the market and require continued research and development before it becomes a serious contender in the CHP market.

Fuel cells are similar to batteries in that they both produce a direct current through an electrochemical process without direct combustion of a fuel source. However, whereas a battery delivers power from a finite amount of stored energy, fuel cells can operate indefinitely provided that a fuel source is continuously supplied.

Fuel cells are combined into “stacks” like a battery to obtain usable voltage and power output. The general design of most fuel cells is similar except for the type of electrolyte used. Alkaline fuel cells are very efficient; however they require very pure hydrogen that is expensive to produce and for this reason are not considered major contenders for the stationary power market.

Engineering and site-specific criteria for CHP efficiency14

The following criteria must be taken into consideration while integrating a CHP technology for its best efficiency and economic viability:

- **Electric and Thermal Load Profiles**

Obtaining an accurate representations of electric and thermal loads is particularly important for load following applications where the prime mover must adjust its electric output to match the demand of the end-user while maintaining zero output to the grid.

The shape of the electric load profile and the spread between minimum and maximum values will largely dictate the number, size and type of prime mover. Sizing a CHP facility is largely dictated by capacity requirements in the wholesale energy market.

- **Quality of Recoverable Heat**

The thermal requirements of the end-user may dictate the feasibility of a CHP system or the selection of the prime mover.

- **Industrial Heat Recovery**

Industrial sites that produce excess heat or steam from a process may offer a CHP opportunity.

- **Noise**

Locating a turbine or engine in a residential area usually requires special consideration and design modifications to be acceptable.

- **Fuel Supply**

This must consider availability of fuel in the area of CHP location as well as fuel prices.

[14] *Review of Combined Heat and Power Technologies.* US DOE, 1999 // http://www.distributed-generation.com/Library/CHP.pdf. PP. 28-31.

CHAPTER 2. STATE SUPPORT FOR COGENERATION DEVELOPMENT: POLICIES, INSTRUMENTS, CASE STUDIES

This chapter is dedicated to the state policies and instruments elaborated for development of cogeneration technologies and will cover the following aspects:

- What are the main barriers to development of CHP technologies and how state policies can address those barriers;
- What are the models of state policies that different countries use in order to promote the idea of cogeneration and its benefits and to foster the development of cogeneration technologies on the national level;
- What factors influence the choice of a certain model and instruments of implementation of the state policy;
- To discuss the practice of implementation of the state policies in different countries, success factors and main barriers.

Cogeneration (CHP) stays in the focus of governmental attention in a lot of countries. The importance of this topic lies within more general objective of providing energy security on national and global level, decreasing of energy consumption, and increasing energy efficiency. Constantly increasing concern over energy security and environmental issues forces national governments to search for ways and efficient policy instruments that allow achieving energy efficiency and reduction of CO_2 emissions.

In this respect cogeneration can be considered as one of the instruments that can help to deliver a range of policy objectives that lay in energy, environmental and economic spheres. Those objectives are as follows:

- Increase of energy efficiency;
- Reduction of greenhouse emissions;
- Increase of energy security;
- Achievement of cost savings;
- Optimization of energy networks functioning in terms of transmission and distribution;
- Reduction of energy consumption;
- Increase of use of local energy resources;
- Reduction of use of fossil fuels.

The policy towards development of cogeneration technologies and increase of its share in the national energy balance is the integral part of the general policy of energy efficiency and CO_2 emissions reduction on the national level.

Growth in CHP share in the national energy balance can help reducing the delivered costs of electricity to end consumers. According to IEA experts increased use of CHP can reduce power sector investments by USD795 billion over the next 20 years and around 7% of total projected power sector investment over the period 2005 – 2030.[15]

These make cogeneration attractive for a whole range of stakeholders – governmental officials, policy makers, private users and investors.

Despite all the indisputable advantages and benefits of cogeneration the current share of CHP is about 10% of world's energy generation. Only a few countries have

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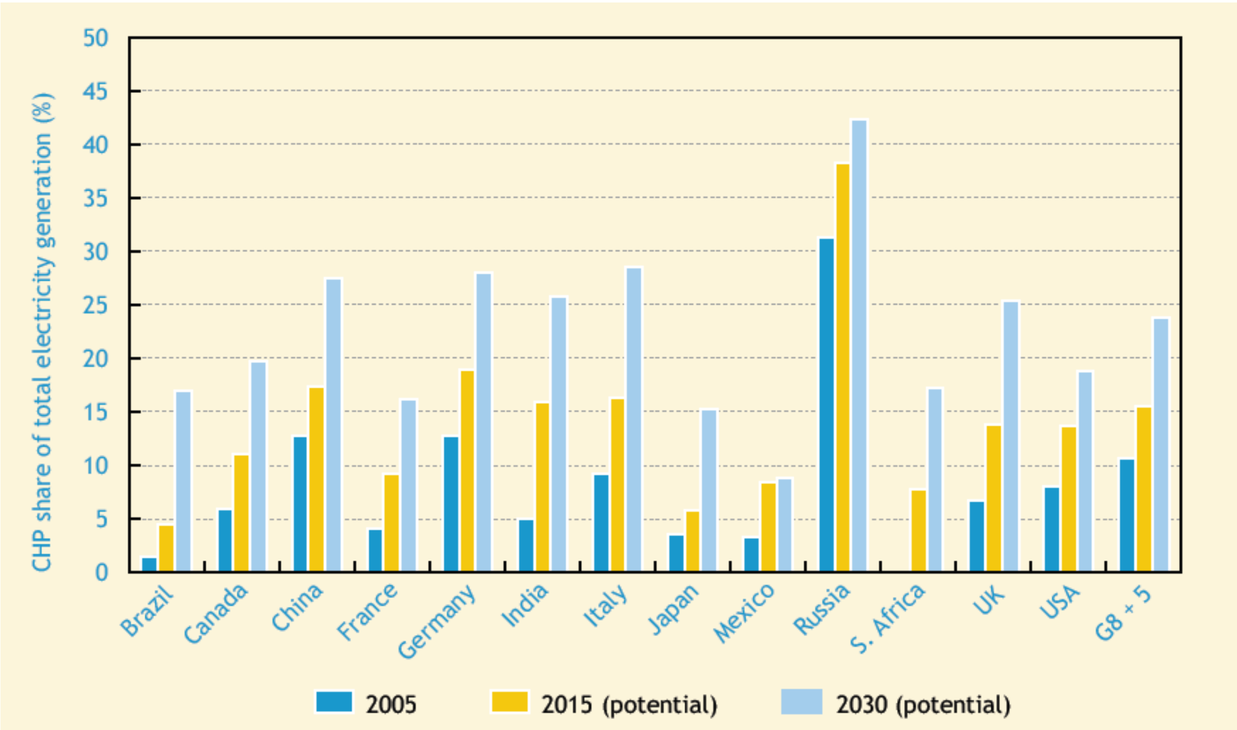
[15] *Combined Heat and Power: Evaluating the benefits of greater global investment*. IEA, 2008 // http://www.localpower.org/documents/reporto_iea_chpwademodel.pdf. P. 4.

successfully expanded it to up to 30-50% of total national power generation. According to the IEA report in year 2008 the absolute world leader in CHP was Denmark with 53% of CHP in national power balance following by Finland (almost 40%), Russia (32%), Latvia (31%), and the Netherlands (28%).

By estimation made by IEA experts the CHP has a great potential to grow from 10% to around 25% by 2030 in G13 countries if those countries will apply the coherent policies towards CHP, district heating and renewable energy based on the best policy implementation practices.

The table below taken from IEA report shows based on estimations for 2008 that most of the world leading economies have the potential for CHP to grow 2-3 times comparing to the current level.



Source: Co-generation and District Energy: Sustainable energy Technologies for Today and Tomorrow. IEA, 2009. P.11.

However, these best case scenarios can become a reality if the existing barriers to CHP development will be removed or minimized. Currently the barriers can be placed under the following categories:

- Economic and market barriers are mainly related to the cost for heat and electricity produced by CHP plants and prices for taking out and selling electricity to the grid.
- Regulatory barriers concern access and interconnection procedures and lack of integrated urban heating / cooling supply planning.
- Social and political connected to lack of awareness and knowledge about the benefits and saving of CHP.

Cogeneration Case Studies Handbook published by Cogeneration observatory and Dissemination Europe gives some specific examples of barriers that cogeneration meets in different European countries:[16]

- Difficulties in integrating the greenhouse gas emissions benefits into emissions trading or other regulations, due to CHP/DHC's status as combined technologies that include heat and power an agreement for a connection to the electrical grid is sometimes difficult to obtain (Slovenia, Belgium, Spain, Italy, Ireland).
- High or volatile natural gas prices make a project's economic feasibility unfavorable or uncertain (Slovenia, Greece, Belgium).
- In certain locations strict noise and other environmental rules have to be followed (Finland, UK, Ireland).
- Due to space limitations a special design of CHP system is sometimes needed (UK, Belgium, and Greece).
- The high capital cost of district heating infrastructure leads to high network connection costs for consumers (UK).
- In communities there is a lack of incentives for the use of district heating (Cyprus).
- The negotiation phase of TPF-financed CHP projects tends to be (too) long (UK).
- Specific technological requirements demand specific, usually more expensive solutions (Germany, Belgium).
- Long bureaucratic procedures are delaying the implementation of projects (Greece).

In general, cogeneration potential development depends on several factors, such as the regulatory framework, capital availability, investment costs, electricity and fuel pricing, structure and level of development and specific of the national energy market. Additionally, the level of CHP development in a country depends on heating and cooling demand in the industrial, commercial and residential sectors.

Before starting the research of the specific cases of national policies of cogeneration development it is needed to outline the basic approach that should be taken into consideration. There is no universal policy model of cogeneration development that can fit all countries. The starting point for the individual country, region or even city will vary significantly. It depends on the whole complex of political and economic factors, such as whether the electricity market is liberalized or regulated, availability and prices of energy resources, weather conditions, and so on. Therefore, the approach towards analysis of thee policy implication should be made on case to case basis and should take into consideration these factors.

State policies towards cogeneration have to be designed in a way that allows to overcome the existing barriers to CHP development. The barriers can lies in market, regulatory and institutional domains.

Transition economies currently have regulated energy market where monopolies control energy generation and supply, whereas most of OECD members with market economies let competition and the market set the price of heat and power. While there can be some overlaps between these general approaches, these are the main factors that

[16] *Cogeneration Case Studies Handbook C.O.D.E: Cogeneration observatory and Dissemination Europe*. 2011 // http://www.code-project.eu/wp-content/uploads/2011/04/CODE_CS_Handbook_Final.pdf. P. 26.

define the approach towards cogeneration. National governments need to be very clear about their approach to ensure that the interaction between policy and market conditions does in fact balance supply and demand in a most effective way.

Those two opposite paradigms have their own strength and restrictions. In regulated energy market with its regulated balance and supply and lack of competitiveness and alternatives the government policy should include the following elements:

- The regulatory regime must provide strong incentives for improving efficiency in supply, transmission, and end use.
- Investment decisions must take into account the interests of consumers, so that all investments are least-cost and supply is secure.
- Tariffs must incorporate full costs.
- The regulators and regulatory process should be independent.
- Regulators should not own the assets they regulate.
- The regulatory regime should be transparent and understandable.
- Social protection programmes should target low-income households, which should make it easier to eliminate heat subsidies and to ensure higher collection rates[17].

Regulated system has some instruments to keep the relatively low prices. However, there is lack of instruments to regulate the service quality. Incorporating the market-oriented elements into the regulated system allows for the private sector to be the active part of energy demand-supply chain and to improve the quality of services.

Liberalization of energy market and removing subsidies to allow the free competition are the main elements of competition-based approach. The role of regulation in this policy approach is to make the better conditions for the players in the market and ensure that the competition is fair and for the benefit of the consumers.

These two policy approaches to policy making in energy sector has a direct reflection on cogeneration development regulation. Not always the policy which is favorable for other spheres of energy sector can be beneficial for cogeneration development. For example, liberalization is not, though, an explicit policy to promote cogeneration and it may even discriminate against cogeneration if market rules do not take cogeneration's lower transmission costs into consideration.

Despite the dramatic difference in policy approach there could be defined a general set of instruments specifically designed for cogeneration that can be used in national policies:

- Financial and fiscal support;
- Utility supply obligations;
- Local infrastructure and heat planning;
- Climate change mitigation (emissions trading);
- Interconnection measures;
- Capacity building;
- Green energy portfolio requirements.

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[17] *Coming in from the Cold: Improving District Heating Policy in Transition Economies.* OECD/IEA, 2004 // http://www.iea.org/publications/freepublications/publication/cold.pdf. P. 79-80.

The detailed and systematized description of the instruments mentioned above could be found in IEA publications followed by examples of their application in some countries[18].

Financial and fiscal support for CHP

State financial incentives are an important instrument for increasing the use of technologies that provide benefits to both residents and the state overall. The incorporation of a financial incentive can make energy efficiency investments more alluring for private and public entities. Homeowners and businesses not only save energy but also reduce pollutants, improve electric system reliability, and save significant amounts of money over the life of their investments. Financial incentives also help newer technologies, such as micro-CHP, to overcome barriers to market entry.

Financial incentives can take many forms: rebates, grants or loans for energy-efficiency improvements, direct income tax deductions for individuals and businesses, and sales tax exemptions for eligible products.

- **Up-front investment support**. This instrument is appropriate when financing for CHP projects is difficult to secure, either because potential developers do not have access to capital or because project returns do not correspond to the short timeframes used by commercial investors. Examples include grants (direct support) and accelerated depreciation (fiscal).
- **Operational support**. Operational support can be used to reflect the full value of CHP electricity and/or heat, for example by internalizing its environmental benefits. Feed-in tariffs (direct) and fuel tax exemptions (fiscal) are common types of operational support.
- **R&D funding**. Government funding for low-carbon CHP technologies, like fuel cells, can help an industry to develop commercial CHP products for a sustainable energy system in the future. Financial support can help to trigger CHP development in a number of situations.
- **Tax incentives for cogeneration**. This instrument includes several tax incentives to promote cogeneration, including investment tax credits and shortened depreciation periods (The U.S. is an example of actively applying these measures). The Slovak Republic provides a corporate income tax deduction for the first five years of revenue from small, new cogeneration facilities. Italy also provides an incentive through reduced taxes on natural gas used for cogeneration. Sweden has recently lowered fuel taxes for cogeneration. Cogeneration also lowers the level of environmental taxes due in many countries because it is less polluting than separate power and heat production. For the most part, transition economies provide few tax incentives specifically for cogeneration, though several provide a reduced VAT for district heating sold to households.
- **Bonus payments and feed-in tariffs**. For instance, the German Cogeneration Act of 2002 gives qualified cogeneration facilities a bonus payment varying between €0.0138 and €0.0511 per kWh, depending on plant type. To qualify, the power must be fed into the public grid. Feed-in tariffs are

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[18] - *Coming in from the Cold: Improving District Heating Policy in Transition Economies*. OECD/IEA, 2004 // http://www.iea.org/publications/freepublications/publication/cold.pdf. P. 203-205;

- *Hodgson Steve*. Successful policies for CHP and district energy: IEA report shows the way forward Social Media Tools. 2009 // http://www.cospp.com/articles/print/volume-10/issue-4/features/successful-policies-for-chp-and-district-energy-iea-report-shows-the-way-forward.html.

most common as a policy to promote renewable energy, but some countries like Denmark and Spain also allow small, efficient cogeneration facilities to benefit even when they do not use renewable sources of energy. The idea is to guarantee a minimum, regulated price, usually for a certain number of years, to stimulate new investment. In some countries cogeneration facilities can gain priority access to the power grid and feed-in tariffs. Policy makers endorsed this provision because such facilities must produce heat for district heating or industrial processes.

- **Grants for new cogeneration**. Several regional energy efficiency funds in Russia have invested in cogeneration using revenue from energy taxes. The Slovak Energy Agency also provides grants to support small cogeneration facilities and the Czech government has a similar program.

Utility supply obligations

- **Requirement for suppliers to buy electricity from CHP**. Utility supply obligations are a market-based mechanism using certificate trading to guarantee a market for CHP electricity. They place an obligation on electricity suppliers to source a certain percentage of their electricity from CHP. Utility supply obligations can assist in creating demand for CHP electricity through obligation on electricity suppliers; and allocating tradable certificates for CHP electricity.

Electricity suppliers can meet the obligation in two ways – by owning a CHP facility or by buying CHP electricity from a CHP facility bilaterally or on the market.

The energy market regulator provides CHP plant operators with certificates for each unit of electricity or carbon dioxide. Electricity suppliers can then purchase the required number of certificates from the CHP plant operators. The sale of certificates provides additional revenue to support CHP plants.

- **Least-cost purchase requirements**. A number of European countries, Slovakia and Poland, for example, require district heating companies to purchase least-cost heat from cogeneration plants. Other countries that still regulate their power sectors require power companies to purchase cogenerated power when it is least-cost (and countries with liberalized power markets all require non-discriminatory access for least-cost power). This is one of the most common measures used to promote cogeneration in transition economies.

Local infrastructure and heat planning

Local infrastructure and heat planning create a rational framework for providing heat and cooling efficiently by linking demand and supply, and supporting the best energy sources available. District heating and cooling infrastructure can create the necessary linkages, while CHP is a flexible energy supply source that can meet demand efficiently. Heat planning typically combines facilitating measures with regulation.

Climate change mitigation (emissions trading)

There is a growing range of policy measures designed to address the challenge of climate change, in particular emissions trading schemes which are becoming an increasingly popular measure. These schemes follow the example of carbon taxation, which has been successful in supporting CHP and DHC development in countries like Sweden.

Interconnection measures

- **Interconnection standards**. This policy instrument provides clear rules for obtaining physical connection to the distribution/transmission network depending on connection voltage levels. They outline the procedures for the application process in a clear and transparent way. They also set out the technical requirements for connection.
- **Measures enabling grid access**. They are related to participation of CHP plants in the grid network, and can, for example, be developed to give CHP generators priority access to the electricity system. These measures include:

- *Net metering:* this allows for the flow of electricity both to and from a customer's facility through a single, bidirectional meter, and can enable the plant to secure an electricity sales price equivalent to the purchase price.
- *Priority dispatch*: this ensures that generators will have priority in exporting into the grid system.
- *Licensing exemption*: this allows CHP operators to generate without a generator license, helping to keep the costs down.

Incentivizing network operators enables them to benefit where they may lose revenue by connecting CHP plants to their systems. Grid connection enables a CHP plant to sell any surplus electricity to the grid, and to import when the site needs exceed the CHP output. A key factor determining the market viability of CHP is therefore its ability to safely, reliably, and economically interconnect with the utility grid system.

Capacity building (Outreach and R&D)

- **Outreach and education** raises the awareness for CHP, informing the potential users about the benefits of CHP and the types of sites particularly suited to CHP. This can be implemented through training programs and active campaigning.
- **R&D** supports the development of CHP technologies and applications towards market commercialization. R&D funding can also be applied towards the training of potential users to facilitate CHP technology uptake.

Incentive policies for CHP can be most effective if the potential users are aware that the CHP opportunity exists and if emerging technologies are mature enough to be applied on a commercial basis.

Green energy portfolio requirements

This policy instrument requires power companies to have a certain percentage of green energy in their generation portfolio. This is often renewable energy, but sometimes cogeneration also qualifies. In some systems, companies can buy green energy certificates when they do not meet portfolio requirements with their own production. Transition economies do not actively use this mechanism at the moment.

Besides the country examples mentioned above the model implication of described instruments include[19]:

Financial and fiscal support:

- Capacity grants, New York State, USA;

[19] *Co-generation and District Energy: Sustainable energy Technologies for Today and Tomorrow*. IEA, 2009. P. 19.

- Feed-in tariff, Germany.

Utility supply obligations:

- Green Certificate Scheme.

Local infrastructure and heat planning:

- Building regulations, United Kingdom.

Climate change mitigation:

- EU Emissions trading scheme.

Interconnection measures:

- Interconnection standard, USA.

Capacity building and outreach:

- Fuel cell CHP research and development program, Japan.

The next part of this chapter will cover national policies supporting cogeneration development designed to address the barriers mentioned in the first part and to make cogeneration technologies proliferate to their most benefits. One of the most comprehensive sources that allowed to do so is set of IEA CHP countries scorecards[20]. This one and other reports used to study the policy of each country are given in every section.

China[21]

China is the second-largest energy consumer and carbon emitter in the world. As a result of economic development, China's energy consumption has been growing rapidly in recent years and energy and environmental issues have become a key challenge to China's sustainable development. As a result, the Chinese government has begun to pay unprecedented attention to energy efficiency and emissions reductions, proposing an ambitious target to reduce energy intensity by 20%. As important energy efficiency technologies, combined heat and power (CHP) and district heating and cooling have received a good deal of attention by the Chinese government.

Over the past several decades, China has issued a series of policies to promote CHP/DHC; as a result, China has become the second-largest country in terms of installed CHP capacity. In 2006, CHP capacity in China increased to over 80 gigawatts (GW), providing 18% of nationwide thermal generation capacity. However, in spite of high-level government attention, China has a much greater potential for developing CHP and DHC.

Historically, Chinese governments have included CHP/DHC as an important energy conservation and environmental protection strategy. As such, since the 1980s, a number of CHP/DHC policies have been issued, including the following:

- Notice on the Report Regarding the Work on Strengthening Urban District Heat Supply Management (1986), enhanced urban district heating supply management.

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[20] - *CHP/DHC country Scorecards*. IEA, 2008-2009 // http://www.iea.org/chp/countryscorecards

[21] *CHP/DHC Country Scorecard: China*. IEA, 2009 // http://www.iea.org/media/files/chp/profiles/China.pdf

- Policies on District Heating Industry Development (1989), proposed policies for the district heating industry.
- Regulations for Encouraging Development of Small Cogeneration Plants and Restricting Construction of Small Condensing Power Plants (1989). Includes policies on technologies, financing channels, peak power regulation, fuel supply, and on-line electricity price. Proposed regulations on CHP development and the reduction of small condensing thermal plants.
- Notice on the Report Regarding the Work on Strengthening Urban Heat Supply Programming and Management (1995), proposed requirements to strengthen urban heat supply planning and management.
- China Energy Conservation Law (1997), CHP was listed as a key national energy conservation technology that should be encouraged.
- Catalogue on National Key Encouraging Development Industries, Products and Technologies (1998), included CHP.
- Some Regulations for CHP Development (1998). The ratio between heat and electricity was considered as an important indicator to define and approve new CHP plants.
- Revised Regulations for CHP Development (2000), proposing specific regulations on CHP technical indicators, management practices and the relationship with the power grid. This regulation is the major regulation governing CHP development in China.
- Pre-Feasibility Technical Regulations for CHP Projects (2002), included requirements on technical and economic pre-feasibility studies of CHP projects.
- Guidance Opinion on Pilot Programmes of Urban Heating Reform (2003). Aimed to stop welfare heating and to promote commercial district heating. Pilot projects for heating reform were started in the provinces of Northeast China, North China, Northwest China , Shandong and Henan.
- Technical Guide on Urban Residential Heat Metering (2004), proposed the technical measures to meet heat metering demand, including controllable room thermostats.
- China Medium- and Long-Term Energy Development Plan (2004), CHP/DHC was an encouraged technology.
- China Mid- and Long-Term Energy Conservation Plan (2004), considered CHP as an important energy conservation field and named CHP as one of the 10 key national energy conservation programmes.
- Regulations for Residential Building Energy Conservation Management (2005), encouraged district heat and cooling (CCHP) technology.
- Enhancement Opinion on Urban Heating Reform (2005), focused on heating price reform, promotion of gradual commercialisation of district heating, optimising urban heating resources and promoting energy conservation.
- Implementation Opinion on Promotion Heating Metering (2006), proposed targets and measures for heat metering.
- National Development and Reform Commission's (NDRC) China Energy Conservation Technology Policy Outline (2006) includes some key recommendations for CHP/DHC, including: CHP and district heating should be promoted instead of small heating boilers; develop CHP in areas with proper heat loads; develop CHP/DHC in large and medium-sized cities in north heating areas; and develop distributed CHP systems under proper conditions.

- Implementation Scheme of the National 10 Key Energy Conservation Projects (2007), under the 10 Key National Energy Conservation Programmes, further specifies important applications and supporting policies for CHP.
- Industrial Guidance Catalogue for Foreign Investments (2007) encouraged the foreign investment and operation of CHP power stations in China.
- Urban Heating Price Management Temporary Measures (2007), proposed reform in the heating price, including gradual use of two components, the basic heat price and the metered heat price.
- China Energy Saving Law (2007 revised edition), proposed several articles to promote CHP/DHC.

In the further part the most important instruments of the policies listed above are described in more details.

Infrastructure and heat planning on national and local level

- *Some Regulations for CHP Development* (1998) and *Regulations for CHP Development* (2000). A key feature of these regulations was that, for the first time, the ratio between heat and electricity was considered an important indicator to define and approve CHP.

In 2000 the revised Regulations for CHP Development were issued which proposed specific regulations on CHP technical indicators, management measures and the relationship of CHP with the power grid. This is the most important regulation governing CHP development in China, and includes the following highlights:

- Requirements for local governments to produce a CHP development plan.
- Detailed CHP project approval conditions.
- CHP technical indicator requirements, including overall efficiency levels and heat and power ratios. For example, for turbine CHP units, it pointed out that the overall annual energy efficiency must exceed 45%; for CHP units greater than 50MW, the annual heat and power ratio must be greater than 100%; for CHP units of 50-200MW, the annual heat and power ratio must be greater than 50%; and for condensing CHP units greater than 200MWfor district heating, the heat and power ratio in heating period should be higher than 100%.
- Power management departments should provide inspection comments about grid connection for CHP.
- Guidelines that CHP projects should be sized based on available heating load, in order to maximize efficiency.
- Guidance encouraging the maximum use of waste heat, coal tailing, and other waste fuels for CHP.
- Suggestions to use CCHP to improve energy efficiency.
- In the heating range of planned CHP/DHC project, other newly-added small coal boilers projects will be restricted if the planned CHP/DHC capacity may cover the heating demand.
- A goal to implement heat metering on the basis of heat consumption by 2010.
- China Medium- and Long-Term Energy Development Plan (2004) and Implementation Scheme of the National 10 Key Energy conservation Projects (2007).

The *Plan*, which considered CHP as an important energy conservation field, listed as one of the 10 key national energy conservation programs that are critical to realizing the energy conservation target.

Implementation Scheme of the National 10 Key Energy Conservation Projects provided important details on CHP target applications and supporting policies, including:

- Stated Goal: In 2005-10, 45 GW of new CHP units will be constructed in the Northern heating area, and 8 GW of new CHP units in the Southern area for industrial heat applications.
- Key Applications: Requires CHP development in the residential and industrial sectors, and encourages distributed CHP and CHP that uses waste fuels.
- Temporary Regulation for Cogeneration and Power Generation of Integrated Utilisation of Coal Tailings (2007). According to the Temporary Regulation more administrative regulations on CHP were proposed.
  - The local government was required to stipulate a plan for CHP and coal tailing utilisation.
  - Regions with severe winters and concentrated heat loads should actively develop CHP to replace small heat-only boilers. In regions with hot summers and cold winters, CHP should be developed where there are concentrated heat loads, and CCHP is also encouraged under the proper conditions.
  - In areas with existing CHP plants, the regulation discourages the development of additional end-use sited CHP plants.
  - Except for large-scale enterprises such as petroleum, chemical, steel, and paper industries, the regulation does not encourage the use of CHP to serve single enterprises. Encouraging the use of a variety of approaches to solve heating problems in medium and small cities, such as the use of biomass, solar, geothermal and other renewable energy, as well as the use of natural gas, coal gas, and other resources to implement CHP.
- *Guidance Opinion on Pilot Programmes of Urban Heating Reform* (2003). It aimed to stop welfare heating and promote commercial district heating. This regulation proposed specific requirements for district heat metering. In addition, the pilot projects for heating reform were started in the provinces of Northeast China, North China, Northwest China, Shandong and Henan.

Financial and fiscal support

Urban Heating Price Management Temporary Measures (2007), which encouraged CHP/DHC, and dictated the reform of heating prices. In these measures, regulators will gradually use two price components: the basic heat price and the metering heat price.

This regulation also encouraged the development of CHP and district heating and allowed non-public capital (including foreign capital) to invest, construct, and manage heating supply facilities to promote the gradual commercialization of district heating industries. The heat tariff, in principle, is determined by the government (tariff administrative agencies at the regional and local levels), but in some regions (where conditions are suitable), the heat tariff may be determined by the market – i.e., by heat suppliers and their customers.

In general, there is currently a lack of favourable fiscal and tax incentives to support CHP/DHC. Although the government has repeated its support for CHP in many of its policy documents, it has not followed that support with concrete incentives to support CHP/DHC projects.

Utility supply obligations

- China Energy Saving Law (1997 Edition and 2007 Revised Edition). In the Law CHP was listed as an energy conservation technology that should be nationally encouraged. The following measures provisioned by the Law concern CHP:
- The country encourages the industrial enterprises to use high-efficiency energy conservation equipment, such as motors, boilers, kilns, blowers, and pumps; and encourages energy-efficient technologies, including CHP/DHC, residual heat and pressure utilisation, clean coal-fired technologies, and so on.
- The power grid enterprises should arrange clean and efficient CHP, utilise residual heat and pressure units, and take other measures according to the requirements of the Energy Conservation Power Control Management formulated by the appropriate State Council department, the online power price executing the country concerned requirements.
- The power grid enterprises bear liability if they do not comply with the above listed requirements.

Interconnection measures

At present, the electricity produced by some CHP projects cannot interconnect with the power grid, which strongly reduces development of CHP technologies. This is mostly because of technical issues of grid connection; however there are also administrative interconnection issues, such as added capacity charges and power grid balancing that need to be addressed by governmental policies.

- Temporary Regulation for Cogeneration and Power Generation of Integrated Utilisation of Coal Tailings (2007) is an attempt to address this barrier. According to the regulation
- The grid electricity price should be determined by provincial pricing administrative agencies and authorised city and county governmental agencies, which will make decisions based on relevant national regulations, heat cost and profit ratios.
- CHP should be given an advantage for connecting to the grid.

Indonesia[22]

Cogeneration in Indonesia has been traditionally used by the industries, although there are two main barriers to wider application of CHP in the industrial sector – the lack of awareness of decision makers and price policy (the energy prices does not fully cover the actual costs).

The active usage of captive power plants in Indonesia is the factor that creates preconditions for CHP development.

Financial support and Interconnection measures

The governmental regulation issued in 1993 allows the the holder of license to provide electricity to the public, first of all the industries, to adopt cogeneration technology for their own use within utility's concession area, and sell the excess power from the cogeneration facility to the utility.

The Ministry of Mines and Energy introduced the tariff for purchase of electricity from small power producers. After power generation from solar, mini-hydro and wind energies, cogeneration from agricultural and industrial wastes was given the next

[22] *Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia*. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf. PP. 58-59.

priority, allowing sale of up to 30 MW for Java-Bali grid system, and up to 15 MW for the other grids. The third priority was given to cogeneration using conventional fuels, followed by power generation alone with conventional fuels.

Japan[23]

Japan is one of the most energy efficient countries in the world. The government has supported increasingly ambitious energy targets as a strategy to reduce dependency on energy imports and to address climate change. As a consequence, CHP use has increased over the past 20 years and now provides 4%of the country's electricity production.

Government support has been an essential driver, with favourable subsidies and tax reductions for CHP. In addition, research and development funding has helped create a cluster of specialised technology companies that target primarily the residential CHP sector with micro-internal combustion engines and fuel cells. Finally, district heating and cooling (DHC) is also beginning to grow.

Investment subsidies and tax benefits are used as the main tools, rather than a feed-in tariff approach. Subsidies are regularly reviewed in the light of technological and economic evelopments, but the government is committed to continued support for CHP.

Financial and fiscal support

1. **Subsidies**

- Subsidies for High-Efficiency Natural Gas CHP (10 kWto 3 000 kW). The Support Programme for New Energy Users provides subsidies for businesses that introduce qualifying new energy systems such as natural gas CHP systems and fuel cells.
- The Programme for the Promotion of New Energy in Local Areas. This Programme provides subsidies for local public entities that plan to introduce qualifying new energy systems, which are close to being commercial but still have high system costs.

Eligible technologies include energy efficient applications such as clean energy vehicles, natural gas fuelled CHP systems and fuel cells, as well as renewables.

Types of subsidies given by different organizations depend on the type of projects:

- Subsidy by New Energy and Industrial Technology Development Organization (NEDO):
- large scale cogeneration for district heat supply (15 per cent of the investment, up to a maximum of US$5 million);
- high efficiency natural gas cogeneration system (less than one-third of investment; if the project is implemented by the local government, the amount can be as much as one-half of investment, with an upper limit of US$174,000).
- Subsidy by Ministry of International Trade and Industry (MITI): cogeneration for petrol

[23] - CHP/DHC Country Scorecard: Japan. IEA, 2009 // http://www.iea.org/media/files/chp/profiles/japan_jun08.pdf;

- Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf.

- stations (up to one-fifth of investment but no more than US$43,000);
- Subsidy by Liquefied Petroleum Gas Center (LPG Center of Japan): LPG cogeneration for LPG Depots (a maximum of US$150,000);
- Subsidy by the Local Government: Cogeneration in regional central disaster hospital (up to one-third, not exceeding US$1.5 million).

2. Tax incentives – accelerated tax depreciation of CHP investment.

The Taxation System for the Promotion of Investment in Energy Supply-Demand offers a 7% tax exemption for small- and medium-sized businesses or an accelerated tax depreciation of 30% of the standard acquisition value of CHP equipment.

The cogenerator may get either 30 per cent depreciation on the installation cost or 7 per cent of tax exemption in the first year of acquisition of cogeneration plant.

Grants.

Grants can be obtained for development of new generation environment-friendly technologies such as ceramic gas turbines, ceramic natural gas engines, large-scale high efficiency fuel cells, etc.

R&D on high-efficiency natural gas CHP and fuel cells. The Japanese government also actively supports R&D, demonstration and commercialisation of gas-engine and fuel cell CHP systems for residential use.

Low-interest loans for district energy.

This loan scheme provided by the Development Bank of Japan consists of low-interest loans for district heating and cooling projects. The objective is to reduce costs and accelerate investment in DHC. The scheme targets electricity utilities in particular. Low interest loans (2.3% per year) can be obtained for 40-70% of the total investment cost.

Interconnection measures

The government has introduced special procedures for grid connection of CHP systems. This includes the development of guidelines for the administrative arrangements required for electricity supply to third party. According to those guidelines, residential CHP systems still have to meet technical standards for grid connection, but do not require on-site inspection by the utility. Simplified network access is particularly important for supporting the emerging market for small and micro-CHP systems to avoid prohibitive administrative overheads during the installation.

Korea[24]

The policy drivers of Korean Government for supporting cogeneration are the growth of economy, increasing demand and energy prices and environmental concerns. The key policy instruments are planning and tax incentives, namely:

Local infrastructure and heat planning

[24] *CHP/DHC Country Scorecard: Republic of Korea*. IEA, 2009 // http://www.iea.org/media/files/chp/profiles/Korea.pdf

According to government's Integrated Energy Supply Policy (IESP) uses urban planning policy to designate new developments as Integrated Energy Supply Areas (IESAs).

After this designation the construction plan must include the heat supply network and all buildings and apartments on site are obliged to connect to the Integrated Energy Facility (IEF).

There are three types of IEFs:

- District heating and cooling.
- Heat supply for industrial complexes.
- Community Energy Systems (CES).

Private companies bid for the right to supply heat and electricity in an IESA, and the winner receives the exclusive right to do so. This creates a captive market for DHC CHP.

Financial and fiscal support

- Tax incentives and low-interest loans are available for businesses installing CHP equipment.
- CHP plants over 100 MWe can buy natural gas directly from the Korea Gas Corporation (KOGAS) at the wholesale price.
- Tax reduction on CHP investment costs. Under the Restriction of Special Taxation Act all three types of IEFs are eligible for tax reduction on the investment costs for developing the schemes. The support allows registered businesses to deduct 10%of the investment in IEFs from their taxable profits in the first year of operation. Since the corporate tax rate in Korea is 27.5%, the value of the support is 2.75%of the total CHP investment.
- Soft loans for CHP investment. Companies investing in CHP can receive a government loan from the Fund for the Rational use of Energy. Loans cover up to 80% of investment costs for private companies and 90% for small and medium enterprises and public institutions. The annual interest rate is 5% (instead of the normal 7%) and the repayment period is seven years, with an eight-year grace period.
- Wholesale fuel price for CHP. Since the amendment of the Oil business Act in 1998 (now related to the City Gas business Act), eligible large gas users can import liquefied natural gas themselves or buy gas from KOGAS at wholesale prices. This has helped create liquidity in the market, and protect large gas users from high retail prices.

In this scheme, CHP plants over 100 MWe are eligible consumers, so individual plants can buy their fuel through bilateral supply contracts with KOGAS, while companies with a portfolio of plants can also import LNG themselves. Access to the wholesale gas market has made systems over 100 MWe more attractive than smaller plants. Many plants just below the threshold are therefore considering expanding their capacity to enable them to qualify.

- R&D. The Second basic Plan for New and Renewable Energy Development and Deployment (2003) outlines the government's activities and targets for hydrogen and fuel cell R&D. It covers the period from 2003 to 2012, and has a budget of uS$11.8 billion.

The Ministry of the Knowledge Economy is responsible for the policy, and KEMCO coordinates the research. This plan aims to support the development of a 250 kWe fuel cell CHP system for commercial buildings, and a 3 kWe fuel cell generation system for residential use. After product development and testing the mass production will start. As part of the government programme KOGAS is testing residential fuel cell CHP systems; Pohang Iron and Steel Company (POSCO) - fuel cells for commercial and industrial applications.

Utility supply obligations

According to the Integrated Energy Supply Policy after designation of an area as IESA by the Ministry of Knowledge Economy (MKE) the construction plan must include the heat supply network and all buildings and apartments on site are obliged to connect to the Integrated Energy Facility.

Interconnection measures

Renewable electricity, including biomass and biogas CHP, is eligible for biomass feed-in tariff: biomass and biogas plants under 50 MWe, including CHP, are eligible for a feed-in tariff to compensate for the additional costs over fossil-fuel generation. Plants can choose between a fixed tariff and a market-based tariff, relative to the System Marginal Price (SMP) of the Korea Power Exchange (KPX). The fixed tariff is generally lower, but offers predictable revenue, while the benefit of the market-based tariff can be higher, but its value is subject to electricity market trends. Plants can receive these tariffs for a period of 15 years.

However, these tariffs do not distinguish between power only generation and CHP, and therefore provide no extra incentive for making the additional investment to achieve a higher efficiency.

Malaysia[25]

The main policy driver for cogeneration development in Malaysia was the intention to reduce the use of oil in Malaysia energy system and increase the share of non-oil indigenous resources such as gas, hydro and coal.

The main policy instruments envisaged by the Electricity Supply Act (1990) and other regulations issues by the Ministry of Energy, Telecommunications and Posts were *interconnections measures* including:

- Electric utilities must sell power to cogenerators' facilities;
- Electric utilities must provide inter-ties with cogeneration systems, if requested by the cogenerator;
- Electric utilities must operate in parallel with a cogenerator facility if the cogenerator wishes to do so;
- Electric utility rates for the sale of electricity to a cogenerator must be non-discriminatory when compared with other customers;
- The electric utility must provide special services to cogenerators, even though similar services are not extended to other customers; these include top-up and stand-by power;
- Rates for stand-by power shall not be based on the assumption that outages of all cogenerator's facilities on a given electric utility system will occur simultaneously or during peak periods. The rates for power purchased during maintenance shall take into account the extent to which the scheduled outages

[25] Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf

of the cogenerator's facility can be usefully co-ordinated with those of the utility's facilities;

- Cogenerators who qualify to sell electricity to the utility will be paid for at the utility avoided cost.

The summary table below demonstrates in a graphic way the key instruments that the economies use to promote cogeneration on their territories.

Instrument/ APEC Economy/Country	Denmark	Finland	USA	China	Japan	India	Korea	Indonesia	Thailand	Malaysia
Financial and fiscal support	■	■	■	■	■	■	■		■	
Utility supply obligations	■		■	■			■		■	
Local infrastructure and heat planning		■		■		■	■			
Climate change mitigation	■		■							
Interconnection measures			■	■	■	■	■	■	■	■
Capacity building			■							
Green energy portfolio requirements			■							

As this chapter shows the main policy drivers towards CHP development are:

- Security of energy supply and energy self-efficiency;
- Energy conservation and energy efficiency;
- Sustainable development and economic growth;
- Environmental concerns and reduce of CO_2 emissions.

The analysis of the state policies of the most successful countries that has gained a substantial growth of CHP share in national energy balance demonstrated that the guarantee of effectiveness of these policies implies:

- A strategic approach targeted at overcoming the existing barriers;
- Comprehensive policies that combines the most appropriate instruments;
- Critical importance of government despite whether it is regulated or liberalized market;
- Consideration of complex of political and economic factors on a country level including the existing energy system, energy resources available, established system of energy management, etc.

The evidence from many countries is clear – CHP does not need substantial financial incentives, but it requires the effective use of well-designed targeted policies that systematically address barriers and allow for full realization of the potential for CHP.

Cogeneration development depends not only on the policies specifically designed for CHP development. It strongly correlates with other policies towards energy efficiency and renewable energy, climate change mitigation, investment and financial policies in general.

Russia[26]

Russia has a well-developed district heating system with extensive use of cogeneration which is responsible for one third of the installed capacity in Russia which is one of the largest in the world.

However, the further development of CHP potential meets a number of serious barriers:

- The district heating system needs a technical modernization in order to reduce systemlosses and enhance reliability.
- Lack of management skills and competences.
- Absence of the strategy of CHP development on the federal and regional level.
- Lack of state support mechanisms and instruments.
- The energy tariffs are regulated and do not fully cover the costs of supply.

In the last decades the government has issued a certain regulations concerning the energy production and supply as well as energy efficiency:

- Governmental Decision on Schemes and Programmers of Prospective development of Energy System (2009) requires the regional authorities to develop their plans of electric energy system in the regions and municipalities for the five-year period. This document, however, does not pay a special attention to cogeneration, thus does not obliged the local government to force CHP development on their territories.
- In 2007 Russia has joined to the G8 initiative of cogeneration development as one the instruments of climate change mitigation. As a result the Presidential commission for modernization of Russian economy strongly recommended the local governments to force the CHP development in district heating networks along with their technical modernization (2010).
- The Federal Law on Energy Efficiency (2009) aims at creation of necessary legal, economic and institutional framework for rising of energy efficiency and energy conservation in the country. Some instruments of this law are already in use, but the comprehensive system of instruments and economic incentives is still to be developed. Implementation of this law gives a certain support to CHP development.
- The Federal Law on Heat Supply (2010) foresees the raise of efficiency of the heating system. To successfully implement the Law a system of by-laws and financial instruments should still be put in force.
- November 2010 the Ministry of Energy of the Russian Federation has distributed to the regions a set of recommendations on elaboration and implementation of regional energy efficiency programs. It was recommended to develop a maximum of cogeneration potential. The efficient implementation of this requirement needs a long-term process of training and capacity development for energy managers on the local level.

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[26] - *Basov V*. What puts the obstacles towards cogeneration development? Searching for the solution. 2011 // http://www.e-apbe.ru/media_about_us/detail.php?ID=56586;

- *IEA CHP/DH Country Profile: Russia*. IEA, 2009 // http://www.iea.org/media/files/chp/profiles/russia.pdf.

However, there is still no regulation directly supporting cogeneration system.

The strong system of governmental support is needed to create the conditions for CHP development in Russia, including the important steps of:

- Elaboration of coordinated and long term strategy and policy for the heat sector.
- Reform of the tariff system.
- Introduction the system of incentives for CHP.
- Creation favorable conditions for private investors.

Thailand[27]

Thailand has one of the most developed CHP systems in Asia. This became possible mostly because of the governmental support policies which have been actively developing in Thailand since 1988 accompanied by the surveys on potential of CHP development. The main focus of these policies was to increase the private investment in cogeneration, renewable energies and waste fuels.

Financial and fiscal support

Further boost has been given through the announcement of a special power purchase price (in September 1996) to the small power generators (SPPs) intending to develop waste-to-energy projects. The price for purchasing electricity from SPPs is based on avoided cost of electricity. For those signing contracts to supply a firm capacity the purchase price is based on the long-run avoided cost of the utility.

In case of the electricity being exported from a cogeneration facility to the power utilities, the cogenerator will be qualified as a small power producer if the following criteria are met:

- Electricity export capacity to utilities should not exceed 60 MW (this can be raised to 90 MW on a case by case basis).
- The cogenerator must generate and supply electricity to the public utility during the utility's system peak months of March, April, May, June, September and October, and the total hours of electricity production supplied to the utility must be no less than 7,008 hours per year.

Utility supply obligations

The power utility has the obligation to purchase electricity from any SPP who cogenerates using any type of fuel, meeting certain requirements. These include the type of thermal cycles to be used, the minimum amount of thermal energy to be used from the cogeneration plant, and the minimum overall efficiency on the basis of the type of fuel used.

Interconnection measures

Cogenerators are allowed to use electricity from the public utility as back-up power. In this case, they must pay demand and energy charges to the utilities.

[27] *Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia*. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf. PP. 53-56.

Cogenerators must be billed energy charges (Baht/kWh) at the same price as other electricity consumers pay, but they pay only half of the demand charges (Baht/kW/month) which are applicable to other small power producers.

The cogenerator is responsible for the cost of system interconnection which includes the costs of the transmission and distribution systems, metering, protective devices and other expenses arising from undertaking to purchase electricity from the cogenerator.

The cogenerator is also responsible for the cost of equipment inspection which refers to the utility system and the expenses to be incurred from corrective actions that may arise in addition to the normal practices of the utility.

USA[28]

The United States has a long history of using cogeneration (CHP). The share of CHP in the US electricity generation was equal to 8% in 2008. The large-scale district energy systems are located in many major cities and 330 university campuses use district energy systems as a low-carbon, decentralized energy solution. This development was achieved in the result of supportive federal policies in the 1970s and 80s, including the Public Utilities Regulatory Policy Act, which required utilities to purchase electricity from CHP plants at a set rate. A number of US States, including California, New York and other States in the Northeast, also provide incentives and recognition in environmental regulations for CHP.

Beyond research and market transformation programs at the Department of Energy and Environmental Protection Agency, national CHP promotion policies on the federal level are currently limited.

US Federal Partnership, US Department of Energy and US Environmental Protection Agency that has been very active in the sphere of CHP technology development, demonstration, and deployment through technical and financial support, best practices information, and education and training, improvements in energy efficiency, cost-effectiveness, and integration have resulted in enhanced market penetration.

In 2001 the US Combined Heat and Power Association in cooperation with US Department of Energy and US Environmental Protection Agency published a National CHP Roadmap which has become a culmination of a wide array of industry-led activities. This Roadmap outlined the measures that had to be taken in order to meet the national goal of doubling the amount of CHP capacity by 2010.

State governments are supplementing the federal policies with their own measures to develop CHP technologies on the regional or city level. Elimination of regulatory and institutional barriers to CHP has been primarily focused at the state and local levels of government. A "patchwork" of state and local policies and regulations still exists, controlled by public utility commissions, state energy offices, governors and state

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[28] - *CHP/DHC Country Scorecard: US*. IEA, 2009 // http://www.iea.org/media/files/chp/profiles/us.pdf;
- CHP US Federal Partnership: The Road to 92 GW. OECD/IEA, 2008 // http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_national_roadmap.pdf;
- CHP in the Big Apple: Opportunities and Obstacles. OECD/IEA, 2008 // http://www.iea.org/media/files/chp/ny.pdf.

legislative bodies responsible for interconnection rules, renewable portfolio standards (RPS's), and environmental permitting issues.

Financial and fiscal support

Support for CHP and distributed generation projects through public benefits funds (PBFs), collected through ratepayer fees in restructured-market states, the most robust of which are California, New York, New Jersey, and Connecticut Success at the national level has been focused on the federal government's support for CHP through the Federal Energy Management Program (FEMP) and building standards that reward energy efficiency and CHP, called the Leadership in Energy Efficient Design (LEED) program. These two programs provide public reward and recognition for utilizing CHP and energy efficiency, in residential, commercial, and institutional buildings, in the public, private, and non-profit sectors.

Additionally, efforts undertaken by the Federal Energy Regulatory Commission (FERC), which regulates the U.S. transmission grid, have resulted in CHP projects of value to the wholesale power grid. FERC has issued mandatory electricity reliability standards; designed new tools to prevent market manipulation.

Issued rules to promote enhancements to grid infrastructure and issued rules on thermal efficiency requirements for cogeneration facilities have served not only to ease the regulatory environment for CHP, but have sent a clear signal that the federal government supports CHP.

Passage of the Energy Policy Act of 2005 (EPAct) created additional opportunities for federal leadership in CHP. Among the directives were enhanced federal building performance standards; improved electric transmission and distribution RD&D; a study of distributed generation; and a study of energy efficiency programs underway at electric utilities.

The Energy Policy Act of 2005 established limited-term tax incentives for two emerging CHP technologies (fuel cells and microturbines) and for renewable generation.

The Energy Independence and Security Act of 2007 authorized a number of grant programs and regulatory incentives for CHP and District Energy, but it is still necessary to develop the legislation to support the implementation of this Act and allocate the appropriate funds to implement the programs.

Financial Incentives for CHP

1. Loans. States offer low-interest loans for a wide variety of energy efficiency measures. Rates and terms vary by program, though a maximum 10-year term is common. For example, New Jersey's Clean Energy Solutions Capital Investment Loan/Grant Program_provides interest-free loans and grants to New Jersey-based industrial, commercial or institutional entities for end-use efficiency combined heat and power projects. Loans are limited to $5 million, of which up to $2.5 million may be taken as a grant. Loans have up to a 10-year term, with optional amortization up to 20 years based on the depreciable life of the asset financed. A minimum of 50% of project costs must be financed by the project sponsor. The loan program receives revenue from the sale of greenhouse gas emission allowances under the Regional Greenhouse Gas Initiative (RGGI).

Connecticut's Low-interest Loans for Customer-side Distributed Resources program (in effect since 2006) provides loans to customers for the installation of distributed generation systems, including CHP, with a capacity range of 50kW – 65MW. Interest rates are 1% below the customer's applicable rate, or no more than the prime rate.

The Energy Efficiency Loans for State Government Agencies program, run by Green Bank of Kentucky, offers three types of loans for state government agencies undertaking efficiency improvements; loan specifics and program requirements depend on the level of funding requested. The program is funded by the American Recovery and Reinvestment Act (ARRA) State Energy Program.

2. Grants. Most grant programs are designed primarily to offset the costs of eligible technologies, although some promote research and development or support project commercialization. For example, Massachusetts' Green Communities Grant Program provides funding for municipalities to pursue energy efficiency and renewable energy projects. Among the conditions for eligibility are a requirement to establish an energy use baseline and develop a plan to reduce energy use 20% below this baseline within five years.

Ohio's Advanced Energy Fund Grants program offers grants up to 25% of project cost (with a maximum of $100,000) for among others to CHP and waste heat recovery projects up to 25 MW. Applications are evaluated according to a number of criteria, including overall system efficiency, the balance of financing committed, and project cost per kW produced.

3. Tax credits and exemptions. Like most property tax exemptions, Arizona's Energy Equipment Property Tax Exemption_program excludes the added value of eligible renewable and energy efficient systems from the valuation of the property for tax purposes. Oregon's Business Energy Tax Credit provides tax credits to businesses for a wide variety of renewable and energy efficiency initiatives. A 50% tax credit is awarded to high efficiency CHP projects that achieve 20% annual energy savings.

4. Rebates. New York's Energy $mart New Construction Program provides technical assistance and cash rebates for the installation of energy-efficiency measures, including CHP, in new or substantially renovated buildings owned by businesses, state and local governments, not-for-profits, colleges and universities and other facilities. The state also offers a smaller scale program for existing facilities.

Climate change mitigation

Many state governments are developing policies and programs aimed at greater investment in energy efficiency, renewable energy, and CHP. Important CHP initiatives at the state level include:

- Enacting output-based air pollution regulations. Output-based regulations relate air emissions to the productive output of a process and encourage the use of fuel conversion efficiency as an air pollution control or prevention measure.

Output-based regulations that include both the thermal and electric output of an energy technology recognize the higher efficiency and environmental benefits of CHP and district energy systems. Several states have implemented output-based regulations with recognition of thermal output for CHP systems, especially for smaller systems.

Some states have adopted output-based allocation methodologies that include both electricity and thermal output of CHP systems, creating an important incentive for more efficient units such as CHP and district energy systems.

Electricity generation technologies, including CHP, have traditionally been subject to input-based emissions regulations, which define limits on the amount of emissions that can be produced per unit of fuel input (e.g., pounds of sulfur dioxide per million Btu of coal).

On the other hand, output-based emissions regulations define emissions limits based on the amount of pollution produced per unit of useful output (e.g., pounds of sulfur dioxide per megawatt-hour of electricity). A major benefit of output-based emissions standards is that they encourage cost-effective, long-term pollution prevention through process efficiency. Efficient distributed production of electricity from fossil fuels reduces fuel inputs compared to conventional generation and transmission systems, and leads to fewer emissions of all pollutants, not just those limited by regulation. Output-based emissions standards thus recognize both the efficiency and pollution prevention benefits of CHP and other distributed generation systems, which is not the case with input-based standards.

In 2003, as the result of an extensive stakeholder process, the Regulatory Assistance Project (RAP) released a national model emission rule for distributed generation systems. The RAP rule explicitly recognizes the benefits of CHP systems' increased efficiency by taking an avoided emission approach. This approach subtracts the emissions from thermal output displaced by a CHP system's more efficient operation from the measured emission rate.

- In recent years, regulators have increasingly adopted market-based regulatory structures, primarily emission cap and trade programs. In these programs, allocation of emission allowances is a critical component.

Interconnection measures

American states are encouraging CHP by establishing uniform processes and technical requirements for interconnection.

- Standard Interconnection Rules. Most of the states, like California, Ohio, Oregon, and other states, have already developed technical and institutional models at the national, regional and state levels that constitute the necessary basis for implementation of interconnection standards.

Emerging interconnection best practices include:

- Coverage of all distributed generation technologies (including CHP).
- Use of existing technical standards: IEEE 1547 and UL 1741.
- System capacity limits for small systems up to at least 10 MW.
- Screens for complexity and size, allowing fast-track processing for smaller, less expensive, less complex systems.
- Standardized interconnection agreement forms.
- Transparent, uniform and accessible application information and procedures.
- Prohibition of unnecessary external disconnect switches.
- Prohibition of requirements for additional insurance.

- Removing unintended utility tariff barriers to CHP. When CHP units are interconnected, electric utilities typically charge special rates for electricity and for services associated with this service, including supplemental rates, standby rates, and buy-back rates. If not properly designed, these rates can create unnecessary barriers to the use of CHP. Appropriate rate design is critical to allowing utility cost recovery while also providing appropriate price signals for clean energy supply. States such as California, New York, New Jersey, Maine, Oregon and Wisconsin are exploring different types of rate structures that allow utilities to maintain profitability and also encourage the use of customer-sited CHP.
- Net Metering. According to the Interstate Renewable Energy Council's most recent (May 2010) review of state net metering policies, 43 states and the District of Columbia have net metering rules in place, but less than one-third

of those give eligibility to small CHP systems. Those states include: Arizona, Florida, Maine, Maryland, Massachusetts, Minnesota, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Pennsylvania, Utah, Vermont, Washington, Wisconsin, and the District of Columbia.

Net metering allows owners of small distributed generation systems to get credit for excess electricity that they produce on-site. Under net metering rules, the customer installs a bi-directional meter that spins backwards when electricity is being sent back to the grid, offsetting the electricity purchased at another time.

Electricity produced in excess of on-site needs over a billing period is called net excess generation (NEG). Many net metering policies allow unused credits from excess generation to be carried over to the following billing period for up to 12 months, at which point any remaining kWh credits become property of the utility. However, a few leading states and the District of Columbia allow NEG to be carried over indefinitely, avoiding the risk to system owners of not being compensated for electricity they produce.

Distributed generation system owners are often compensated for excess generation either at the utility's avoided cost, or, less often, at higher retail rates. The latter is preferable, as it equally values the kilowatt-hours bought from the grid and the kilowatt-hours that distributed generation system owners sell back to it. Compensation at retail rates also decreases payback times for installed systems.

Best practices for net-metering include:

- Eligibility for all distributed generation technologies, including CHP.
- Eligibility for all customer classes.
- System size limits that exceeds 2 MW.
- No limit on aggregate capacity of net-metered systems as a percentage of utility peak demand.
- Indefinite net excess generation carryover at the utility's retail rate.
- Prohibition of special fees for net metering.
- Third-party ownership and meter aggregation.

- CHP-Friendly Standby Rates. Along with clear interconnection standards, a second condition for the economic viability of CHP is that the avoided costs of purchasing electricity from the grid be greater than the capital and operating costs involved in building the facility. Excessive standby rates and other charges can upset this balance by adding to operating costs, negatively impacting the economics of CHP systems.

Standby rates are charges levied by utilities when a CHP system experiences a scheduled or emergency outage, and then must rely on power purchased from the grid. These charges are generally composed of two elements: energy charges, in $/kWh, which reflect the actual energy provided to the CHP system; and demand charges, in $/kW, which attempt to recover the costs to the utility of providing capacity to meet the peak demand of the facility using the CHP system. Utilities often argue that demand charges act as a strong incentive for CHP system owners to manage their peak demand.

Demand charges system recognizes only the costs to the utility of a highly improbable emergency outage of the CHP system. It fails to recognize the benefits that highly efficient distributed generation systems provide, including increased system reliability and power quality, and reduced distribution losses.

The use of demand charge further discourages CHP by maintaining a high demand charge, initially levied for a one-time outage, for a period ranging from several months to more than a year. Thus it turns a charge for a one-time demand peak into a long-term fee for the CHP facility. However, there are examples of rate tariffs favorable to CHP that include both energy and demand charges, such as Portland General Electric's Schedule 75, Partial Requirements Service.

Best practices for standby rates include:

- Rates weighted towards energy charges rather than demand charges.
- Demand charges based upon the (low) probability of an emergency outage coinciding with a period of grid peak demand.
- Elimination of demand ratchets; or, at worst, limiting their use to thirty days.

Capacity building

One of the most innovative and exciting areas of work undertaken under the US CHP Challenge and the CHP Initiative has been education and outreach on CHP technologies, market potential, regulations, policies, voluntary programs, legislative opportunities. These efforts have been deployed by hundreds of local, state, regional, and federal governments, private organizations and businesses, non-governmental and non-profit entities, educational organizations, and private individuals.

- Leading by Example. States are also establishing programs that achieve energy savings within their own state facilities. State governments work with state agencies, local governments and schools to identify and develop CHP opportunities at their facilities. For example, Massachusetts has developed an Executive Order in which it plans to take a leading role in demonstrating CHP in state buildings.
- Network of CHP Regional Application Centers. DOE provided funding support to establish the Midwest CHP Regional Application Center (RAC), based at the University of Illinois – Chicago. This RAC served as the model for seven more centers across the country, primarily housed at colleges and universities, and all partnering with other public organizations, universities, and research centers. The RACs offer CHP technical assistance, training, educational opportunities, and outreach support.

Utility supply obligations

An Energy Efficiency Resource Standard (EERS) is a quantitative, long-term energy savings target for utilities, under which they must procure a portion of their future electricity and natural gas needs using energy efficiency measures, typically equal to a specific percentage of their load or projected load growth. EERS targets slowly increase over time to stay ahead of technological and institutional innovation. Energy savings are typically achieved through customer end-use efficiency programs run by utilities or third-party program operators, sometimes with the flexibility to achieve the target through a market-based trading system. Nineteen states have an EERS in place, and three others have policies under consideration.

Green energy portfolio requirements

- Renewable Portfolio Standard (RPS) has been adopted in 28 states and Washington, D.C.
- Several states that have already implemented an RPS subsequently expanded it to include energy efficiency as an eligible resource, effectively establishing an EERS. Examples of combined EERS-RPS policies are found in Nevada, Connecticut, and North Carolina.

These standards are often paired with financial incentives or support programs to implement and encourage eligible technologies. Thus, when CHP is explicitly listed as eligible for RPS or EERS credit, it creates a large incentive for deployment.

Despite all the actions and measures described above there still are a number of key barriers to further CHP development to be removed:

- *Relative energy prices and uncertainty*: Similar to other countries, the relative price of fuel and electricity and the costs of alternatives have an important impact on the commercial viability of CHP and DE. For the economics of a CHP project to be favorable, the project needs a high "spark spread", defined as the difference in cost of electricity and fuel. CHP is most economic in areas where the electric prices are high and fuel prices are low. In addition in recent years, fuel prices have been very volatile, which has created an environment where potential CHP sites see the investment in CHP as too risky.
- *Grid interconnection*: The current lack of uniformity in interconnection standards makes it difficult for equipment manufacturers to produce modular packages, and reduces the economic incentives for on-site generation.
- *Utility tariff structures*: Electricity rate structures can have significant impact on CHP economics and on utility attitudes toward CHP development. Rate structures that link utility revenues and returns to the volume of electricity sales provide a disincentive for utilities to encourage CHP and other forms of on-site generation. Rate structures that recover the majority of the cost of service in non-bypassable fixed charges and/or ratcheted demand charges reduce the economic savings potential of CHP.
- *Standby/back-up charges*: Electric utilities often assess specific standby charges to cover the additional costs the utilities incur as they continue to provide generating, transmission, or distribution capacity (depending on the structure of the utility) to supply backup power when requested (sometimes on short notice). The level of these charges can create unintended barriers to CHP.
- *Lack of recognition of CHP in environmental regulations*: Higher efficiency generally means lower fuel consumption and lower emissions of all pollutants. Nevertheless, most US environmental regulations have established emission limits based on heat input (lb/MMBtu) or exhaust concentration (parts per million [ppm]). These input-based limits do not recognize or encourage the higher efficiency offered by CHP. Moreover, since CHP generates electricity and thermal energy, it can potentially increase on-site emissions even while it reduces the total global emissions. Thus, output-based emissions approaches environmental permitting can be an important way to recognize the benefits of CHP.
- *Tax policies*: Tax policies can significantly affect the economics of investing in new on-site power generation equipment such as CHP. CHP systems do not fall into a specific tax depreciation category. As a result, the resulting depreciation period can range from5 to 39 years. These disparate depreciation policies may discourage CHP project ownership arrangements, increasing the difficulty of raising capital and discouraging development.

In further part the **case-study of New-York City** will be described as an example of pro-CHP policies implemented on the state level.

There are currently 135 small-scale CHP systems currently installed around the city with an overall capacity of 118 MWe, placing New York far ahead of most other cities in terms of small-scale CHP deployment.

The Key Policy Drivers for the policy measures supporting cogeneration were the high cost of electricity in the area, reliability and environmental concerns.

New York City has the highest electricity prices in the continental United States. Because of its ability to produce multiple forms of energy from a single fuel source CHP can be quite cost competitive with grid-based power sources with a relatively quick payback period.

New York City faces an imminent electricity supply shortfall due to steady demand growth, the anticipated retirement of existing in-city power generation capacity, and difficulty siting and financing large new in-city power plants or transmission. *PlaNYC2030*, the long-term growth and sustainability plan released by Mayor Michael Bloomberg in April 2007, foresees a variety of approaches local government will pursue to reduce the size of this gap, including the use of CHP.

In this plan the Mayor announced a goal of reducing local greenhouse gas emissions by 30% by 2030. Because of the high efficiency of CHP systems, more widespread use could help reduce emissions associated with power and thermal energy production.

In order to achieve these goals and meet the economic and environmental challenges a set of instruments was designed and implemented including the following:

- Establishing an 800 MWe target for local CHP deployment by 2030.
- Passing a new law requiring local government agency buildings to be assessed for CHP viability.
- Requiring large new development schemes (> 350,000 ft2) to assess the viability of CHP as a condition of building permit approval.
- Encouraging the use of microgrid and small-scale district heating systems in massive new real estate development projects planned for Manhattan and Brooklyn.
- Financial support from the State of New York – subsidies were available for both CHP system viability assessments and project installations.

Denmark[29]

Denmark is one of the most energy efficient countries in the world. By the year 1997 the country achieved its energy self-sufficiency. Cogeneration plays in important role in this taking a considerable chare in national energy balance.

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[29] - *CHP/DHC country Scorecard: Denmark*. IEA, 2009 // http://fjvu.dk/sites/default/files/chp_dhc_scorecard_denmark.pdf;

- *Coming in from the Cold: Improving District Heating Policy in Transition Economies*. OECD/IEA, 2004 // http://www.iea.org/publications/freepublications/publication/cold.pdf;

- *Birger Lauersen*. Denmark – Answer to a Burning Platform: CHP/DHC. OECD/IEA, 2008 // http://www.iea.org/media/files/chp/denmark.pdf;

- *Benchmarking Report: Status of CHP in EU Member States*. COGEN Europe, 2006 // http://www.seai.ie/Publications/Your_Business_Publications/Benchmarking%20Report%20-%20Status%20of%20CHP%20in%20EU%20Member%20States.pdf;

- *Benchmarking Report: Status of CHP in EU Member States*. COGEN Europe, 2006 // http://www.seai.ie/Publications/Your_Business_Publications/Benchmarking%20Report%20-%20Status%20of%20CHP%20in%20EU%20Member%20States.pdf.

This became possible only because of the consistent and coherent governmental policy towards cogeneration.

This policy was built in the large frame-work of pro-active energy policy promoting energy efficiency increased use of renewable energy and technological development.

The key policy instruments defining the strategy of CHP development are presented below:

Local infrastructure and heat planning

Under its Heat Supply Act, Danish government were to develop a heating strategy on the country level. In order to do so the government obliged the municipalities to analyze their needs in heat and electricity and then to develop a heating plans. According to the Law planning process was divided into three phases:

Phase 1: Local authorities had to prepare reports on their own heat requirements, the heating methods used and the amounts of energy consumed. Heating options were also assessed. These plans were used to highlight priority areas for heat supply, and to identify where to locate future pipelines and heat supply installations. Local plans were aggregated at county level to prepare regional heat supply strategies.

Phase 2: Local authorities had to prepare a draft of their future heat supply needs. The county councils then prepared regional supply need plans.

Phase 3: The county councils prepared definitive regional heat plan.

The result of these actions the power generation and supply system was decentralised. Electricity is supplied from a much larger array of smaller scale units based mainly on CHP (which are co-located with heat loads) and dispersed wind farms located in rural areas.

Efforts were made to introduce collective heating schemes in the most of areas. Municipalities could set mandatory and separate district heating and natural gas zones where buildings are connected to one or the other heat source.

This sort of government leadership helped form the foundation for the later success of Denmark's cogeneration and district heating industry.

Financial and fiscal support

The government provides some subsidies to promote district heating and cogeneration:

- Taxation on fuel for heat: Placing a high tax on fuel used for heat generation, with no tax on the fuel for electricity production, has encouraged a shift from heat-only production to CHP operation. In January 2002, CHP producers using natural gas could calculate the fuel used for electricity generation and subtract this from their total fuel consumption. The level of energy tax varied depending on the fuel used:
- Fuel oil: €223 per tonne.
- Coal: €139 per tonne.
- Natural gas: €c0.13 perm3.

Introducing tax exemption for renewable fuels not only encouraged the transition to CHP generation, it also made biofuels competitive with fossil fuels.

- CHP electricity production subsidy (feed-in tariffs)

This subsidy was originally only available for electricity produced by renewable technologies and fuels, but was extended to include natural gas based CHP in 1992. In 2006, the shares of total electricity capacity of CHP and wind were 47% and 24%, respectively. At certain times, electricity production from CHP and wind exceeded national demand and surplus electricity had to be exported at a loss. This loss is effectively paid for by consumers.

As a result, some CHP plants were being supplemented by heat-only systems so that heat demand can still be met without an electricity surplus.

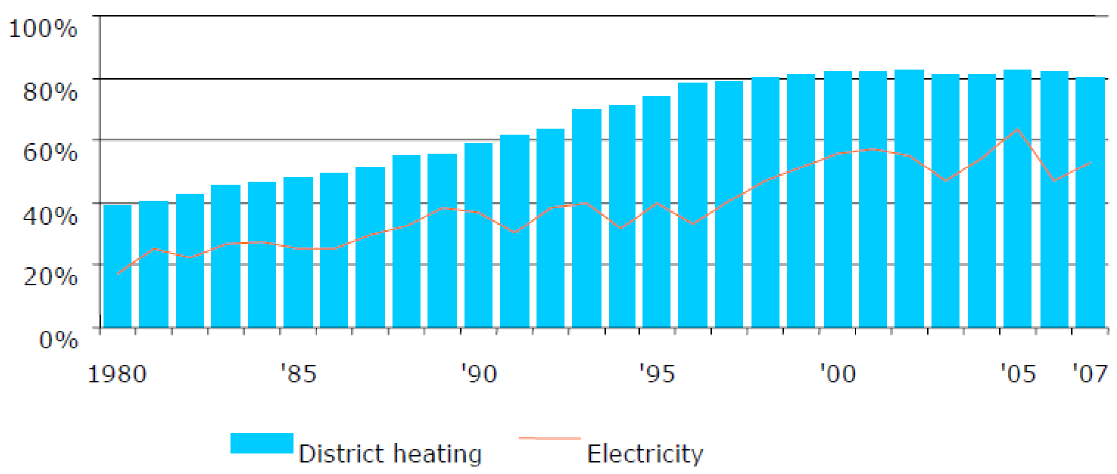
Prices and investments are regulated and district heating companies, which are primarily municipally or communally owned, are legally not allowed to make a profit.

Utility supply obligations

The localities and district heating companies are legally required to assure reliable district heat supply to all buildings in district heating zones by:

- **Obligation to buy electricity from local CHP**. Until 2005 all CHP operators were obliged to buy the electricity produced by local CHP units. This ensured long-term revenues, encouraging investment in CHP. Currently the electricity is sold on the market and is subsidised by the tariffs and surcharges discussed.
- **Obligation to connect or remain connected** (1982, amended 2000). Local authorities have the power to require that all consumers connect either to a natural gas supply or to a district heating network. This obligation applies to new and existing buildings, but for existing buildings connection needs to occur at the latest 9 years after notification of owners. This obligatory connection ensures the critical mass of consumers for building or expanding district heating systems, guarantees the business case, and thus facilitates financing through commercial loans.
- **Electric heating ban** (1988, amended 1994). Electric heating is banned in all new buildings and in existing buildings that have a water-based central heating system or access to a public supply of natural gas or district heat. This helps reserve the heat loads for the collective heating systems.

All these measures lead to constant growth of CHP proportion in electricity and heating production in Denmark:



Source: *"The Danish example" – the way to an energy efficient and energy friendly economy*. DEA, 2009 // http://www.ens.dk/en-US/policy/danish-climate-and-energy-policy/behind-the-policies/Thedanishexample/Documents/The%20Danish%20Example%20Engelsk%20FINAL%20200209%20vs2_final.pdf. P.5

Finland[30]

Finland is another world leader in energy efficiency and effectiveness in functioning of energy market and infrastructure. CHP has a significant share in national energy balance: in 2007 CHP produced 74% of the heat for district heating and generated 29% of the country's electricity supply and 34% of the production.

This was achieved almost without direct governmental support to CHP. All the policies were concentrated on creating the fair market conditions for CHP to compete directly against other heat sources so the market itself can balance supply and demand.

In Finland with its cold climate and limited resources of energy CHP has been the natural economic choice for many applications offering a faster return on heat supply infrastructure investment. The main drivers of CHP have been the need to reduce energy imports, the need to maximize economy of energy supplies.

Highly economic and mainly centralized CHP has offered favorable energy prices, s even at the European level, to Finnish customers. Regardless of low sale prices, CHP has been a successful business to its owners, usually municipalities.

Introducing energy and tax policies Finnish government creates the favorable conditions for CHP. The main elements of this policy are:

Local infrastructure and heat planning

Finland does not have national district heating legislation or regulations, nor does it regulate district heating prices. There are no requirements for local heat plans or district heating zones.

However, according to the Electricity Market Act (1995), anyone conforming to the necessary safety and environmental standards could build a power plant without a licence (excluding nuclear and hydro plants). Commercially viable projects have been able to move ahead promptly and to deliver the expected returns. This straightforward entry into the electricity market has been important in speeding up the development of large CHP schemes that may otherwise have taken a few years to gain approval.

The Act has was amended in 2004, but made a significant contribution to development of energy infrastructure in general and CHP in particular.

Innovative energy sector regulations allow DH companies to set their own heat tariffs, and customers are free to purchase competing systems, making it essential that DH be a cost-competitive source of heat.

Financial and fiscal support

There is no direct tax support for CHP; although in the past there have been occasional tax rebates to support CHP.

In some cases, governmental energy taxes apply that increase economic attractiveness of CHP over heat-only generation. Electricity taxation has focused on the end use, not on electricity production, which has provided fair conditions to electricity production optimization.

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[30] *CHP/DHC country Scorecard: Finland*. IEA, 2009 // http://www.iea.org/media/files/chp/profiles/Finland.pdf. P. 15

CHP has benefited from these fair conditions, although fuels used for heat production are subject to excise taxes.

At the same time taxation on fuel used for heat production but not on waste heat. This results in the waste heat from power-only plants avoiding tax while the heat from CHP is taxed.

One of the few direct support measures is a subsidy for small-scale CHP generation that the national government provides on a limited basis, but this subsidy is less than the one for renewable technologies like wind.

Utility supply obligations

In the electricity market there has never been any obligation upon grid or distribution companies to purchase electricity generated from CHP, which has been sold competitively on the market.

Climate change mitigation

Finland was the first country to enact a carbon tax in 1990, based on the carbon content of fuels used in heat production. In 2009 this tax stood at €18.02/tonne of CO2. Natural gas received a 50% rebate on this tax while peat received a complete exemption, thus incentivizing the use in CHP systems of renewable fuels and fuels with lower carbon content.

However, the carbon emission mitigation measures currently put a certain obstacles to further CHP development. As emissions allowances are at the moment only allocated when new generation plants are added to a heating network regardless of the demand connected. As new customers are connected to a district heating network, no new emission allowances are awarded despite more fuel being used to serve these customers, raising emissions. This may be a missed opportunity for additional CHP/District heating installations.

India[31]

At the moment the economy of India is seeing an unprecedented growth. That consequently has seriously raised an energy demand and increased CO2 emissions. A as response the Government of India put a target of decreasing of energy intensity and established an energy efficiency target of 25% of current consumption.

CHP is considered as one of the ways to assist on the way to achieving these targets. According to IEA estimate, in 2005 CHP capacity in India was over 10 GW from over 700 units, with a heat-generating capacity of 170MW. This is about 5%of the total electricity generated.

The governmental policy designed to achieve these targets include:

Local infrastructure and heat planning

Major changes have been made in the legislative, policy and regulatory environment in India, which have provided the foundation for competition and efficiency in the power sector. As a result, almost all states have created State Electricity

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[31] - *CHP and District Cooling: An Assessment of Market and Policy Potential in India.* IEA, 2009 // http://www.iea.org/media/files/chp/profiles/russia.pdf;

- *Cogeneration. Part 1: Overview of Cogeneration and its Status in Asia.* The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2010 // http://www.unescap.org/esd/publications/energy/Co-gen/part1ch1.pdf.

Regulatory Commissions (SERCs); they have also introduced vertically integrated State Electricity Boards (SEBs) into generation, transmission and distribution entities.

Financial and fiscal support

Government has issued guidelines related to clearance of projects and fixing of tariff for export of electricity by cogenerators.

Ministry of Non-conventional Energy Sources (MNES) and the Indian Renewable Energy Development Agency (IREDA) have extended financial assistance such as subsidies, low-cost loans and technical assistance:

- In order to launch demonstration projects, MNES provides capital subsidy of Rs 20 million/MW of surplus power (comprising Rs 7 million/MW as subsidy and balance as soft loan) to cooperatives and public sector sugar mills, and Rs 7 million/MW of subsidy (maximum of Rs 60 million per project) to other sugar mills.
- An interest subsidy of Rs 1.5 million/MW is given for projects with 1-4 MW of surplus power generating capacity, and Rs 3.5 million/MW for those with more than 4 MW surplus capacity.
- IREDA provides up to 75 per cent of the financing of the project at lower than market interest rates, and allows for a repayment period of 10 years, allowing for a moratorium period before the cogenerator is actually required to start repaying the loan.

The Central Electricity Regulatory Commission (CERC) has incorporated an incentive mechanism (called the Availability Based Tariff) for generators to supply power during peak demand and penalties for generating during off peak times when load is low.

Some state governments are also providing incentives for cogeneration, such as capital cost subsidies and exemption from generation taxes.

Finally, there are various fee structures and feed-in tariffs set in place for supplying power into the grid.

Interconnection measures

Industries are allowed to develop cogeneration facilities without necessarily going through competitive bidding process. If the cogeneration plant is a topping-cycle, it must supply at least 5 MW to the grid for not less than 250 days in a year in order to assure grid stability and adequate planning of the power system. Depending on the type of fuel used, the plant should meet certain efficiency criteria to be eligible as a cogeneration facility. If the cogeneration facility is a bottoming cycle, the total useful power output should not be less than 50 per cent of the total heat input through supplementary firing.

The schedule for power supply to the grid should be mutually worked out between the State Electricity Board and the cogenerator, keeping in mind that the surplus power may vary during the day and with season. While negotiating tariff, the basic consideration should be to share the benefits of higher efficiency. Industry will be assured of power supply, possibly at a lower tariff than that charged by the utility due to cross subsidization.

Following SERC regulations, states have also provided for open access on the transmission and distribution networks.

Lately, the Ministry of Power has been involved in simplifying procedures by persuading State Electricity Boards (SEB) to allow third-party sale of electricity, buy-back surplus power at higher rates (close to Rs 2.25 per kWh in most instances), and offer clear and transparent wheeling and banking policies. SEBs are now more receptive to the idea of captive power generation and are encouraging proposals for cogeneration facilities.

CHAPTER 3. EXPERIENCE WITH CHP PROJECT IMPLEMENTATION IN THE APEC REGION

Rising power demand makes many Asia-Pacific countries again turn their attention to cogeneration as an economical solution to the problem. Just five years the electricity prices were significantly lower than natural gas prices, and CHP systems were not able to provide significant energy cost savings to end-users. Now the situation has dramatically changed. The new technologies of shale gas production have led to the "shale gas revolution" in the U.S., and cogeneration is becoming increasingly attractive to consumers. Renewed interest in CHP can be also partially explained by the need to meet green targets, adopted by a number of APEC Member Economies.

However, the penetration of CHP technologies in the APEC region faces significant challenges, not only in the form of different levels of cogeneration investment attractiveness among APEC Member Economies, but also in the form of varying geo-physical and climatic conditions not always suitable for standard cogeneration system engineering solutions. Therefore, the objectives of Chapter 3 are to investigate the possibility of implementation of special cogeneration technologies for distributed energy systems in the APEC region with a special focus on the engineering solutions for various geo-physical and climatic conditions in APEC Member Economies. Also it aims to review the experience with CHP pilot project implementation in the APEC region, and to elaborate a set of practical recommendations to APEC policymakers on how to overcome the existing barriers to the wider use of CHP systems in the major APEC economies and on how to enhance the CHP investment attractiveness in the region.

To achieve these objectives, the following methods will be used:

- Engineering-economic analysis of CHP system applicability to various geo-physical conditions of the APEC region, as well as their performance evaluation in different climatic zones, including cold-climate regions;
- CHP market analysis will be carried out to identify opportunities and barriers to cogeneration development in the major APEC Member Economies;
- Assessment of the progress in the sphere of international regional CHP cooperation, in particular identification of key industry players, positive and negative experience with CHP pilot project implementation, specialists, experts and researchers, engaged into cogeneration plant designing, construction and maintenance.

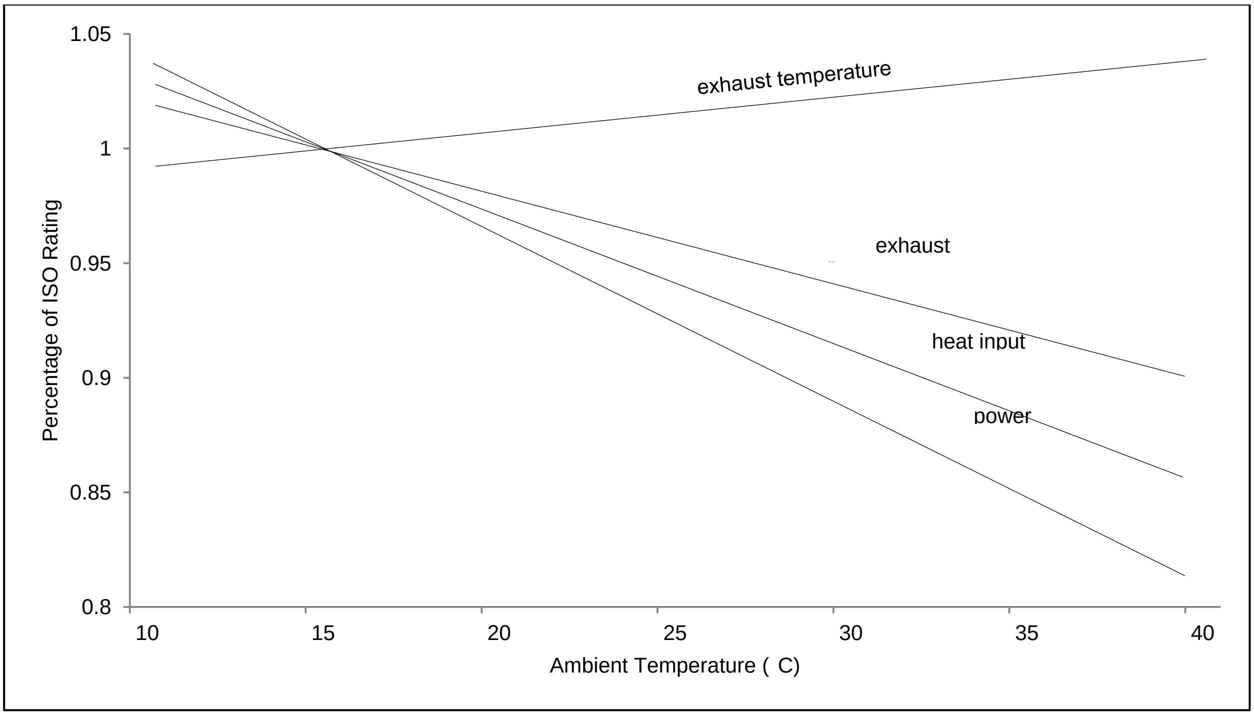
The core findings of this Chapter include the description of possible engineering solutions and business model choices for the APEC Member Economies, identified barriers to the CHP system expansion in the region, and recommendations on the wider use of CHP in APEC.

Standard Engineering Solutions for CHP Systems in Various Geo-Physical and Climatic Conditions of the APEC Region

CHP engine manufacturers usually specify the nominal parameters that allow an optimal running of the engine. However, the impact of operating conditions such as the ambient temperature, compression ratio, turbine inlet temperature, isentropic compressor and turbine efficiencies, and mass flow rate of steam on the CHP engine characteristics is also well-known.

Theory says that the ambient temperature is proportional to the air density, and air density is inversely proportional to the engine volumetric efficiency. Thus the ambient temperature is inversely proportional to the engine volumetric efficiency[32]. In regions with warm climate CHP systems powered by gas turbines require a redesign of their components to reduce the temperature of air aspirated into compressor and to enhance their capacity.

Gas turbine parameter as function of ambient temperature.



Source: *Abdusamad, J.* The effect of gas turbine inlet cooling on part load performance of Benghazi /Libya combined cycle plant (452.75 MW). Newcastle University, 2008, p. 3.

http://www.ncl.ac.uk/mech/study/postgrad/conference/documents/Abdusamad.pdf

In tropical climates of Malaysia, Indonesia, Vietnam, Thailand, Philippines, Papua New Guinea, where the average temperature is between 25°C and 35°C throughout the year, one method to improve performance of gas turbine is to lower intake air temperature to around 15°C and 100 percent before entering the air compressor of the gas turbine.

In conventional reciprocating internal combustion engines the compression ratio and the expansion ratio are actually the same. Hence, we can express the theoretical cycle efficiency as[33]:

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[32] *Saikaly, K., Criner-Thai, K., Nicol, F., Gournet, C.* Influence of meteorological conditions on natural gas cogeneration engines performances. Proceedings of the European Combustion Meeting 2011, 2011.

http://data.cas.manchester.ac.uk/database3/SAMPLE%20III/Dropbox%20stuff/ECM/ECM%202011%20Papers/042.pdf

[33] *Matsushita, Y., Fujiwaka, T., Tanaka, K., Noguchi, T.* Lean Burn Miller Cycle Gas Engine Cogeneration System. 2003, p. 2.

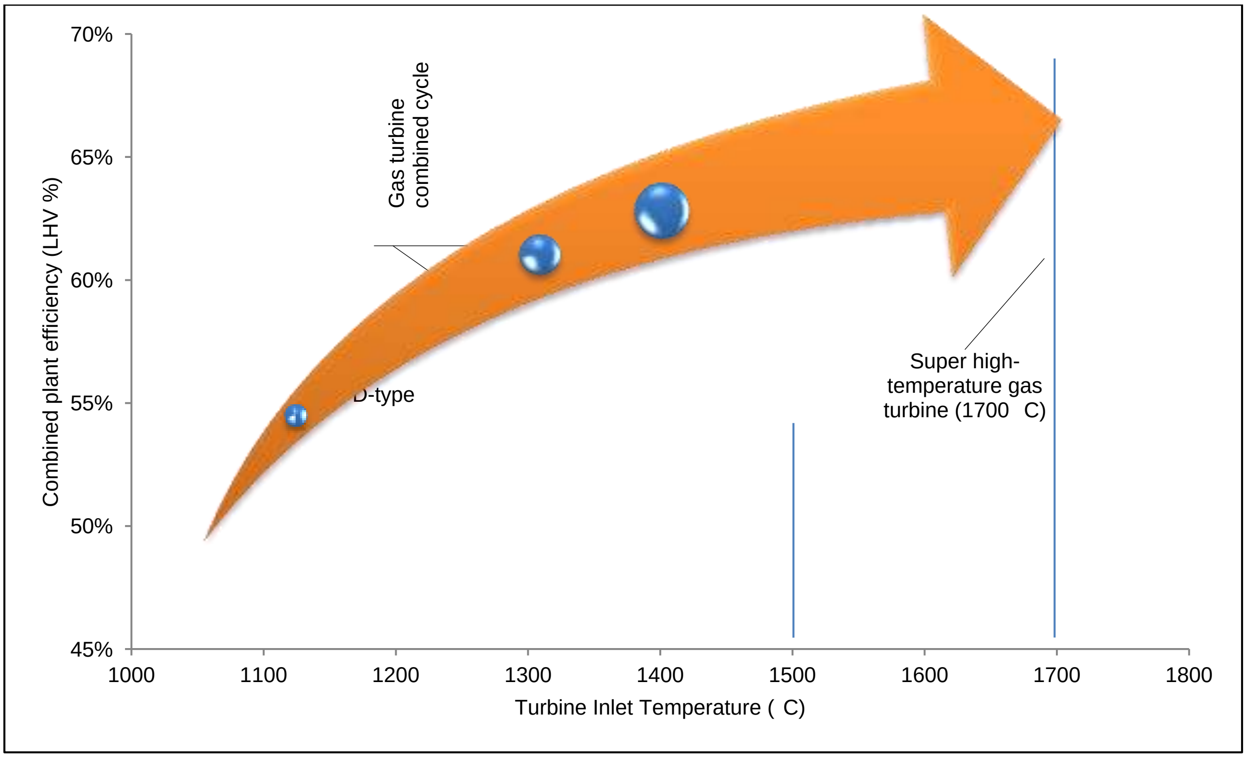
$$\eta = 1 - \varepsilon^{1-k}, \qquad (1)$$

where **ε** is the compression ratio, **k** – isentropic exponent of the working fluid.

Thermodynamically, as we can see from the equation (1), the theoretical cycle efficiency **ŋ** could be enhanced by increasing the compression ratio **ε**. However, in practice the artificially high compression ratio causes a high gas temperature in the cylinders, leading to knocking, whereby unburned gas spontaneously ignites during flame propagation. Rapid increases in cylinder temperature and pressure caused by knocking may damage the engine.

The turbine inlet temperature also impacts the efficiency of gas turbine. If the gas inlet temperature increases, so does the power to heat ratio. The IEA notes that "whether it is cost effective or not depends on the trade-off between the higher investment costs and the lower fuel costs as a consequence of increased efficiency"[34]. Chart below illustrates the interconnection between the turbine inlet temperature and the overall efficiency of a CHP system.

Generating efficiency of CCGT vis-à-vis turbine inlet temperature.



Source: *Ishikawa, M. et al.* Development of High Efficiency Gas Turbine Combined Cycle Power Plant. Mitsubishi Heavy Industries, Ltd., Technical Review Vol. 45 No. 1, 2008.

As shown in chart below, high steam mass flow rate is more efficient since the fuel utilization rate is higher, but in terms of economics the lower steam mass flow rate is more feasible since the power-to-heat ratio is higher.

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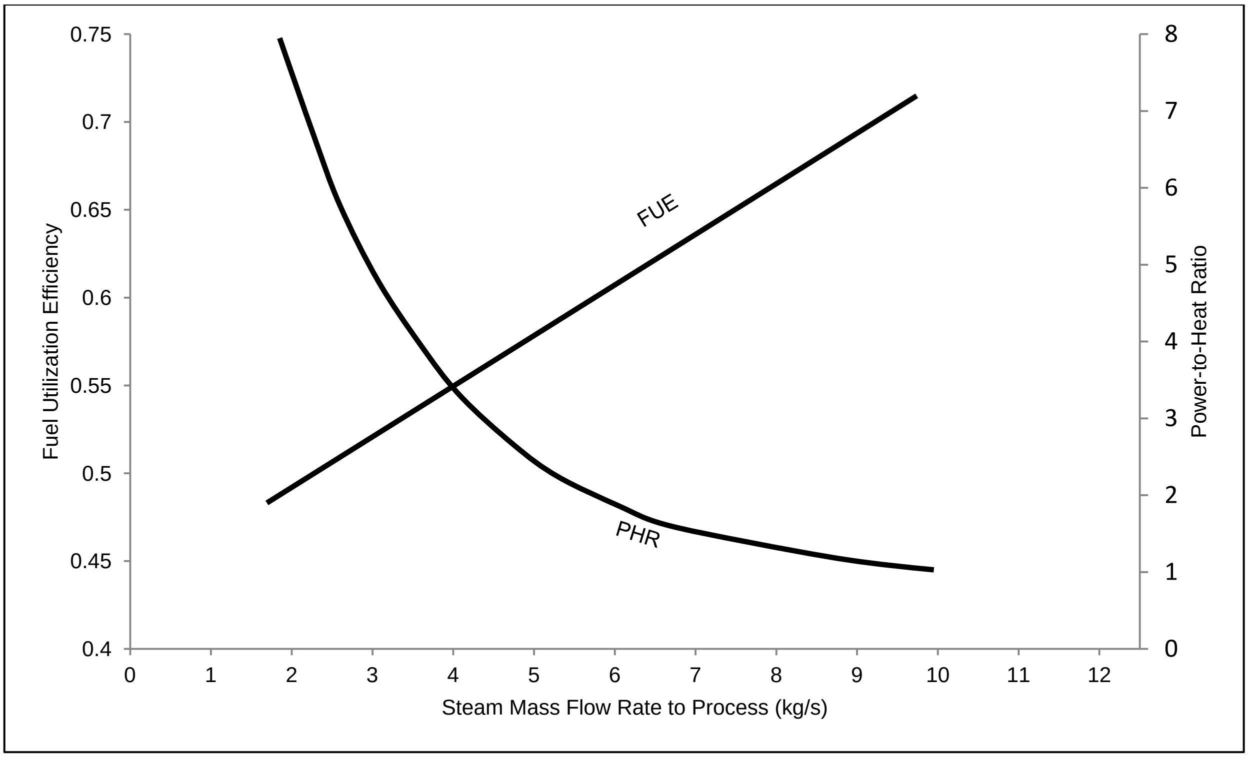
http://www.igu.org/html/wgc2003/WGC_pdffiles/10413_1046100761_31942_1.pdf

[34] *Combined Heat and Power.* IEA ETSAP – Technology Brief E04, 2010, p. 2. http://www.iea-etsap.org/web/E-TechDS/PDF/E04-CHP-GS-gct_ADfinal.pdf

Changes in FUE and PHR with Steam Mass Flow Rate to Process.



Source: *Colpan, C.* Exergy Analysis of Combined Cycle Cogeneration Systems. 2005, p. 74.

https://etd.lib.metu.edu.tr/upload/12605993/index.pdf

Other important factors of CHP system functioning include region altitude (elevation), connection to the power grid, power quality, and cooling water. Different types of CHP engines differ in their sensitivity to the altitude. Gas turbines are very sensitive to the barometric pressure. An increase in altitude (decrease in the barometric pressure) usually leads to the decrease of air compressor capacity and to the performance deterioration of the whole CHP system. Regions with high altitude are not good candidate sites for CHP systems powered by gas turbines. Among APEC Member Economies these regions are located primarily in Indonesia and in the western part of China. Combined cycle schemes are to a lesser extend sensitive to the altitude, since only the gas turbine component of a CHP installation would suffer from the decrease of air compressor capacity. Reciprocating engines are also less sensitive to the barometric pressure, than gas turbines, and in most cases a simple redesign of the turbo-charger is sufficient to enhance their performance. The least sensitive to the altitude CHP engine is powered by steam turbine. The reason is that they have lower capacity of the combustion air fans, i.e. lower requirements for pressure and the amount of air for steam boiler, and in this case high altitude could be simply ignored.

The presence or absence of a power grid also affects the CHP system performance characteristics. CHP plants, operating in “island” mode with no power grid infrastructure have to bear the entire electrical load supplied to the consumer, thus limiting the thermal output capacity. For island and remote territories in the APEC region this could be important because they usually have no connection to the power grid. Gas turbines, combined with HRSG, could offer a viable solution to the problem. If the thermal load is low, reciprocating engines are usually used. They can be supplemented by the load balancing heat exchanger. The steam turbines in the case of no power grid infrastructure have to satisfy both electrical and thermal load. This leads to the decrease of CHP system overall efficiency.

Power quality can be also an important criterion particularly in the case of “island” mode and CHP systems equipped with electric arc furnaces. The issue of power quality can be decisive in the use of the certain type of a prime mover. Although modern technologies, such as static Watt and VAR controllers, may resolve this problem, but this could be done only at the expense of increased capital costs.

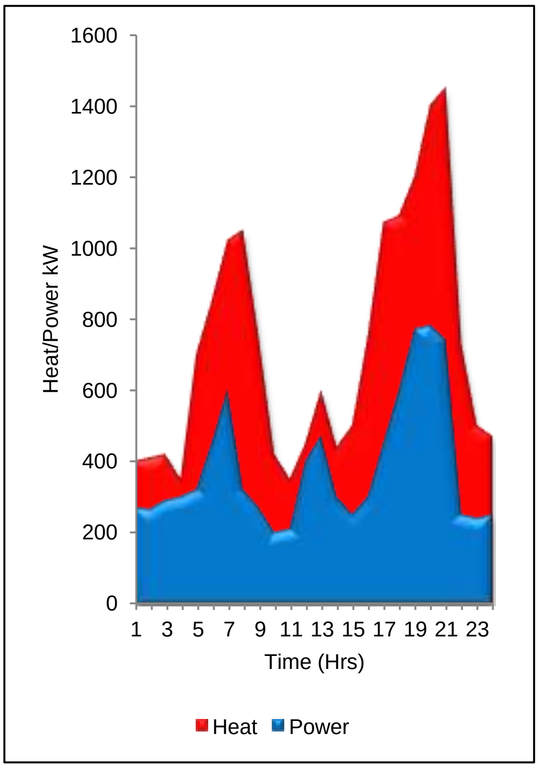
The presence or absence of the cooling water affects only those CHP systems that are powered by condensing steam turbines. If the site is located near water (even near seawater), there is obviously no problem, since the fresh or even the seawater-cooled condensers can be now widely used for abstracting heat. If there is no water nearby, three options are available: to transport water to the site over long distances, to build cooling towers and to use air-cooled condensers.

In standard configurations, CHP systems can increase energy efficiency up to 80 percent in cold climates by utilizing the waste heat released by the generation system for space heating. In cold-climate regions, energy for heating accounts for a large part of the total energy supply and use. However, the required investments in the form of pipelines, thermal isolation, and pumping, and corresponding heat losses, maintenance costs make it difficult to transport heat over long distances. That is why cogeneration plants often operate as captive power plants that are typically embedded close to the end user and therefore help reduce transportation and distribution losses.

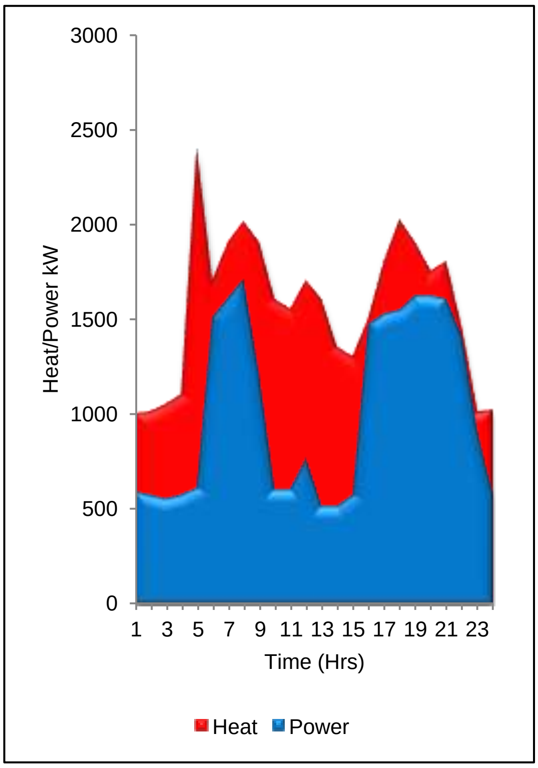
The thermal energy use profile could significantly vary between the summer and the winter seasons. While in summer the heat consumption has two distinctive peak loads occurring in morning and afternoon/evening periods, in winter the use of heat is relatively constant throughout the day.

Micro-CHP systems can be widely used in regions with cold climate and high electricity prices. In peak consumption situations, for example, in times of extremely cold weather, heat is also produced separately in heating plants.

Summer Day Heat and Power Demand.



Winter Day Heat and Power Demand.



Source: http://www.esru.strath.ac.uk/Downloads/CHP_spreadsheet.xls

In ambient temperatures below -7°C spark-ignited engines generally start easier and accept load sooner than diesel engines. The latter may require a fuel heating to prevent fuel filters from clogging when temperatures fall below the cloud point of the fuel. When a Liquefied Petroleum Gas (LPG) is used, either the LPG storage tank must be sized to provide the required rate of vaporization at the lowest ambient temperature expected, or liquid withdrawal with a vaporizing heater must be provided35. Moreover, diesel without additives starts to gel already at -10°C.

Other measures to increase operating efficiency of CHP installations in cold climates as specified in the Firebag Cogeneration Project include[36]:

- To design foundations and piles for 3 m of frost jacking force;
- Pure Bitumen turns solid at winter ambient, therefore the heat tracing is required;
- Special attention should be paid to notch toughness at low ambient;

Thus, the operating efficiency of a CHP system depends on the altitude of the region, connection to the power grid, power quality, cooling water access, the ambient

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[35] *Application Manual – Liquid Cooled Generator Sets.* Cummins Power Generation, 2011, pp. 14-15.

http://cumminspower.com/www/literature/applicationmanuals/t030-ch-2-en.pdf

[36] *Jones, T., Harris, K., Scott, S.* Firebag Cogeneration Project. Suncor Energy, Jacobs Canada, 2007, pp. 25-26.

http://www.pminacconference.com/dnn/Portals/0/docs/suncorfirebag_day1_session4.pdf air temperature, compression ratio, turbine inlet temperature, isentropic compressor and turbine efficiencies, and mass flow rate of steam on the CHP engine. These parameters should be taken into account in different geo-physical and climatic conditions of the APEC region.

Diversity in Business Model Choice of CHP Project Implementation in the APEC Region

The country-specific investment attractiveness of cogeneration depends on the national regulatory advantages, such as tax exemptions, the payment of a CHP bonus for electricity fed into the grid, and avoided concession levies and grid charges for electricity generated on site. If these incentives are excluded, and as long as the external benefits of the improved environmental performance of cogeneration are not being taken into account, none of the CHP technologies is economically viable.

The global commercial CHP market will reach by the year 2022 the total installed capacity of 80 GWe, according to Pike Research[37]. Commercial CHP market includes hospitals, schools, high-rises, prisons and other buildings, and represents a smaller portion of installed CHP globally than industrial applications.

Commercial CHP installations are primarily located in developed countries in Northern Europe, Japan, the U.S., and Korea. However, as Pike Research notes, the Asia-Pacific region will also experience a growth in commercial CHP. The Asia-Pacific commercial CHP market will grow at the fastest pace in the abovementioned time period, and in 2022 along with Europe and North America will represent 92 percent of the global total installed commercial CHP capacity.

Commercial CHP Installed Capacity by Region, 2012-2022.

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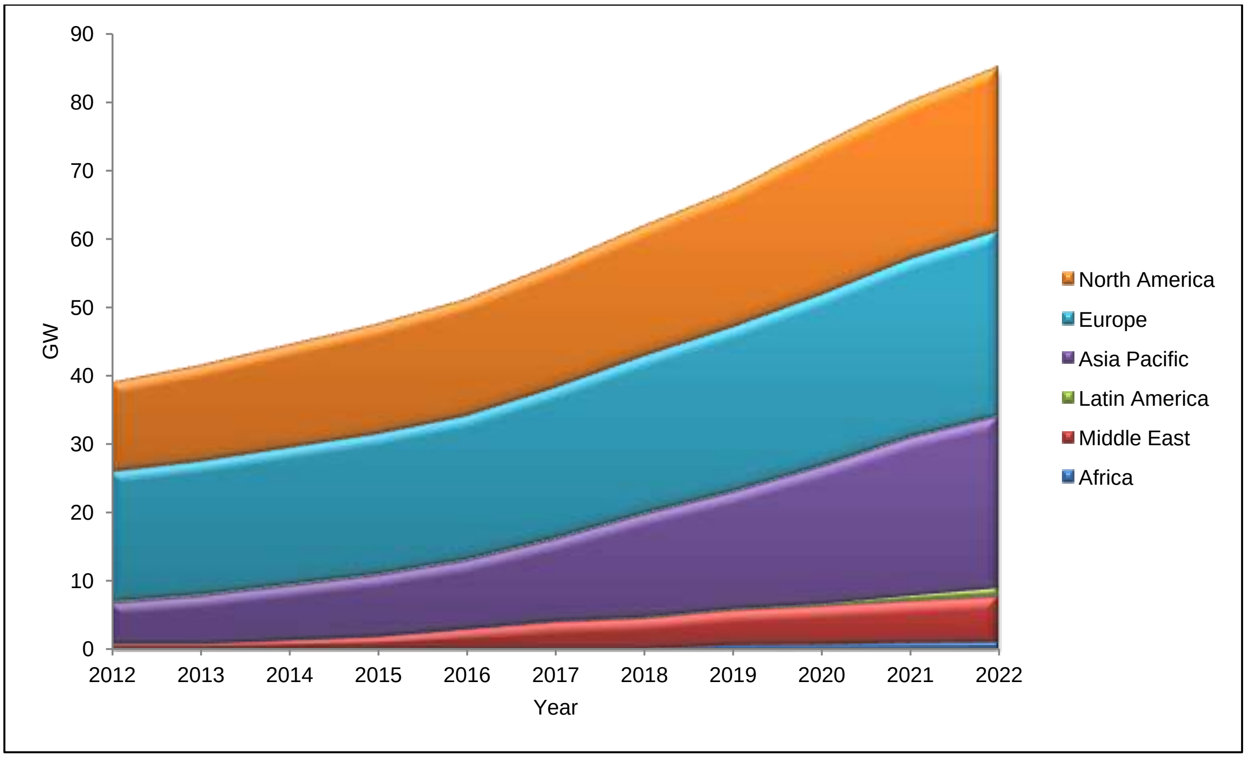
[37] **Commercial CHP Market to Reach $11.2bn by 2022, Pike Says. Environmentalleader.com, 2012.**

http://www.environmentalleader.com/2012/08/16/commercial-chp-market-to-reach-11-2bn-by-2022-pike-says



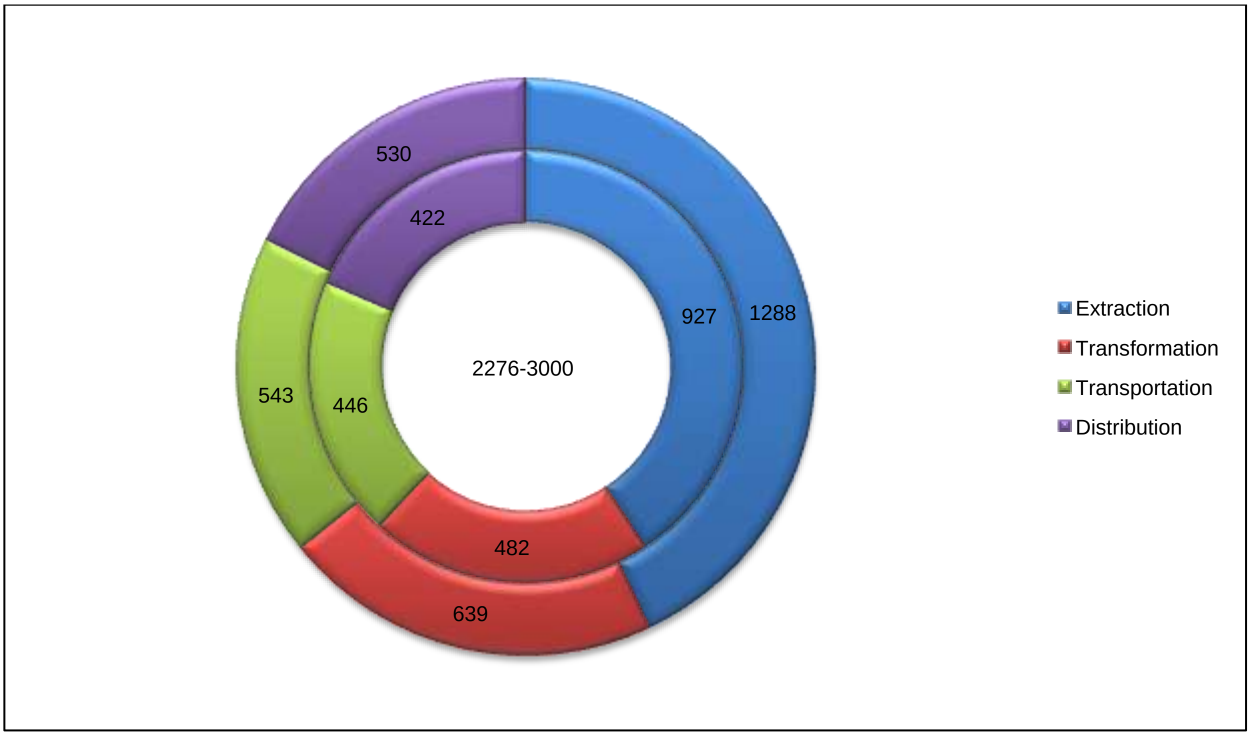
Source: Pike Research.

Smaller-scale CHP systems are now providing a good return on investment opportunities due to the development and deployment of customized, reliable and efficient smaller systems that are not only pre-engineered by their manufacturer, but are also pre-packaged and pre-tested. APEC Member Economies, where the potential for micro-CHP development is sufficient enough (Japan, Korea, Canada), can take advantage of this tendency, enhancing thus their CHP market investment attractiveness.

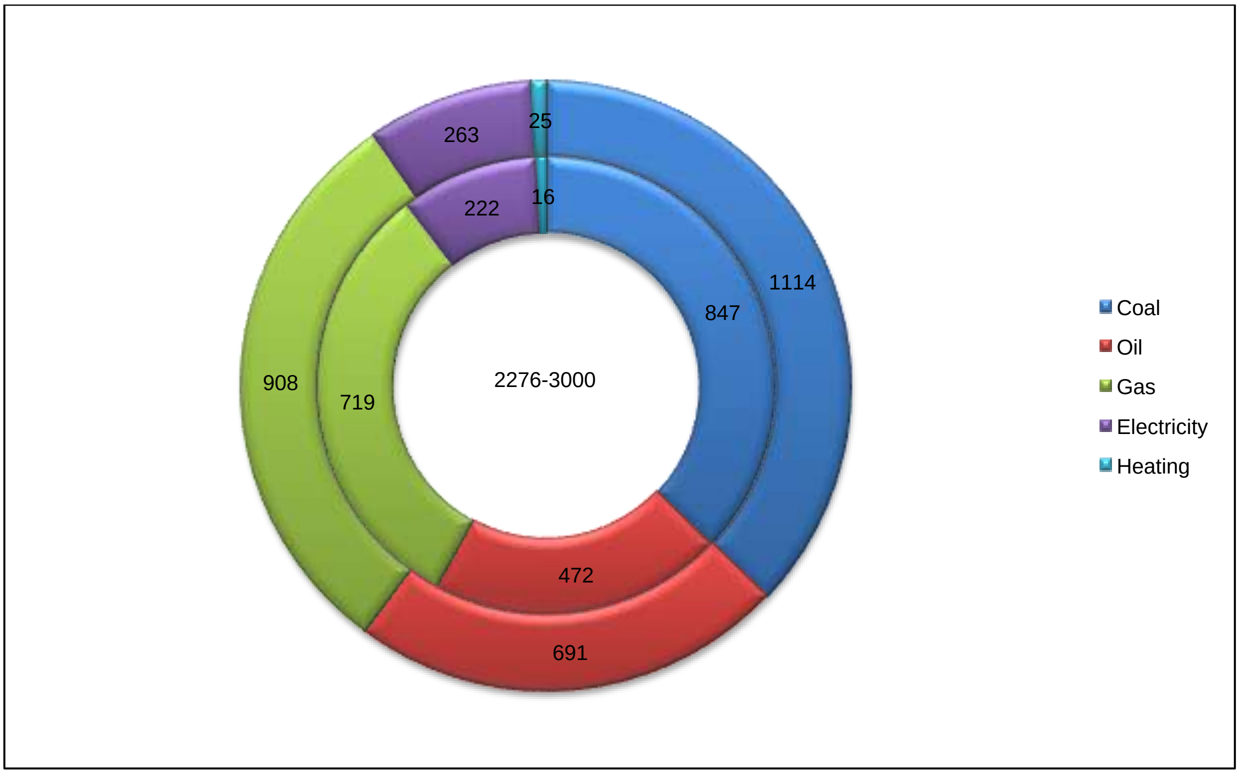
Chart below represents the assessment of energy investments in the APEC region and in Russia up to 2030. As it could be noted, North America, China and Russia are leading in attracting attention of researchers. They give the overwhelming part of energy investments into APEC to these three regions.

Outlook for energy investments in Russia and in the APEC region up to 2030, billion 2009 U.S. dollars.

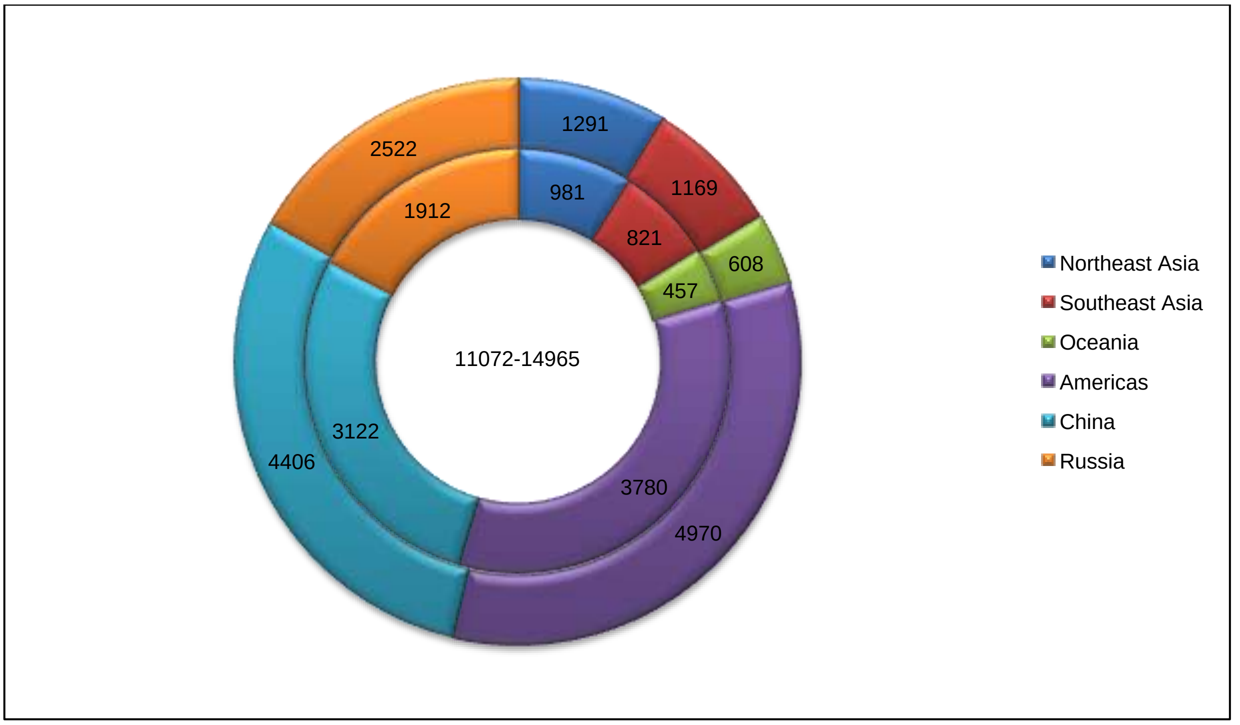
a). Following the energy supply chain.



b). By energy industry.



c). Investments by region.



Source: APEC 4th Energy Demand and Supply, 2009.

Now we assess the cogeneration investment attractiveness of major APEC Member Economies in more detail.

Japan

Japan plays a role model for the development of cogeneration, at least in the Asian APEC economies. As a economy that is heavily dependent on imported primary energy to meet the energy services, Japan has mastered the cogeneration technology, including the commercialization of large capacity and efficient vapor absorption chillers, and has widely adopted district heating and cooling networks. By creating city gas networks, Japan could promote cogeneration extensively as an energy saving resource in the industrial, commercial, medical and public facility sectors. Cooling systems operating on cogenerated heat were incorporated into the design of shopping centers, offices, school and hospitals due to such factors as their energy efficiency, compactness, ease of maintenance and their economical attractiveness. Japan was a pioneer in popularizing gas powered CDE networks thanks to which an entire district or a community of housing could have its heating and cooling requirements provided by the installation of a suitably sized plant in the basement area of a single building within the confines of the area of supply[38].

The investment attractiveness of CHP in Japan correlates with the general investment attractiveness of its economy. Cogeneration experienced three major stages of renewed interest in Japan: in the 1980s till the burst of Japanese Bubble economy, in the mid-1990s till the Asian Financial Crisis of 1997, in the mid-2000s till the global financial and economic crisis of 2008. The slump in FDI inflows during the recent recession severely hurt CHP market in this economy. Some companies in Japan stopped

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[38] *Mohanty, B.* Development of cogeneration and district energy (CDE) networks in South-east Asia. Asian Institute of Technology, 2011, p. 4.

http://six6.region-stuttgart.de/sixcms/media.php/773/ABS-53-Brahmanand-Mohanty.pdf operating their CHP plants and units; some firms moved their production to other Asian countries. However, with new energy policy after the Fukushima-Daiichi nuclear disaster in 2011, Japan aims to enhance its CHP capacity to 7 GW by 2030[39].

This new policy will spur investments into cogeneration in Japan, especially into small-scale cogeneration (micro-CHP). COSPP Magazine in this connection notes that

"Japan certainly appears ready to take micro-CHP and fuel cell CHP to global markets, and the IEA suggests that Japan could use its expertise in these areas to boost energy efficiency in developing economies in Asia and throughout the world. But a growing domestic market is also being fuelled by rising fears over blackouts and fuel costs, which has led to unprecedented demand for home-grown 1 kWe fuel cell micro-CHP systems from manufacturers such as Panasonic, JX and Toshiba"[40].

Thus, the CHP investment attractiveness (both internal and external) of this country will be high, reflecting more CHP-friendly approach, adopted by the Japanese policymakers after the Fukushima-Daiichi nuclear disaster. Japan has positively influenced other economies in the region such as China, Malaysia, Korea and Thailand to adopt similar schemes to meet the overall energy demands.

China

The National Development and Reform Commission of China has set a goal of 200 GW of CHP capacity by 2020. International organizations have tried to make use of this large market with the Global_Environment Facility investing more than $100 million in distributed energy, including on-site power production and cogeneration in China's industrial sector, as well as several projects in distributed power and heat from biomass. The same COSPP Magazine article states that

"Investments of this type should help to accelerate the growth of distributed energy and cogeneration. Capital and tax incentives from sources such as The World Bank are also helping to make the numbers add up, while rising electricity tariffs and increased natural gas availability due to pipeline extensions are also making new investments more feasible. Looking to the medium term, distributed energy and cogeneration systems should become more inviting investments due to: greater policy consistency, market restructuring, the wider acceptance of CHP technologies, feasibility studies and demonstration projects"[41].

Another significant change that has occurred in recent years is the construction of large CHP plants without external financing. In July 2012 the ambitious Huaneng Tongxiang gas-fired cogeneration project developed by Huaneng Power was approved. In 2011 two other large-scale gas-fired cogeneration projects – the 400 MW Huaneng Jinling Plant in Jiangsu province and the 1500 MW Huaneng Chongqing Liang Jiang plant in Chongqing – were approved by the local Development and Reform commissions.

Foreign investors also show more interest in China's CHP market. In 2011 the Singapore-based fund manager Swiss-Asia Financial Services launched an

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[39] *Investors look again at CHP as Asian energy demand increases.* Cogeneration & On-Site Power Production, 2012.

http://www.cospp.com/articles/print/volume-13/issue-5/features/investors-look-again-at-chp-as-asian-energy-demand-increases.html

[40] Ibid.

[41] Ibid.

infrastructure investment fund, the China District Energy Fund, with a target size of €500 million ($630 million). The fund's very first investment was to buy a CHP plant in Chengdu, the capital of Sichuan province, and its core strategy is to buy, refurbish, upgrade and expand brownfield CHP energy assets in Greater China, and then exit them via either a stock-market listing or sale to another fund over a period of 7–10 years.

"Due to the steady cashflow generative nature of CHP assets, the fund presents a relatively low level of uncertainty in the return drivers and offers an attractive investment proposition in an inflationary environment. Investors will also be able to take advantage of the expected RMB appreciation in the medium term" – said Pying-Huan Wang, Swiss-Asia's head of infrastructure investments"[42].

Thus, CHP market development in China has good prospects. With government incentives, aimed at attracting FDI flows into the economy, beneficial domestic market conditions, ambitious government plans to enhance CHP installed capacity cogeneration in China will gain a strong foothold.

Korea

The district heating market in Korea has expanded steadily during the past decade due to the combination of tax incentives and government planning policy. However, the share of industrial CHP in electricity consumption remains relatively low, covering about 11% of industrial electricity consumption over the last decade.

"The call for more combined heat and power plants parallels Korea's switch to natural gas from a coal-dominated market. Natural gas burns cleaner than coal and is generally the fuel of choice in CHP plants. Korea District Heating Corporation (KDHC) recently completed four new CHP plants totalling 801 MW plus 763 Gcal that will lift the company's total capacity to 1510 MW plus 1419 Gcal. Each of the new CHP units is designed for combined-cycle operation and to burn imported LNG""[43].

Government plans to boost production of renewable energy could soon make Korea one of the fastest growing markets for fuel cell-powered CHP systems in the Asia-Pacific region. Government long-term energy development targets call for renewable energy to generate at least 20% of Korea's total electricity supply by the end of the decade. Fuel cells are likely to be an important part of the renewable energy generation mix due to growing interest in captive power generation for backup power supply[44].

Thailand

Thailand is heavily dependent on imported oil and was among the first Asian countries starting to implement cogeneration solutions. There are two government programs namely Small Power Producer (SPP) regulations and the Very Small Power Producer (VSPP) regulations that were adopted by the Thai government to encourage CHP development. In this connection it can be noted that

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[42] Ibid.

[43] Ibid.

[44] *Korea's ambitious plans for fuel cell CHP capacity.* Cogeneration & On-Site Power Production, 2012.

http://www.cospp.com/articles/print/volume-13/issue-4/features/south-koreas-ambitious-plans-for-fuel-cell-chp-capacity.html

"Most investors in the SPP or VSPP projects are small or medium-sized companies, although Banpu and Glow have built up their business from the SPP and the private power programme and are both listed on the Stock Exchange of Thailand".

The Thai DE/CHP roadmap contains specific recommendations on how to increase investment attractiveness of cogeneration sector in Thailand[45]:

- restart the SPP program to allow new CHP generators to sell electricity on the Thai national grid;
- rationalize and enforce environmental regulations relating to the electricity generation (for example, air emissions regulations are more lenient for coal plants than biomass plants for the same pollutants);
- arrive at mutually agreed-up principles for determining feed-in tariff levels for different technologies. The levels for municipal solid waste and solar electricity should probably be reviewed and changed.

Singapore

Singapore is unique in Asia in the sense that the government does not subsidize any form of energy supply but simply encourages competition through a liberalized electricity market framework. However, companies invest in cogeneration and trigeneration projects despite the absence of government subsidies and other direct financial incentives. These projects range in capacity from a few hundred kilowatts to hundreds of megawatts, frequently operating at efficiencies above 80%, utilizing a variety of fuels (including gas, wood and waste), and producing electricity, steam, chilled water, compost and heat.

There are several CHP market opportunities in Singapore, specified by CHP experts:

"First, installed electricity capacity in Singapore exceeds existing peak demand. Roughly 57% of capacity does not operate continually. If all existing power plants are taken into account, and assuming that electricity demand grows at a rate of 5% per year, Singapore will not need to build any new capacity until about 2018. The existing capacity presents an attractive investment opportunity for more widespread adoption of CHP, as excess capacity can be converted to CHP generation at a lower cost than building new plants.

Second, investments in fossil fuelled infrastructure, even the form of CHP and DG, still emit greenhouse gases. Singapore has been conscientiously monitoring and reducing its carbon intensity and achieved a reduction from 28% in 1990 to 21% in 2007. This was mainly due to the increased share of natural gas in electricity generation.

Third, electricity reliability has been a relatively well-managed issue in Singapore as disruptions in supply from natural gas pipelines has occurred only five times in the past few years (and disruptions were quickly resolved). The energy environment in Singapore compares favourably to the situation in the United States, where hundreds of pipeline ruptures occur each year. A majority of existing power plants, including many CHP and DG plants, rely on natural gas as their primary fuel,

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[45] *Developing the market for decentralized energy in Thailand.* Cogeneration & On-Site Power Production, 2010.

http://www.cospp.com/articles/print/volume-11/issue-2/features/developing-the-market-for-decentralized-energy-in-thailand.html *all of which is imported to the country. The relatively good track record in electricity and natural gas supply reliability creates additional incentives for the development of gas-fired CHP and DG in Singapore"*[46].

North America

The following key tendencies in the North American energy and industry sectors will have a decisive impact on the future cogeneration development in the country:

- In recent years, American manufacturing has improved its cost competitiveness vis-à-vis other countries. A boom in natural gas production has supported manufacturing: the surge in domestic natural gas production can lower energy costs, reduce pollution and drive investment in the industries that supply equipment the natural gas sector and those that use natural gas as an input to production, like the chemical industry and CHP. Recent data from the Energy Information Administration (EIA) indicate that by the end of 2011 natural gas extraction increased by over 24% since 2006[47];
- Market analysis from Frost & Sullivan, "North American Cogeneration Market", finds the installed capacity of cogeneration systems expects to grow at a compound annual growth rate (CAGR) of 0.7 percent from 2008 to 2015, reaching 134,022 MW in 2015. The gas turbine segment anticipates higher growth compared to the steam turbine segment, as restrictions are likely to be imposed by federal global warming legislation[48];
- Obama has issued an executive order in August 2012 that set binding targets for the proliferation of cogeneration plants by 2020. Under this order, the number of such plants should double by 2020.

According to the EEA/ICF CHP Installation Database, currently the U.S. has an installed capacity of 81.611.320 kW with 3726 CHP units in all states:

Table 1. Installed CHP Capacity in the U.S.

#	State	Number of CHP units	Total Capacity, kW
1.	Alabama	38	3302545
2.	Alaska	113	480085
3.	Arizona	17	170667
4.	Arkansas	16	497325
5.	California	978	8440378
6.	Colorado	31	680091

[46] *Singapore success: CHP and trigeneration in the tropics.* Cogeneration & On-Site Power Production, 2009.

http://www.cospp.com/articles/print/volume-10/issue-1/features/singapore-success-chp-and-trigeneration-in-the-tropics.html

[47] *Investing in America: Building an Economy that Lasts.* Whitehouse.gov, 2012, p. 4.

http://www.whitehouse.gov/sites/default/files/investing_in_america_report_final.pdf

[48] *North American Cogeneration Market.* Frost & Sullivan, 2009.

#	State	Number of CHP units	Total Capacity, kW
7.	Connecticut	156	710399
8.	Delaware	3	52500
9.	District of Columbia	4	14475
10.	Florida	69	3411926
11.	Georgia	39	1214470
12.	Hawaii	33	431233
13.	Idaho	21	222645
14.	Illinois	137	1329337
15.	Indiana	37	2262278
16.	Iowa	34	590299
17.	Kansas	17	134455
18.	Kentucky	7	123120
19.	Louisiana	64	6889790
20.	Maine	25	897684
21.	Maryland	22	861097
22.	Massachusetts	159	1555778
23.	Michigan	87	3057572
24.	Minnesota	55	918464
25.	Missouri	19	228020
26.	Mississippi	23	570377
27.	Montana	17	112962
28.	Nebraska	17	105092
29.	Nevada	13	345104
30.	New Hampshire	19	58473
31.	New Jersey	209	3073430
32.	New Mexico	12	273933
33.	New York	464	5559410

#	State	Number of CHP units	Total Capacity, kW
34.	North Carolina	61	1529785
35.	North Dakota	11	67530
36.	Ohio	45	521183
37.	Oklahoma	15	678938
38.	Oregon	60	2518962
39.	Pennsylvania	135	3276430
40.	Rhode Island	25	114168
41.	South Carolina	24	1185644
42.	South Dakota	5	24200
43.	Tennessee	24	495248
44.	Texas	124	17318788
45.	Utah	20	223572
46.	Vermont	28	21947
47.	Virginia	48	1730744
48.	Washington	34	1227282
49.	West Virginia	12	381510
50.	Wisconsin	87	1550040
51.	Wyoming	13	169935
TOTAL:		**3726**	**81611320**

Source: EEA/ICF CHP Installation Database, 2012.

http://www.eea-inc.com/chpdata/index.html

Bodies such as the American Council for an Energy-Efficient Economy (ACEEE) rank Europe much higher than the States on energy efficiency progress. However, when it comes to cogeneration specifically, Europe is lagging behind. The level of CHP penetration in European markets is lower than in the U.S., at just 11%.

In North America, the majority of the cogeneration capacity is located in the oil refining and extraction industries, the pulp and paper industry, and chemical manufacturing industries. In Canada, there were two periods of substantial growth in cogeneration capacity. The first period was in the 1970 when energy prices quickly rose in Canada. The second period started in 1990 and continued until the last couple of years. Cogeneration use in the United States has been also growing steadily in recent years. The installed CHP capacity in the USA has grown from 10 GW in 1980 to approximately 82 GW in 2012. Presently, this corresponds to nearly 8% of their national electricity generating capacity.

A large amount of the growth has occurred since 1998 at which time a CHP summit was held to promote the use of cogeneration. At this summit, the US department of energy and the US Environmental protection agency announced their goal to increase the national CHP capacity to 92 GW, double the cogeneration capacity of 1998.

To sum up, the actual degree of cogeneration development varies widely from one country to another. There are several determining factors, including the level of economic and industrial development, status of power sector in terms of demand versus supply, availability of fuels, electricity pricing, government policies on the role of private sector in energy supply, and local climatic condition.

"Policy makers in APEC economies should realize the specific benefits that can be accrued from cogeneration and support such developments by creating appropriate regulatory and economic environment and removing barriers to the development of cogeneration, such as non-transparent and inconsistent procedures for the participation of non-utility players in generating and selling electricity to the power grid, technical hurdles of interconnection and high charges, securing a fair price for the export of cogenerated electricity to the grid. Considering the fact higher upfront investments are necessary to set up on-site CHP systems, suitable incentive measures have been extended to encourage private sector investment by making the projects financially attractive. Industries and commercial clients find it attractive to purchase energy services from CDE networks because of the economic advantages and the ease of availability of the different forms of energy from a single provider closer to their operation site.

Many of the existing policies are not conducive for the promotion of CHP. Typical barriers can be classified into the following four categories:

- Regulatory: Lack of consideration of cogeneration as an option for the power sector development; restriction on private power generation or the sale of privately generated electricity to the power grid; treatment of cogeneration on taxation regime; lack of incentives for cogeneration as a means to reduce national greenhouse gas emissions;
- Technical: non-availability of natural gas grid near potential sites with important industrial and commercial client base; interconnection with the electric utility;
- Economic/financial: cost of fuel purchased in bulk for cogeneration not the same as the price at which it is supplied to the utility-based power generating facilities; low price of electricity sold to the utility grid; high cost of electricity purchased from the grid; use of system charges and procedures, including the high stand-by costs;
- Awareness: inadequate awareness of the different stakeholders: policy makers do not realize the multiple benefits of CDE at the micro and macro level, potential developers are not always aware of the different financing options, and the potential clients underestimate the direct benefits;

As Asia-Pacific region continues to grow rapidly, there is increased pressure to develop new urban districts for decongesting the overcrowded city centers, and to create infrastructure for well-planned industrial estates for matching with the high growth in the industrial sector. At the same time, the threats of climate change are real and need to be addressed seriously by the national decision makers. Those countries lagging behind in the development of CHP can learn from their neighbors as well as from the best practices and examples around the world in order to lift the existing barriers and secure the benefits from the healthy growth of cogeneration and district energy in their cities and industrial complexes"[49].

The following recommendations for the enhancement of CHP investment attractiveness in the APEC region should be taken into account[50,51]:

- In order to become interesting for the building industry and energy service companies, decentralized cogeneration would need a support scheme that gives sufficient incentives, regardless of the amount of electricity consumed on location and/or fed into the grid;
- The benefit from cogeneration could be maximized by prioritizing and deferring loads (demand response) and by employing time-resolved metering of electricity feed-in;
- A CHP growth target should be set at a level that is thought to be achievable on the basis of both bottom-up and top-down market analyses;
- CHP sector should be considered as a separate industry in all APEC economies. APEC CHP policy should represent a long-term vision. The policy approach should address each CHP sector (e.g. industrial, district energy, commercial, and micro-CHP) and, in so doing, will address each CHP technology;
- A special standard for assessing "high efficiency" or "high quality" CHP should be drawn up.

CHP APEC Regional International Cooperation

A vast majority of the Asia-Pacific countries has yet to tap the existing cogeneration potential to the maximum. Considering the rapid industrial growth in many parts of the region, one would expect many more new process industries and commercial buildings to be added to the existing stock within a short span of time. These investments can be even better managed if the concept of cogeneration is well understood by the developers and investors. The end-users will have greater choices and more alternatives, in addition to having enhanced scope for decision making and professionalism. At the same time, the power utilities can have access to low cost and reliable excess energy produced in some areas faced with chronic deficit of power supply in the past[52].

This part of Chapter 3 is organized as a description of successful examples of regional international cooperation among APEC Member Economies in developing cogeneration. The following case-studies were chosen to demonstrate examples of CHP cooperation.

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[49] *Mohanty, B.* Op. cit., p. 11.

[50] *Pehnt, M., Cames, M., Fischer, C., Praetorius, B., Schneider, L., Schumacher, K., Voß, J.-P.* Micro Cogeneration. Towards Decentralized Energy Systems. Springer, 2006, p. 308.

[51] *Benchmarking Report. Status of CHP in EU Member States.* COGEN Europe, 2006, p. 42.

http://www.seai.ie/Publications/Your_Business_Publications/Benchmarking%20Report%20-%20Status%20of%20CHP%20in%20EU%20Member%20States.pdf

[52] *Chapter 2: Examples of Cogeneration Projects Implemented in Asia.* UNESCAP.org.

http://www.unescap.org/esd/publications/energy/Co-gen/part2ch2.pdf

Ogorodny Proezd-Novomoskovskaya[53]

In 2012, Russia's Gazenergostroy and China's biggest construction company, Norinco International Cooperation Ltd, plan to start building a gas turbine power plant. The project is called Ogorodny Proezd-Novomoskovskaya and the combined capacity of its three power units amounts to 600 MW, 750 Gcal.

The Chinese company will act as the general contractor to build the utility and raise financing to construct the gas turbine electric power plant. The Chinese investors initially undertook to finance 100% of the project but the figure was reduced to 85% as a result of negotiations, according to the Gazenergostroy President Sergei Chernin. Russian developers will finance the remaining 15% of the project.

As of today, the project feasibility study and most of the construction and process documentation has been prepared. In addition, a contract for gas supplies up to 2030 has been signed, along with agreements with major sales companies to purchase all the electricity and heat generated. Furthermore, international consulting expert Pöyry Energy has completed the appraisal of the project. Project costs are estimated at around 800 million euros, or 1,200 euros per kilowatt of installed capacity.

The Chinese investors have undertaken to provide electrical facilities for the project. The power plant will have three gas turbines and three steam turbines. The gas-steam cycle efficiency will be just under 50%. According to Chernin, the utility will supply power to the northeast of the capital and its central part. The project is expected to be launched into operation in December 2014.

Datang Gaojing combined-cycle cogeneration power plant[54]

The U.S. technology equipment company GE will supply three 9FB gas turbines for a 1,378 MW Datang Gaojing combined-cycle cogeneration power plant under construction in Beijing. The new facility will help meet surging electricity demand in the Chinese capital while also meeting environmental targets of China's Five-Year Plan.

In addition to the 9FB gas turbines, GE will supply related equipment and services to GE business partner and licensing associate Harbin Electric Corporation, which is building the plant for owner and operator China Datang Corporation. The GE 9FB technology will provide over 1.3 GW of power and when combined with Harbin's district heating solution for winter operation, at greater than 59 per cent at ISO conditions, it is expected to be one of the most fuel-efficient Chinese power plants to date. The plant will begin commercial operation in October 2013.

In addition to increasing the region's electrical capacity, the Datang Gaojing plant supports the Chinese government's strategy to replace and supplement coal-fired plants with cleaner natural gas-fired, gas turbine combined-cycle power plants. Compared to China's existing electrical grid, this plant will release 99 per cent less SOx, 88 percent less NOx and 49 percent less CO2 per unit of electrical output. The electricity generated

[53] *Kuzmin, V.* Chinese investments to create biggest private CHP plant in Moscow. RGC, 2012. http://rbth.asia/articles/2012/03/20/chinese_investments_to_create_biggest_private_chp_plant_in_moscow_15568.html

[54] *Owen, C.* US firm supplies tech for Chinese cogeneration project. Oil and Gas Technology, 2012. http://www.oilandgastechnology.net/upstream/us-firm-supplies-tech-chinese-cogeneration-project

by the Datang Gaojing plant will help support load management, and the heat recovered from the turbines' exhaust will provide district heating.

Teplichnoe CHP system in Saransk

Russian state-owned vegetable supplier Teplichnoe will install three GE natural gas-fired, Jenbacher cogeneration units at its greenhouse production facilities in the city of Saransk reflecting a broader trend of turning to on-site power technologies to reduce operational costs and increase energy security among Russian industries.

As part of its plans to boost output at its production facilities, the company is building the new energy center to provide more reliable and cost-effective on-site power and heat for its vegetable production facilities. Three of GE's 1 MW J320 Jenbacher gas engines will power Teplichnoe's new energy center. The units will provide heat to the food company's massive greenhouse facility while the electricity from the plant will support other production activities at the site.

GE will ship its Jenbacher units to Saransk during the second quarter of 2012. Scheduled to begin operating in the third quarter of 2012, the new cogeneration plant will utilize a design that offers capacity for future expansion. The project is being supported by ZAO INTMA, one of GE's authorized distributors for Jenbacher gas engines in the Russian Federation.

Cogen Plant Construction Collaboration in the Russian Far East

Japanese companies Kawasaki Heavy Industries Ltd. and Sojitz Corp. jointly landed an order from a Russian government-backed firm for 35 gas turbine cogeneration systems for the Russian Far East, valued at approximately 24 billion yen in 2010.

Kawasaki Heavy and Sojitz will supply the systems between 2011 and 2014 with the Vladivostok-based Far Eastern Center for Strategic Research on Fuel and Energy Complex Development (FEC).

Russia is now laying down a 1,800-kilometer natural gas pipeline to link Sakhalin with Vladivostok via Khabarovsk. The cogeneration systems, consisting of gas turbine power generation systems and hot water boilers, will supply electricity and hot water to cities, towns and villages along the pipeline. On top of the 35 systems, the Japanese firms plan to supply some 200 cogeneration systems in stages down the track under a framework agreement with the Russian side.

The following table identifies major barriers common in the diffusion of energy technologies in APEC economies and summarizes how these barriers were addressed in the case-studies.

Overcoming major barriers during implementation of CHP case-study projects.

Project	Overcoming barriers			
	Lack of technical expertise on the part of the technology buyer on technology selection	Unavailability of capital	High risk for a FSDP	Lack of local capacity to operate the equipment

Project	Overcoming barriers			
	Lack of technical expertise on the part of the technology buyer on technology selection	Unavailability of capital	High risk for a FSDP	Lack of local capacity to operate the equipment
Ogorodny Proezd-Novomoskovskaya	The mediatory role of the consultant facilitated an easy choice of the buyer on appropriate technology for its needs	–	–	–
Datang Gaojing combined-cycle cogeneration power plant	–	Three factors contributed in securing capital investment: the cogeneration project itself was financially attractive; good investment climate of the country; and the better financial performance of the company	–	–
Teplichnoe CHP system in Saransk	–	–	–	–
Cogen Plant Construction Collaboration in the Russian Far East	–	–	The financial and technical assistance as well as the independent monitoring helped mitigate the risks, and gave assurance that the project would perform according to the desired expectations	As part of the technology package, the supplier would need to provide a special workforce training on site by experts on power plant/cogen operations. However, this was not done.

Key CHP players in the APEC region

Key industry players in the APEC region include:

k2G-CENERGY Power Systems Technologies, Inc.

2G-CENERGY® is a US Corporation owned by 2G Bio-Energy Technology Corporation (2G Bio-Energietechnik AG) Germany, and 2G-CENERGY's senior management team.

Ameresco, Inc.

Ameresco Inc. is an energy service company. Ameresco is the largest independent energy services company in North America. It has participated in energy projects in the government, healthcare, public, and education sectors. Ameresco claims experience in demand-side management, energy savings performance contracts, cogeneration facilities, renewable energy sources, energy procurement, risk management, billing services and power plant development, financing, construction and operations.

Capstone Turbine Corporation

Capstone Turbine Corporation incorporated in 1988 is a California based gas turbine manufacturer that specializes in microturbine power along with heating and cooling cogeneration systems.

Caterpillar, Inc.

Caterpillar Inc. also known as "CAT" is an American corporation which designs, manufactures, markets and sells machinery and engines and sells financial products and insurance to customers via a worldwide dealer network. Caterpillar is the world's largest manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines.

Cogenra Solar

Cogenra is the leading developer of commercial-scale solar cogeneration projects in North America.

Cummins Power Generation

Cummins Power Generation is a world leader in the design and manufacture of power generation equipment, including PowerCommand standby and prime power systems.

Dresser-Rand

Dresser-Rand Group Inc. is a global supplier of rotating equipment and aftermarket parts and services, headquartered in Houston, Texas, United States, and Paris, France.

ESS

ESS provides environmental consulting and engineering services for power generation projects and related fuel storage and transmission facilities. ESS offers full life cycle support from site selection, permitting, and construction to operational compliance and decommissioning support.

FlexEnergy, Inc.

FlexEnergy, Inc. is a technology company that designs and manufactures innovative systems capable of producing continuous energy with near-zero emissions from a broad range of fuel sources, including otherwise unusable low quality gas.

FuelCell Energy

Based in Danbury, CT (USA), FuelCell Energy manufactures ultra-clean stationary fuel cell power plants that generate electricity with up to twice the efficiency of conventional fossil fuel plants.

Fuji Electric

Fuji Electric Holdings Co., Ltd. operating under the brand name FE, is a Japanese holding company that retains manufacturing companies of pressure transmitters, flowmeters, gas analyzers, controllers, inverters, pumps, generators, ICs, motors, and power equipments.

GE Energy

GE Energy is a division of General Electric and is headquartered in Atlanta, Georgia, United States.

Honeywell International

Honeywell International, Inc. is a major American conglomerate company that produces a variety of commercial and consumer products, engineering services, and aerospace systems for a wide variety of customers, from private consumers to major corporations and governments.

IntelliGen Power

IntelliGen has been involved with all aspects of pre-packaged onsite cogeneration products since 1988. IntelliGen focuses on incorporating the highest quality components to ensure reliable operation and long equipment life. IntelliGen stands behind its equipment and has a keen focus on operations and maintenance including remote monitoring.

Leva Energy

Leva Energy, Inc. manufacturers power-generating burners for distributed generation (DG).

Tecogen, Inc.

Tecogen is a manufacturer of natural-gas-fueled, engine-driven, combined heat and power products that aim to reduce energy costs, reduce greenhouse gas emissions, and alleviate congestion on the national power grid.

UTC Power

UTC Power is a fuel cell company based in South Windsor, Connecticut. It is part of United Technologies Corporation and has been in business for over 50 years. The company has experience in all five major fuel cell technologies.

China is the most important CHP market for the U.S. companies. China's major markets include Beijing, Guangzhou and Shanghai and China's 14 tier-II markets. In each of these 14 tier-II cities, the Commercial Service (through its American Trading Centers' program in China), works with the staff from the China Council for the Promotion of International Trade. Together, these agencies help US firms find local partners and identify major projects. China has more than 100 cities with populations of greater than one million, creating opportunities all over the economy.

For example, GE and China Huadian Corporation have signed a five-year joint collaboration agreement for distributed energy combined heat and power (DECHP) projects in China that is expected to boost US exports. GE anticipates that at least 50 gas turbine-generator sets will be sold and installed in China, resulting in US$500 million in total revenue. Of that amount, approximately $350 million is estimated in US exports.

In addition, according to the US Department of Commerce, the agreement could support approximately 2100 US jobs and provide new opportunities for further job growth in both countries.

The use of DECHP could be the most efficient use of natural gas in China and will be a significantly cleaner alternative to the higher greenhouse gas emissions from coal-fired power plants.

Key elements of U.S. export strategy for renewable energy and energy efficiency include:

Released in December 2010, the export strategy was developed through the U.S. Trade Promotion Coordinating Committee Working Group on Renewable Energy and Energy Efficiency, which includes representatives from the departments of Commerce, Energy, State, and Agriculture, as well as the Export-Import Bank of the United States (Ex-Im), the Overseas Private Investment Corporation (OPIC), the U.S. Trade and Development Agency, and the Office of the United States Trade Representative.

The strategy includes several new services to help US clean energy companies export products and services, described below.

- The federal government launched a new online portal to provide clean energy companies easy access to government export resources;
- The Commerce Department committed to an increase in the number of clean energy trade and trade-policy missions;
- Government will create new foreign buyers' guides for U.S. RE&EE technologies.
- OPIC will invest an additional $300 million in financing for clean energy in emerging markets and new financial products for energy efficiency subordinated debt financing and clean energy technology equipment leasing;
- OPIC and Ex-Im will streamline financing applications;
- The Office of the US Trade Representative will address market access barriers facing the US RE&EE industry in foreign markets through a new subcommittee;
- The USDA's Market Access Program will expand to include biomass wood pellets. The program has focused on biofuel products but not biomass in the past.

Solutions for greater deployment of CHP systems in APEC region

The following solutions are proposed[55]:

1. Change the legislative acts to streamline the process for cogeneration project owners seeking connections to the distribution network and substantially improve system-wide process and workload efficiencies;
2. Introduce a standardized connection process to replace the case-by-case approach that is currently the status quo;
3. Incorporate cogeneration facilities of up to 5 MW in size. This would give embedded generators that meet the required technical standards a right of connection to the distribution grid;
4. Streamline the connection process for non-standard projects by implementing agreed timeframes, common information requirements and contract terms.

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[55] *Unlocking Barriers to Cogeneration. Project Outcomes Report.* ClimateWorks Australia, 2011, pp. 10-43.

http://www.climateworksaustralia.com/ClimateWorks_Unlocking_Barriers_to_Cogeneration_Report.pdf

Small to medium sized cogeneration projects would be treated similarly to micro generators such as household solar panels. Household solar panels and other micro-generators have a dedicated standardized connection procedure. We recommend applying this to cogeneration projects, recognizing that for small to medium sized projects it is more efficient to use a similar standardized process as opposed to the connection process in the current rules that is based on a process developed for much larger generators. The standard right to connection would be similar to that to be introduced for micro generators, and already existing for conventional generators;

5. In addition to the rule changes above, there is an opportunity before the formal connection process begins to encourage greater engagement and information exchange between the distribution service network providers (DNSPs) and cogeneration project owners;
6. Project owners pay DNSPs a fee-for-service to work in a collaborative fashion during the connection enquiry stage of a proposal to shape and improve the potential project;
7. DNSPs are required to publish an annual "exceptions" report showing areas where constraints (such as no fault level headroom) exist in the network that may prevent connections within a defined near term period such 12 months;
8. Encourage economies of scale through the development of larger multi-site and district level cogeneration projects by:
   - Extending the use of metering arrangements that support the aggregation of separate sites. This would enable larger cogeneration systems to service multiple contiguous sites;
   - Making larger district level cogeneration projects eligible for consideration as a "registrable exempt network" in lieu of existing licensing requirements, to enable cogeneration project owners to charge for the use of their services and recover the capital costs of their investment.

Production of electricity from these facilities might very well increase, through the modernization of old cogeneration facilities, especially when also switching fuel from coal to natural gas, leading to a sizeable increase of the CHP coefficient, and therefore to a larger electricity yield per unit of heat produced.

The strongest growth can be expected for decentralized facilities, not least because of the very low starting base. But here, economic performance needs to be improved significantly, and technical breakthroughs (fuel cells) need to be realized. Considering the developments that can be expected, decentralized cogeneration facilities are unlikely to play the role attributed to them by 2020 in many studies.

CHAPTER 4. CHP FINANCINGCHP FINANCING[56]

The decision of whether and how to finance a CHP system is a critical step in the development of a CHP project. CHP systems require an initial investment to cover the cost of equipment, installation, and regulatory/permitting costs; these costs are then typically recovered through lower energy costs over the life of the equipment. A company might decide to invest in a CHP project if the value of the future stream of cost savings is greater than the up-front investment in equipment. The structure of financing can impact project costs, control, and flexibility, and affect the company's long-term economic health and ability to generate cash. Creative techniques can help spread risk among different participants and help overcome any capital constraints a prospective host may have. Financial investors have a primary motive that is based on a return on their investment/capital. There are a variety of capital providers in the market, and different investors have different objectives and enthusiasm for risk. The terms under which capital is provided vary from source to source, and will depend on such factors as the lender's appetite for risk, the project's expected return, and the time horizon for repayment.

State Incentives for CHP[57]

State financial incentives are an important instrument for increasing the use of technologies that provide benefits to both residents and the state overall. The incorporation of a state financial incentive can make energy efficiency investments more alluring for private and public entities. Homeowners and businesses not only save energy but also reduce pollutants, improve electric system reliability, and save significant amounts of money over the life of their investments. Financial incentives also help newer technologies, such as micro-CHP, to overcome barriers to market entry.

Financial incentives can take many forms: rebates, grants or loans for energy-efficiency improvements, direct income tax deductions for individuals and businesses, and sales tax exemptions for eligible products. The majority of financial incentives for CHP systems, however, are loans and grants; tax exemptions, grants and bonds are less commonly used.

Economics of CHP Projects[58]

Polish National Energy Conservation Agency (KAPE) developed a comprehensive guide " CHP PROJECT HANDBOOK", which defines individual stages of CHP projects providing a tool for evaluating the project framework. The CHP Project handbook states that economics of a CHP system for a facility depends on the following major cost components:

- investment costs
- annual operating cost
- costs of financing

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[56] http://www.epa.gov/chp/documents/pguide_financing_options.pdf, **PROCUREMENT GUIDE: CHP FINANCING**

[57] Policies and Resources for CHP Deployment, ©ACEEE, ACEEE CHP website aceee.org/chp/index.htm.

[58] http://www.kape.gov.pl/PL/Programy/Programy_UniiEuropejskiej/SAVE/aP_PROCHP/Handbook/atext.html#_Toc33795977, http://www.kape.gov.pl/new/index_en.phtml

The role of CHP project developers is to optimise the above stated cost positions, hence to provide for cost efficient and technically optimal realisation of client's requirements. There are two major components of annual operating cost for CHP: the annual energy costs and the annual maintenance costs.

Annual Energy Cost

Estimating the annual energy cost is the most complex and time-consuming aspect of evaluating the economics of a CHP system. Such an estimate requires the following information:

- Annual power load profiles for the facility
- Annual cooling and heating load profiles for the facility
- Performance characteristics of power generators
- Performance characteristics of the chillier and cooling tower
- Applicable gas and electric utility rates for the facility

Evaluation of electric power, heating and cooling load profiles for a facility presents the most difficult part of estimating annual energy cost. Estimates of these load profiles depend on many factors, including such factors as purpose and form of energy consumption needed at the facility, its geographical location, floor area and occupancy. Many CHP schemes use natural gas as primary fuel. For these systems fuel constitutes the majority of the variable/operating cost.

Annual Maintenance Cost

Annual costs of maintaining and operating the CHP plant comprise:

- Labour for operating and servicing the plant;
- Maintenance materials and labour, including scheduled maintenance carried out by manufacturers;
- Consumables, e.g. lubricating oil, feed-water treatment chemicals, as applicable;
- Back-up electricity prices and top-up minus prices for feeding electricity into the network or selling it to a third party.

Annual maintenance cost for various components of a CHP system is different and is negatively correlated to the equipment capacity. Typical maintenance cost ranges for some of the system components are as follows:

- Reciprocating engine maintenance costs vary in the range of 0.0075-0.0 15 EUR/kWh.
- Gas turbine maintenance costs vary in the range of 0.0045-0.0105 EUR/kWh.
- Steam turbine maintenance costs are approx. 0.003 EUR/kWh.

Cost of Financing

Cost of financing is the effective interest rate at which commercial customers of banks and other financial institutions can borrow. Effective interest rate is the interest rate plus any service cost incurred for initiating a loan. Cost of financing impacts the regular payments, to be made by the borrowing company, over a period of time to pay back the loan taken for installing CHP systems. These payments in turn influence the economic attractiveness of an alternative.

If the CHP plant provides a relatively small proportion of the site's energy demand and the unit costs of providing top-up heat and electricity remain unchanged, annual savings can be easily calculated by subtracting the CHP total running cost from the existing cost of the energy supply it displaces. However, this is often not the case and the proportion of site energy provided by CHP is such that the costs of providing the top-up heat and electricity change significantly. The reduced amount and different load profile of imported electricity may mean higher tariffs and the reduced and possibly intermittent loading of conventional boilers may have some effects on heat costs. In this case, comparison of total site energy costs with and without CHP is necessary.

Existing energy costs are compiled from fuel and electricity bills, internal costs records, etc., updated if necessary to current price levels. If existing site energy performance is capable of significant improvement by other energy efficiency measures, these should also be treated as a complementary or even competing option to CHP. If the CHP is operated on full load for at least 6000 hours per year in a way allowing for the utilisation of produced heat and power in an environment, where it replaces alternative supply options that are priced sufficiently high in relation to the CHP fuel, there can be achieved favourable simple payback periods of three to five years, or even less. The economics of CHP projects are much more sensitive to changes in the electricity price than to changes in fuel price. For example a 10% increase in electricity prices might reduce the payback period by 15%, while a 10% reduction in fuel price would reduce the payback period only by 6%.

Factors favouring short payback periods include:

- Low investment costs;
- Low fuel price;
- Comparable price of heat
- High electricity price;
- High number of annual operating hours;
- High overall thermal efficiency.

A detailed and comprehensive account of various CHP financing options is given on a UK Department of Energy and Climate Change (DECC) website[59]. It provides guidance on financing CHP and states that there are several ways to estimate and finance a CHP project development. To realise benefits of investing in cogeneration plant, it is necessary to select an appropriate technology and operation type of the plant. A combination of the right type of operations and capital investment makes financing CHP unique and, accordingly, has led to CHP financing solutions only seen in the CHP sector. It is necessary to review the common methods of financing the investment of CHP and see how to compare the projected performance of CHP against conventional methods of heat and electrical generation. The impact of financing CHP on a company's balance sheet must be reviewed.

Custom CHP Finance

There are various methods for establishing the capital, fuel and maintenance costs. The economic benefit of installing a CHP unit on any particular site arises out of the relationship between annual operating cost savings and capital outlay. The annual cost savings must be sufficient to meet the requirements for return on the capital invested by the owners of the plant.

A number of financial appraisal techniques are available. A large-scale CHP project cannot be evaluated financially as an isolated project because its capital cost is likely to be sufficiently large to affect the company's overall financial profile. The effects of the project on the company's finances, and its impact on the profit/loss account and

[59] http://chp.decc.gov.uk/cms/chp-finance/

balance sheet, should therefore be considered in some detail. CHP projects will also be competing with other projects for (usually) limited capital resources.

CHP Choice & Costs

The capital cost of any CHP plant depends on its size and type. However, there are a number of issues that should be taken into account in relation to costs:

- A CHP plant is more efficient than a simple power plant when the heat output is used effectively. Where CHP power generation produces heat that subsequently remains unused, the plant is effectively operating in the open cycle mode and therefore, probably, at a lower efficiency than the competing external power station.
- The plant will operate at its greatest energy efficiency, thereby maximising savings, when it is maintained as close as possible to its maximum load – as long as all the output is used.
- Economies of scale do exist. As the size of a CHP plant increases, capital and installation costs, expressed as $/kW, both fall. Operating and maintenance costs are also significant factors, especially for reciprocating-engine-based systems.
- Although a plant sized to meet maximum electrical demand will produce the greatest savings in purchased electricity, it may end up operating at part load – and thus less efficiently and economically – for a greater part of the time.
- Although electricity can be exported to the national grid during periods of surplus, these surpluses are most likely to arise at night when selling prices are at their lowest.

The first step in most financial appraisals is to assemble information on the capital costs and the annual cost benefits of the project and then to calculate the cash flow.

Capital Costs

Calculating the capital cost is unlikely to be as straightforward for a CHP plant as for lesser capital expenditure projects such as replacing an item of machinery. A replacement machine is likely to be bought through the capital budgeting process: the project engineer will have little interest in the financing method and may regard it as a problem solely for the finance department. A CHP plant, on the other hand, will need special consideration because the scale of its cost and the long-term nature of the commitment required may mean that its inclusion in the normal capital budget is inappropriate. A CHP project is not directly process related, so confidence in the capital cost estimate is more difficult to achieve than with more familiar, core-business investments.

Benefits

The first step in determining the annual cost benefits of a project is to evaluate its profit/loss and cash flow benefits. These are rarely the same. For CHP, the annual cash benefits consist of the difference between the annual costs of the two options:

- Possessing a CHP plant.
- Not possessing a CHP plant.

It is important to use common assumptions regarding, for example, potential fuel price increases, when evaluating the costs of each option.

Overall Cost Savings

The first step is to determine the site's base-load energy demands and non-CHP energy costs over several time bands. This also indicates the heat to power ratio of the site during each time band.

The second step is to calculate the costs of meeting the same energy demands using the CHP plant selected. The energy cost savings associated with the CHP plant can then be determined.

The third component incorporates a cost estimate for maintaining the CHP plant. This is deducted from the energy cost savings to give the net annual cost saving potentially achievable by the plant. This potential saving is then assessed against the installed cost of the plant.

Custom CHP Financing Options

Financing options can be divided into two key groups, i.e. those that appear on a company's balance sheet and those that do not. The table below shows both groups.

Possible financing methods for CHP projects	
Capital purchase or 'on-balance-sheet' financing	**Operating lease or 'off-balance-sheet financing**
Financed by: ▪ Internal funding ▪ Debt finance ▪ Leasing Capital purchase or 'on-balance-sheet' financing	Financed by: ▪ Equipment supplier ▪ Energy services company ▪ Other sources of funding Operating lease or 'off-balance-sheet financing

Choosing between On/Off Balance-sheet Financing

Choosing an appropriate method of financing will depend on the state of the company's profit/loss account and balance sheet, and also on the degree of risk and benefit associated with the project. If a company opts for a capital purchase, i.e. an on balance-sheet approach to funding, it may obtain the maximum benefits but it will also carry all the risk. A capital purchase may produce the highest NPV, but the initial cash flow will be negative.

Many companies will not, or cannot, provide the funds for the capital purchase of a CHP plant. There are several reasons for this:

- The return on investment for such a project may be lower than – and would, therefore, have an adverse impact on – the company's return on capital employed.
- Even if the return on investment is satisfactory, there may be other, more attractive claims on the company's cash resources.
- A capital purchase may increase the company's gearing or reduce liquidity to unacceptable levels.

Such a company may, therefore, prefer an off-balance-sheet financing option. Where a scheme is financed under an operating lease arrangement, the overall NPV will be lower than for the capital purchase option but the cash flow will always be positive – unless the project is only marginally viable or the lender's charges for money borrowed are high. Much ingenuity has been expended by ESCOs in devising schemes that combine the off-balance sheet advantages of operating leases with retention of the benefits of capital purchase. However, in recent years, accounting standards have become increasingly strict, and any such scheme is now subject to the provisions of Financial Reporting Standard. It is possible to involve an ESCO contractor with a project, regardless of the financing method chosen. Such a company may well have a valuable role to play in managing and lessening the risks to the end-user. When choosing a financing option, it should be remembered that:

- All potential financing options should be evaluated with equal care.
- The commitment from the end-user will be the same, i.e. high, whichever route is chosen.
- The choice of funding route should generally be secondary to the decision to proceed with the project.

Whichever method of financing is chosen, the decision to invest in large-scale CHP involves a long-term commitment.

Joint Ventures

A number of large-scale CHP schemes have recently been funded as joint ventures between the end-user and an ESCO contractor. Joint ventures are a highly specific form of legal entity and are normally only warranted for large, complex schemes which can justify the high set-up costs. In such cases, the joint venture serves to 'ring fence' the operation and limit the financial liabilities of the partners.

On balance sheet

The capital purchase of a CHP plant will appear on the company's balance sheet as a fixed asset. A capital purchase is generally funded using internal sources, external (debt) finance or a mixture of both. Another option is to lease a CHP rather than purchase it.

Internal Funding

With internal funding, the company provides the capital for the CHP installation. In so doing, it retains full ownership of the project and should reap the maximum potential benefits. At the same time, the company bears a considerable element of technical and financial risk, although the degree of this risk can vary with the installation option chosen. For instance, where a company places the work with a turnkey contractor, the contract terms may reduce the risk the company has to bear by placing more of it on the contractor. Similarly, the terms of contracts with consultants, equipment suppliers and subcontractors can be designed to minimize the investment risk.

Debt Financing

A large capital purchase is often funded by a new debt plus some internal funding. As with full internal financing, the residual technical and financial risks remain with the investing company, apart from those that lie with suppliers and contractors. At the same time, the company retains the full benefits of the installation. With new debt, it is possible to match an appropriate source of capital to a specific project. In particular, the borrowing timescale can be matched to the timescale of requirements, i.e. short-term finance should be obtained for short-term cash needs and long-term finance for long-term needs such as a CHP plant. For example, if a company investing in a CHP plant intends to generate a flow of savings/income over a period of 15 years, that company should attempt to finance the plant over the same period. If this is not possible, then the borrowing timescale should, at least, be as long as the payback period for the project plus the period required for recovering the 'cost of money'. In this way, the repayment schedule can be financed out of the savings/income generated by the CHP system.

When a company obtains finance, it should bear in mind that the lender regards the loan as an investment. For every investment, there is a trade-off between risk and return: the higher the risk associated with an investment, the higher the return required on that investment.

Factors influencing the perceived risk and return include:

- The company's current level of borrowings.
- The credibility of the company's projections of project benefits.
- The confidence of the lender in the company.
- The confidence of the lender in the technology to be employed.
- The level of security that can be offered by the company - the lender normally requires security so that the amount of the loan can be recovered if the company fails.
- The confidence of the lender in the general economic situation.

Commercial banks and other lenders can provide loans to support CHP projects. Most lenders look at the credit history and financial assets of the owner or developer, rather than the cash flow of a project. If the facility has good credit, adequate assets, and the ability to repay borrowed money, lenders will generally provide debt financing for up to 80 percent or more of a system's installed cost. Typically, the loan is paid back by fixed payments (principal plus interest) every month over the period of the loan, regardless of the actual project performance.

Debt financing usually provides the option of either a fixed-rate loan or a floating-rate loan. Floating-rate loans are usually tied to an accepted interest rate index like U.S. treasury bills.

Another potential source of loans is vendor financing, in which the vendor of the CHP system or a major component provides financing for the capital investment. Vendors can provide financing at attractive costs to stimulate markets, which is common for energy technologies. Vendor financing is generally suitable for small projects (below $1,000,000); however, some large vendors do provide financing for larger projects. Host or facility owners should ask potential developers and equipment suppliers if debt financing is a service they can provide. The ability to provide financing may be a key consideration when selecting a developer, equipment vendors, and/or other partners.

Leasing

Leasing is a financial arrangement that allows a company to use an asset over a fixed period. There are three main types of arrangement:

- Hire purchase agreement
- Finance lease (also known as 'lease' or 'full pay-out lease') and an
- Operating lease (also known as 'off-balance-sheet' lease).

Under a hire purchase agreement, the purchasing company becomes the legal owner of the equipment once all the agreed payments have been made. For tax purposes, the company is the owner of the equipment from the start of the agreement. The basis of the finance lease arrangement is the payment by the company of regular rentals to the leasing organisation over the primary period of the lease. This allows the leasing organisation to recover the full cost – plus charges – of the equipment. Although the company does not own the equipment, it appears on the balance sheet as a capital item and the company is responsible for maintenance and insurance. At the end of the primary lease period, either a secondary lease – with much reduced payments – is taken out, or the equipment is sold second-hand to a third party, with the leasing organisation retaining most of the proceeds of the sale.

Internal financing is not necessarily an easy option. Although CHP is a long-term investment, it will often have to compete with other potential business projects that are closer to the company's core area activities. Furthermore, it may have to compete within a short-term appraisal environment. So obtaining approval for CHP as a self-financed project may prove to be a problem. Although a company normally pools all of its existing sources of finance so that it is not possible to state which one has been used to fund which new project, each form of capital nevertheless has a cost associated with it. It is therefore usual to calculate a composite rate that represents the average cost of capital weighted according to the various sources of finance. This rate is known as the weighted average cost of capital (WACC).

With finance leasing, the leasing organisation obtains the tax benefits, and these are passed back, in part, to the company in the form of reduced rentals. In principle, the rental can be paid out of the energy savings, thereby assisting cash flow. Finance leasing may have tax advantages over internal and debt financing if the company has insufficient taxable profits to benefit from the tax allowances available on capital expenditure. With this route, the level of financial and technical risk taken on by the company is similar to that of a self-financed project.

Off-balance-sheet

Two types of organization can arrange or supply off-balance-sheet financing for CHP plant:

1. Equipment Supply Organizations
2. ESCO

Equipment Supply Organizations

An equipment supplier may, as an alternative to outright purchase, offer a leasing package to the company. The equipment supplier will normally design, install, maintain and, sometimes, operate the CHP system. A common commercial arrangement is for the energy to be supplied at prices that incorporate agreed discounts on the open market price. The company pays for the fuel and agrees to buy the electricity and/or heat generated at the agreed price. To assure the equipment supplier of a continued income from the sale of utilities to the company throughout the 5-10 year contract period, the company may be required to make a commitment in the form of a substantial standing charge, a lease payment or a high 'take or pay' volume of the energy supplied. This arrangement transfers most of the technical risk from the company to the equipment supplier. However, the company's savings are also significantly lower than under a capital purchase arrangement. The company also retains the risks relating to fuel price fluctuations. This form of financing arrangement has commonly been used to finance small, 'packaged' engine-based CHP systems.

Energy Services Company (ESCO) Contractors

An ESCO arrangement can vary widely. In some instances, the ESCO contractor will design, install, finance, operate and maintain a CHP plant on the company's site. In other cases, the company subcontracts only the operation and maintenance of CHP plant that has been installed by other contractors under a design and manage or turnkey arrangement. In both cases, the ESCO contractor supplies heat and power to the company at agreed rates. The ESCO contractor may also take responsibility for fuel purchase and for other on-site energy plant.

From a financing point of view, the basis of an agreement of this type is the transfer of CHP plant capital and operating costs, together with all the technical and operating risks of CHP, from the end-user to the ESCO contractor. The company's savings when funding a CHP plant through an ESCO arrangement would normally be less than under a capital purchase arrangement because the ESCO contractor needs to recover the cost of the capital investment and cover operating costs, overheads and profit. However, under certain circumstances, the savings can be greater than with a capital purchase arrangement. For example, the ESCO contractor may be able to size a CHP plant to meet the heat requirement of the company and produce surplus electricity that can be exported and sold. The company will still receive only part of the value of the energy savings but, because the energy savings are greater, the company's share may have a value greater than the savings that would have been achieved under a smaller capital purchase scheme. The ESCO contractor will also be able to increase the benefits compared with an in-house solution by avoiding the learning curve costs.

Different ESCO contractors may produce widely differing proposals, depending on the company's requirements and the ESCO contractor's objectives. Among the many variables to be resolved will be:

- Who will operate the plant on a day-to-day basis and, therefore, bear the performance risk?
- Who will maintain the plant?
- Who will own the plant at the end of the initial agreement period of 10-15 years and at what ongoing cost?

Any transaction with an ESCO contractor still involves a long-term commitment by the company. The company's audited accounts should contain a summary of this commitment. Evidence will also be needed to satisfy the company's auditors that the arrangement is an operating lease and not a finance lease. If ownership transfer to the company is implied or stated in the contract, the arrangement must appear on the company's balance sheet. It should also be noted that an ESCO contract and finance are not intrinsically linked. It is possible to enjoy the core benefits of an ESCO arrangement – cost reduction and operational risk transfer – irrespective of the finance route chosen.

Sourcing investment capital[60]

Many of the District Heating schemes and old generation plant are owned by municipalities that lack funds for this level of investment. EU structural funds have met some of the immediate needs to stabilize the DH infrastructure, but this is not enough. Pan-European utilities have acquired many of the larger DH schemes in the last decade, and have made significant investments, but due to the wider economic issues, and the

[60] *Investment, Financing and the International Community, Coming in from the Cold, Improving District Heating Policy in Transition Economies*, OECD/IEA, 2004

financial consequences of changes in nuclear policy in other countries, are now finding themselves more capital constrained. The sovereign debt crisis continues to reverberate across Europe, and national governments are likewise constrained in what infrastructure capital or stimulus they can provide the energy industry.

It is expected that international financial institutions, such as the European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB) will continue to be catalyst investors in infrastructure across the CEE, but substantial private capital will need to be invested alongside their investments. Can cogeneration assets in the CEE region be an attractive investment for private equity?

A well-conceived CHP scheme has some attractive fundamentals:

- long-term, secure revenues through power purchase agreements and heat sales;
- revenue is substantively disconnected from the general economic cycles, unlike investments in other sectors such as retail, property or manufacturing;
- long life asset (20–30+ years) with proven technology and predictable service costs;
- positive geo-political drivers for energy efficiency and carbon reduction;
- base load generation, with operational flexibility, is an asset in a market where intermittent renewable energy is increasing;
- far less reliant on government subsidies than other carbon reduction energy sources (especially solar);
- one of the lowest cost routes for carbon abatement.

It is critical from an investor's perspective that the commercial risk of the heat consumer is clear. Municipalities in most cases are considered secure, but commercial heat users need to be highly stable, long-term consumers or CHP plants risk being stranded within their economic life. Regulation of heat pricing also needs to be well understood and factored into the investment equation.

Stability of margins[61]

To achieve secure returns from secure revenues obviously requires stability of margins, which puts a clear focus on fuel supply contracts and as much parity as possible between fuel supply indexing and revenue. This is often the most challenging aspect of financing a CHP project, whether gas-, coal- or biomass-fuelled. The gas supply market is particularly volatile, going through significant market changes across the CEE – driven by deregulation, privatization and pipeline infrastructure improvements widening the supply base potential.

In the CEE region, the security of energy supply through gas storage, duel fuel systems and alternative fuels is a significant issue in national energy strategies. To some extent, district heating CHP systems are protected against supply disruptions, as evidenced in the 2009 crisis, where domestic heat sources were maintained with demand reduction being managed through industrial consumption control and changing sources of electricity generation. Indigenous fuel sources are also playing an increasing role, such as unconventional gas, biomass, biogas, hydro and other renewables.

[61] http://www.cospp.com/articles/print/volume-13/issue-4/features/financing-chp-and-district-heating-in-central-and-eastern-europe.html Cogeneration& On-Site Power Production online magazine, Financing CHP and district heating in Central and Eastern Europe, 01.07.2012

Business case for CHP

The best way of looking at the business case for CHP – as for any energy technology – is to consider all of the costs and all of the benefits over the full lifetime of the project. For a district heating project, this would mean considering[62]:

- The capital costs of the district heating network, CHP or other prime mover, and installations of equipment in people's homes or in other buildings
- The ongoing costs of operation and maintenance of a system
- The benefits associated with the scheme, including the income generated from selling heat and / or electricity to customers within the network or through the grid, and the money saved in comparison to an alternative way of supplying heat and power
- Other benefits, such as avoided costs of the EU ETS or CRC Energy Efficiency Scheme or income from feed-in tariffs or the renewable heat incentive (see below).

CHP projects funding models

Listed below are some approaches used to fund CHP and district heating projects. Models where the private sector partner bears the upfront costs are becoming more commonplace and provide demonstrable returns; some corporate or public sector bodies, however, may prefer to provide their own upfront capital to retain control of a scheme or asset for strategic reasons

Capital purchase

A more traditional procurement approach whereby the customer bears the up-front capital cost, but where the purchase of equipment is linked to service contracts and maintenance.

Discount energy purchase / energy supply contracts

Measures are installed, operated and financed by the provider at no up-front cost to the customer. Energy costs are capped for the duration of the contract and the provider recoups the capital outlay by signing a contract to provide energy from the system to the customer at a lower cost than their previous bills. This model is commonly used in the public sector for CHP / cogeneration projects.

Energy performance contracting

These contracts go a step further than energy supply contracts. Measures are installed, operated and financed by the provider at no up-front cost to the customer and with a guarantee of savings. Capital costs are recouped by the provider from the fuel bill savings achieved by the customer. The introduction of Feed In Tariffs for electricity generation from renewable sources mean that revenue income can also be used to pay the provider’s initial capital outlay. Guaranteeing savings means that energy performance contracting is “technology blind”, finding the most cost-effective way to deliver savings (whether financial or environmental).

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[62] http://www.chpa.co.uk/making-the-case_285.html, Making the case

Third party finance

Where financial institutions provide loans to either the energy services provider or the customer to address up-front capital costs, guaranteed by the energy cost savings that the project will achieve. Contractual structures are likely to be similar to an energy performance contract, with an additional layer for the finance agreement.

Private Finance Initiative (PFI)

Many large hospital and schools projects were funded through a PFI approach. In general, these have been large scale redevelopment projects with a much wider range of works involved (other than just energy). It is important to note that, as well as the savings achieved through reduced energy use after improvements, energy services providers can reduce the cost of energy in other means, for example, greater economies in purchasing fuel, efficient plant management and maintenance, efficient design of controls and reduced overhead requirements from a 'shared services' approach.

Success Factors[63]

The main factors, which enabled the successful implementation of different CHP projects can be divided into policy-related success factors and specific success factors related to particular issues of certain systems. The most often mentioned policy-related success factors are:

- investment subsidies and subsidies for demonstration projects (Belgium, Greece, Spain);
- a feed-in tariff scheme (Slovenia, UK, Cyprus, Greece);
- a green certificates scheme (Belgium, Poland);
- third party financing (UK, Greece);
- policy favouring the use of RES (Cyprus).

Specific success factors are largely case-dependant. Of these, an environmentally-friendly-orientated customer organization (Belgium, UK), good access to the energy infrastructure (Germany), an obligatory feasibility study assessing the merits of connection to district heating in comparison to other heat supply solutions for new developments (UK), the local availability of follow-up, service and maintenance of the system (Belgium) etc. play an important role.

National and International Public Financing Schemes

Some of the major multilateral and bilateral organizations that provide financing or technical assistance for district heating projects include:

- The World Bank.
- The Global Environment Facility (GEF).
- The United Nations Development Programme (UNDP).
- The European Bank for Reconstruction and Development (EBRD).
- The European Investment Bank (EIB).
- The European Union TACIS, PHARE and Obnova programmes.
- The Nordic Environmental Finance Corporation (NEFCO).
- The Nordic Investment Bank (NIB).
- The U.S. Agency for International Development (USAID).

[63] *Economic and financial aspects of cogeneration*, UNESCO-CHP Asia pdf

Multilateral investment banks such as the World Bank, the EBRD, the NIB and the EIB generally finance projects through loans or acquisitions of equity stakes. As a rule, they require co-financing from public or private sources and have special requirements and procedures for lending. For instance, the World Bank requires a sovereign guarantee for the loan; the EBRD's guarantee requirements depend on who will receive the loan, so guarantees can range from sovereign to municipal or corporate.

One problem with financing from international financial institutions is that the project development process may take several years from concept to construction. This sometimes results in investments that are no longer needed or might have been financed commercially. Given the high transaction costs, financing from international financial institutions usually works only with relatively large projects. Several small-scale district heating companies with similar investment needs can get together and apply for loans under "project umbrellas", but this also generally requires long and complicated project preparation.

Using Public Funds for Targeted Environmental Goals

Many international or governmental institutions finance projects that contribute to environmental goals. For instance, the GEF, a joint program of the World Bank, the UNDP and the United Nations Environment Programme, provides grant funding to certain energy efficiency projects with global environmental benefits. Another example is the Ecofund, which was founded in Poland in 1992. It manages a debt-for-environment swap fund, one of the largest environmental funds in the region. The Ecofund finances environmental projects, including energy efficiency improvements in district heating systems. It provides grants or preferential loans for 10 to 30% of total project costs (municipalities can obtain grants for up to 50% of a project's value in certain cases). The remaining costs have to be financed from the investor's own funds, commercial bank loans or loans from national or regional environmental funds.

In the Czech Republic, the State Environmental Fund uses state revenue from environmental fines and taxes to finance small and medium-scale cogeneration and district heating projects through a combination of direct grants and soft loans. Public entities have easier access to the grants and can obtain loans at a low interest rate (30% of the market interest rate),12 while private investors may obtain a preferential rate equal to 90% of the market rate. Similar environmental funds operate in Poland at the national, regional and local levels. These funds typically only cover a small portion of a project's costs, but they allow project developers to make investments in environmentally friendly technologies that would not be possible without these resources.

Many countries have energy efficiency funds that finance district heating projects. National governments, international financial institutions and donors have made the initial capital investments in these funds. The funds are often managed by local commercial banks, and one of their main objectives is to build the capacity of domestic financial intermediaries to finance energy efficiency investments. For example, Hungary established the Energy Efficiency Co-financing Program with a $5 million grant from the GEF. Russian regions have energy efficiency funds that are financed through energy taxes. The Belarusian government has a similar fund that allocates up to $300 million per year for energy efficiency projects, including district heating.

What Lenders and Investors Look For

This section discusses various financing methods for CHP, and identifies some advantages and disadvantages of each. As discussed before, the primary financing options available to CHP projects include:

- Company earnings or internal cash flow
- Debt financing
- Equity financing
- Lease financing
- Bonds (for public entities)
- Project or third-party financing
- BOO options including energy savings performance contracting
- CHP projects have been financed using all of these approaches.

Most lenders and investors decide whether or not to lend or invest in a CHP project based upon its expected financial performance and risks. Financial performance is usually evaluated using a projection of project cash flows over time. Known as a pro forma, this cash flow analysis estimates project revenues and cost over the life of the project including escalations in project expenses, energy prices, financing costs, and tax considerations (e.g., depreciation, income taxes). Thus, preparing an investment grade pro forma is an important step in ensuring the financial feasibility of a CHP project.

A lender or investor usually evaluates the financial strength of a potential project using the two following measures:

Debt coverage ratio

The main measure of a project's financial strength is the host's/owner's ability to adequately meet debt payments. Debt coverage is the ratio of operating income to debt service requirements, usually calculated on an annual basis

Owner's rate of return (ROR) on equity

Required RORs for internal funds typically range from 12 to 20 percent for most types of CHP projects. Outside equity investors will typically expect a ROR of 15 to 25 percent or more, depending on the project risk profile. These RORs reflect early-stage investment situations; investments made later in the development or operational phases of a project typically receive lower returns because the risks have been substantially reduced. The economic viability of a particular CHP project is also determined by the quality of CHP Project Risks and Mitigation Measures.

- Construction—Execute fixed-price contracts, include penalties for missing equipment delivery and construction schedules, establish project acceptance standards and warranties.
- Equipment performance—Select proven, compatible technologies; get performance guarantees/warranties from vendor; include equipment vendor as project partner; ensure trained and qualified operators; secure full-service O&M contracts.
- Environmental permitting—Initiate permit process (air, water) prior to financing.
- Site permitting—Obtain zoning approvals prior to financing.
- Utility agreements—Confirm interconnection requirements, schedule, and fees; have signed contract with utility.

- Financial performance—Create detailed financial pro forma, calculate cash flows, debt coverage, maintain working capital/reserve accounts, budget for major equipment overhauls, secure long-term fuel contracts when possible.

The uncertainties about whether a project will perform as expected or whether assumptions will match reality are viewed as risks. To the extent possible, the project's costs, revenues, and risk allocation are negotiated through contracts with equipment suppliers, fuel suppliers, engineering/construction firms, and operating firms.

Company Earnings or Internal Cash Flow

A potential CHP project owner may choose to finance the required capital investment out of cash flow generated from ongoing company activities. The potential return on investment can make this option economically attractive. In addition, loan transaction costs can be avoided with self-financed projects. Typically, however, there are many demands on internal resources, and the CHP project may be competing with other investment options for internal funds including options tied more directly to business expansion or productivity improvements.

Equity Financing

Private equity financing has been a widely used method for financing certain types of CHP projects. In order to use private equity financing, an investor must be located who is willing to take an ownership position, often temporarily, in the CHP project. In return for a significant share of project ownership, the investor is willing to fund part or all of the project costs using its own equity or privately placed equity or debt. Some CHP developers are potential equity investor/partners, as are some equipment vendors and fuel suppliers. Investment banks are also potential investors. The primary advantage of this method is its applicability to most projects. The primary disadvantage is its higher cost; the returns to the host/owner are reduced to cover the off-loading of risk to the investor.

Equity investors typically provide equity or subordinated debt for projects. Equity is invested capital that creates ownership in the project, like a down-payment in a home mortgage. Equity is more expensive than debt, because the equity investor accepts more risk than the debt lender. (Debt lenders usually require that they be paid before project earnings get distributed to equity investors.) Thus the cost of financing with equity is usually significantly higher than financing with debt. Subordinated debt gets repaid after any senior debt lenders are paid and before equity investors are paid. Subordinated debt is sometimes viewed as an equity-equivalent by senior lenders, especially if provided by a credit-worthy equipment vendor or industrial company partner.

The equity investor will conduct a thorough due diligence analysis to assess the likely ROR associated with the project. This analysis is similar in scope to a bank's analyses, but is often accomplished in much less time because equity investors are more entrepreneurial than institutional lenders. The equity investor's due diligence analysis will typically include a review of contracts, project participants, equity commitments, permitting status, technology, and market factors.

The key requirement for most pure equity investors is sufficient ROR on their investment. The due diligence analysis, combined with the cost and operating data for the project, will enable the investor to calculate the project's financial performance (e.g., cash flows, ROR) and determine its investment offer based on anticipated returns. An equity investor may be willing to finance up to 100% of the project's installed cost, often with the expectation that additional equity or debt investors will be located later.

Some types of partners that might provide equity or subordinated debt may have unique requirements. Potential partners such as equipment vendors and fuel suppliers generally expect to realize some benefit other than just cash flow. The desired benefits may include equipment sales, service contracts, or tax benefits. For example, an engine vendor may provide equity or subordinated debt up to the value of the engine equipment, with the expectation of selling out its interest after the project is built. The requirements imposed by each of these potential investors are sure to include not only an analysis of the technical and financial viability, but also a consideration of the unique objectives of each investor.

To fully explore the possibilities for private equity or subordinated debt financing, host or facility owners should ask potential developers if this is a service they can provide. The second most common source of private equity financing is an investment bank that specializes in the private placement of equity and/or debt. Additionally, the equipment vendors that are involved in the project may also be willing to provide financing for the project, at least through the construction phase. The ability to provide financing can be an important consideration when selecting a developer, equipment vendors, and/or other partners.

Lease Financing

Leasing can be an attractive financing option for smaller CHP projects. The operating savings resulting from the installation of CHP—the bottom-line impacts on facility energy costs—are used to offset the monthly lease payments, creating a positive cash flow for the company. Lease financing encompasses several strategies in which a facility owner can lease all or part of a project's assets from the asset owner(s).

Typically, lease arrangements provide the advantage of transferring tax benefits such as accelerated depreciation or energy tax credits to an entity that can best use them. Lease arrangements commonly provide the lessee with the option, at pre-determined intervals, to purchase the assets or extend the lease. Several large equipment vendors have subsidiaries that lease equipment, as do some financing companies. Leasing energy equipment has become the fastest-growing equipment activity within the leasing industry. The lease payments may be bundled to include maintenance services, property taxes, and insurance. There are several variations on the lease concept, including operating, capital, and leveraged leases. An operating lease appears as an operating expense in the financial statement. Operating leases are often referred to as "off-balance-sheet" financing and usually treated as operating expenses. To qualify as an operating lease, the agreement must NOT:

- Transfer ownership of the equipment at the end of the lease term.
- Contain a bargain purchase option.
- Have a term that exceeds 75 percent of the useful economic life of the equipment.
- Have a present value at the beginning of the lease term of the minimum lease payments greater than 90 percent of the fair value at the inception of the lease, using the incremental borrowing rate of the lessee as the discount rate.

Capital lease obligations are reflected on the balance sheet and may be subject to lender or internal capital budget constraints. The general characteristics of a capital lease are:

- It appears on the balance sheet as debt for purchase.
- It requires transfer of ownership at the end of the lease.
- It specifies the terms of future exchange of ownership.
- The lease term is at least 75 percent of the equipment life.

- The net present value of lease payments is about 90 percent of the equipment value.

In a leveraged lease**,** the lessor provides a minimum amount of its own equity, borrows the rest of the project capital from a third party, and is entitled to the tax benefits of asset depreciation.

Project or third-party financing[64]

Project or third-party financing is an approach to obtaining commercial debt financing for the construction of a project in which the lenders look at the creditworthiness of the project to ensure debt repayment rather than at the assets of the developer/sponsor. Third-party financing can involve the creation of a "legally independent project company financed with non-recourse debt and equity for the purpose of financing a single purpose industrial asset." This entails establishing a company (e.g., a limited liability corporation) solely in order to accomplish a specific task, in this case to build and operate a DG/CHP facility. Lenders look primarily to the cash flows the asset will generate for assurances of re-payment. Moreover, they are explicitly excluded from recourse to the owners' underlying balance sheets.

In deciding whether or not to loan money, lenders examine the expected financial performance of a project and other underlying factors of project success. These factors include contracts, project participants, equity stake, permits, and technology. A good project should have most, if not all, of the following completed or in process:

- Signed interconnection agreement with local electric utility company
- Fixed-price agreement for construction
- Equity commitment
- Environmental permits
- Any local permits/approval

Lenders generally expect the owners to put up some level of equity commitment using their own money and agree to a fixed-term (8- to 15-year) repayment schedule. An equity commitment demonstrates the owner's financial stake in success, as well as implying that the owner will provide additional funding if problems arise. Lenders may also place additional requirements on the project owners. Requirements may include maintaining a certain minimum debt coverage ratio and making regular contributions to an equipment maintenance account, which will be used to fund major equipment overhauls when necessary.

The transaction costs for arranging project financing can be relatively high, driven by the lender's need to do extensive due diligence; the transaction costs for a 10 MW project may be the same as for a 100 MW project. For this reason, most of the large commercial banks and investment houses have minimum project capital requirements on the order of $10 to $20 million. Developers of smaller CHP projects may need to contact the project finance groups at smaller investment capital companies and banks, or at one of several energy investment funds that commonly finance smaller projects. Depending on the project economics, some of the investment capital companies and energy funds may consider becoming an equity partner in the project in addition to providing debt financing.

[64] *Esty, Benjamin*. Modern Project Finance: A Case Book. 2004.

Build-Own-Operate Options

A final third-party financing form is the BOO option, in which the CHP facility is built, owned, and operated by an entity other than the host and the host purchases heat and power at established or indexed rates from the third party.[65] There are also build-own transfer projects, which are similar to BOO projects except that the facility involved is transferred to the host after a predetermined timeframe. Such projects may be implemented by an energy services company (ESCO) or sometimes by equipment suppliers and project developers acting as ESCOs.

In a BOO project, the ESCO finances the entire project, owns the system, and incurs all costs associated with its design, installation, and maintenance. The ESCO sells heat and power to the host at a specified rate that offers some savings over current energy expenditures, or can enter into an Energy Savings Performance contract (ESPC) with the host. In an ESPC, the ESCO and the host agree to share the cost savings generated by the project; in return, the ESCO guarantees the performance of the CHP system. An ESPC mitigates the risks associated with new technologies for facility owners, and allows operation and maintenance of the new system by ESCO specialists. ESPCs are frequently used for public-sector projects. There are no upfront costs other than technical and contracting support. Traditional ESPCs have three components:

- A project development agreement
- An energy services agreement
- A financing agreement

As such, an ESPC is not a financing agreement by itself, but it may contain the financing component. Most lending institutions prefer to see the financing section as a stand-alone agreement that can be sold into the secondary market. This helps create demand for this financial instrument, usually resulting in better pricing. The host must usually commit to take a specified quantity of energy or to pay a minimum service charge. This "take or pay" structure is necessary to secure the ESPC. The project host gives up some of the project's economic benefits with a BOO or ESPC in exchange for the ESCO becoming responsible for raising funds, project implementation, system operation, system ownership or a combination of these activities. Some of the disadvantages of this approach to financing include accounting and liability complexities, as well as the possible loss of tax benefits by the facility owner.

Financing Options for Public Entities

Public sector facilities have additional financing options to consider.

Bonds

A government entity (e.g., municipality, public utility district, county government) can issue either tax-exempt governmental bonds or private activity bonds, which can be either taxable or tax-exempt, to raise money for CHP projects. Bonds can either be secured by general government revenues (revenue bonds), or by specific revenues from a project (project bonds). The terms for bond financing usually do not exceed the useful life of the facility, but terms extending up to 30 years are not uncommon. The primary benefit of governmental bonds is that the resulting debt has an interest rate that is usually lower (1 to 2 percent) than commercial debt. However, in addition to initial qualification requirements, many bond issuers find that strict debt

[65] This approach is often called "chauffage".

coverage and cash reserve requirements may be imposed on an energy project to ensure the financial stability of the issuer is preserved. These requirements may even be more rigorous than those imposed by commercial banks under a project finance approach. To qualify for a tax-exempt governmental bond issue, a project must meet at least two criteria:

Private business use test

No more than 10 percent of the bond proceeds are to be used in the business of an entity other than a state or local government

Private security of payment test

No more than 10 percent of the payment of principal or interest on the bonds can be directly or indirectly secured by property used for private business use.

Capital Cost Effects of Financing Alternatives

Each financing method produces a different weighted cost of capital, which affects the amount of resources required to cover CHP system installation costs. Generally speaking, the financing methods are ranked from lowest cost to highest cost as follows:

- Internal cash flow financing
- Governmental bond financing
- Commercial debt financing
- Project financing
- Private equity financing

Governmental bond financing achieves its advantage through access to low-interest debt. Project finance generally produces a higher financing price because funds are required to pay interest charges as well as ROR on equity. Private equity can be the most expensive option because it usually demands a higher return on equity than project finance, and equity often makes up a larger share of the capital requirement. BOO and ESPC options remove capital financing from the users' responsibilities.

Risk Allocation and Mitigation

The project cycle of a cogeneration project has several stages[66]. Typical for Asian regions project's risks allocation and possible ways of its mitigation are described in the Cogeneration Project Development Guide, Developing and Implementing Biomass, Clean Coal and Natural Gas Cogeneration Projects in ASEAN, EC-ASEAN COGEN Programme[67].

The sources of funds are different in each stage as well as the risks associated with the completion of each stage. It is important to note that until the project is built and capable of operating, there is no revenue source to repay the investment. Without revenue, the project's lenders and investors are unable to recover their original investment. Until the plant is operating, the risks increase for the participants as more money is lent or invested in the project. The risk of non-completion is the greatest risk of the project during the construction stage. This phase is lengthy and needs to be managed carefully. As the development and construction stages proceed, more sources

[66] *Cogeneration Project Development Guide Developing and Implementing Biomass*, Clean Coal and Natural Gas Cogeneration Projects in ASEAN, Second Edition, March 2004.

[67] www.cogen3.net

of funding become available. Then, once a project demonstrates that it is capable of operating commercially, the sources of capital increase dramatically. In addition, unlike a company that has multiple sources of revenue, an energy project generally has one or two sources of revenue which adds a premium to their borrowing costs. The project developer has to consider the risks involved in the development, construction and operation of energy projects. Similarly, depending on the risks inherent in the project, the lenders will require different types of risk mitigation measures. Below are some potential risks and the measures that could be possibly undertaken to mitigate them at different stages of the project. Since some risks exist in all projects, some requirements are standard in all types of projects.

Fuel Risk

Fuel is usually the largest operating expense for a cogeneration project and it presents one of the greatest risks. Parties involved in the project should look at the linkage between the fuel cost and energy costs. If the fuel contract tracks the pricing for the fuel in the power purchase contract, this reduces the risk to the lender that increased fuel cost cannot pass through. In the event that the fuel costs and energy payments do not track, lenders may require some form of risk mitigation. This can be in the form of a dividend restriction or a reserve fund. Risks associated with the supply of fuel are typically dealt with by the operating company entering a long-term fixed price fuel supply agreement pursuant to which penalties would be payable for failure to perform. Thorough fuel supply availability study as well as firm agreements with the fuel suppliers is essential to ascertain the security of the fuel supply. Moreover, due care should be given to obtain accurate data.

Sales/Off-takers Risk

Lenders do not like to accept sales risk as not all output can find a purchaser. The project developer will seek a long-term sales contract with a reliable third party for at least the term of the loan. Sales risk is important because most banks will require the sales contract to continue for a period after the repayment of loan. This will protect the bank in case there is any problem with the sales. The contract for power off-take is called Power Purchase Agreement (PPA). In the purchase agreement, the producer would sell to off-taker power generated from its plant. The off-takers are usually the grid that purchases the power to meet anticipated future power supply needs. The lender will look into off-takers creditworthiness and their long term viability.

Technology Risk

Despite the advantages proven technologies in terms of emission and efficiency, technology risk can be a significant risk factor. The project should not involve unproven or pilot technology. The reliability of the process and the equipment to be used must be well established. If a new technology is involved, more than a lending risk will be involved, unless the project borrowings are guaranteed by a strong credit such as a government agency or a large company with an excellent credit standing. For new technologies, the lenders will normally ask for additional support and guarantees from the sponsors. Sponsors will not be prepared generally to assume the full risks themselves, and will require guarantees and warrantees from the manufacturers. Unless the manufacturers are large, creditworthy companies, they will be forced to provide private insurance or bank bonds to cover this risk. If the project is largely self-supporting without an all-encompassing guarantee from a government agency or some other form of credit, the parties involved should insist that the project use existing technology. Lenders who rely on cash flows from a project to service debt expect the project to be similar to other full-size working projects, with proven technology and engineering. Typically, lenders should feel comfortable with three to-five previous plants of the same technology with at least five years of reliable operation. Insurance can also be used to mitigate this risk. For new technologies, the cover restrictions may apply during construction (testing) and operation where unproven technology is used. It is difficult to define “prototype” or “new” technology since underwriters tend to look at each model or plant design on its own merits. Underwriters do not wish to assume responsibility for “test bed” risks, which should be carried by the equipment manufacturer to demonstrate satisfactory performance (typically 8,000 hours) under normal conditions. Cover restrictions are normally lifted once sufficient operating hours have been achieved. In the interim, a developer should look to protect the project by obtaining adequate guarantees and warranties from the manufacturer geared to plant performance and also covering the financial consequences of breakdown.

Environmental Risk

Environment is a growing concern to the lenders. The government and lenders will require planning, environmental and other consents and approvals have been obtained. A thorough environmental impact assessment is required for all major energy projects. Lender may also look to potential change in future environmental regulation, which may risk the project’s future economic operation. Operational environmental management programmes are normally required. Pre-existing conditions at the energy plant will need to be assessed for hazardous materials. Liability for clean-up must be assumed by responsible parties as lenders will not take the risk. In some cases, lenders will not lend to a project on a questionable site, even if clean up has been undertaken. The risk of gradual damage to the environment is not insurable within the ordinary third party liability market. Typically, only the costs incurred as a result of sudden and unforeseen accidents can be insured and often cover is restricted to a maximum sum in any year. There is a market for gradual pollution – environmental impairment, but the cover is limited and expensive. Alternative means of avoiding this risk should be used.

Operating Risk

Once a project is constructed, the lender will be concerned with who the project operator is. The lender will require an appropriately qualified operator to maintain and to meet the projected operating budget. The lender will review proposed operations to see if sufficient funds have been allocated for the operation and maintenance, and the sufficient trained personnel in order to available to operate the plant.

Country Risk

Country risk consists of a politically motivated embargo or boycott of a project, debt repayments or shipment of product, which may reflect the foreign policy of the country. Country risk also considers circumstances in which the host country cannot permit transfer of funds for debt service because of its own economic problems. In some circumstances, lenders may feel comfortable in assuming some or all of the responsibility and risk of solving such problems should they arise. Country risk is important because banks set lending limits on a country by country basis. An unstable environment warrants a lower country limit. Unfortunately, the countries with the lowest country limits often have the greatest need for energy.

Political Risk

Political and regulatory risks are inherent in doing business. These risks affect all aspects of a project, from site selection and construction through completion, operations and marketing. Where possible, these risks are assumed by sponsors. Where this is not possible, lenders sometimes assume such risks. The ultimate political risk is expropriation and banks are sometimes exposed to this risk by a borrower to lessen the likelihood of expropriation. The distinction between country risk and political risk is a thin one. There are many tools used by governments to make outside investment in projects more attractive. These include local legislation to confer benefits on foreign investors or memoranda of understanding or implementation agreements that demonstrate commitment to projects. These tools can reduce short-term risks but in the long-term, a track record of political stability provides the best assurance. Some form of political risk insurance is often used. National export credit agencies (ECAs) provide this to their exporters. More extensive cover can be obtained from multilateral development agencies such as the World Bank.

Recommendations of IEA[68]

To facilitate commercial financing of district heating projects, governments should focus on the following measures:

- Developing tariffs that cover costs and provide a return on investment.
- Instituting stable and predictable legal and regulatory frameworks.
- Encouraging district heating companies to focus on customers and reduce overcapacity.
- Enforcing payment discipline and setting up targeted subsidies for poor households.
- Pursuing overall reforms in the financial sector.
- Establishing clear accounting standards and financial reporting requirements for companies.
- Involving the private sector.

National and international financial support schemes ideally should be designed to help create the conditions for commercial financing and private investments. Loan guarantees and training programmes are typically better suited for this than direct grants. Guarantees leverage commercial financing, which automatically increases their impact. When commercial financing is available, public financing should be very limited and targeted.

Governments can take specific steps to create favorable conditions for an ESCO market. In particular, they can improve the legal and regulatory basis for performance contracting. Replacing cost-plus tariffs by incentive regulation will stimulate the development of ESCOs. In addition, fiscal and other incentives such as investment tax credits, accelerated depreciation, adaptation of public procurement can promote investment in energy efficiency. Improving the overall investment climate and access to commercial financing is also very important.

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[68] *Investment, Financing and the International Community, Coming in from the Cold, Improving District Heating Policy in Transition Economies*, OECD/IEA, 2004.

CHAPTER 5. WORKSHOP SUMMARY AND RECOMMENDATIONS

Introduction

The use of cogeneration technologies in distributed power systems is recognized as one of the most environmentally friendly and cost-effective ways to improve energy efficiency. Efficiency cogeneration plants is 80-85%.

In 2011, "International Energy Agency" (IEA) report on renewable energy sources and cogeneration technologies, said that the co-generation is an effective method to improve the energy efficiency. However, as the IEA, now needs support at the state level for the use of the full potential of cogeneration. EU countries (Denmark, Germany, Finland, the Netherlands) for their leadership on the use of cogeneration technologies. At the same time, the IEA notes the significant potential to increase electricity from cogeneration in the member countries of APEC, China, Japan, Russia, Canada, USA, etc.

During the seminar, with the participation of international experts with recognized competence and experience in the design and use of technology cogeneration discussed characteristics of the available technologies and the benefits of its applications. The workshop developed and proposed measures to support the dissemination of these technologies.

In order to most effectively advance the Seminar organized by the review, reflecting: the stage of technological development of cogeneration technology, the current practice of such projects in the APEC economies, government policies, the possibility of co-operation of local communities in order to effectively utilize the benefits of cogeneration possible concrete steps towards cooperation in APEC economies this area.

The results of the Workshop, which is a central element of this project, will determine Russia's contribution to the work of APEC during its presidency in 2012, and possibly for the next few years, the development and practical application of the technology of cogeneration.

The main objective of the Seminar - an interactive discussion on the results of a preliminary analysis by the international group of consultants. Duration of the seminar - two days. The seminar is held in the same room in plenary thematic sessions, without division into parallel sessions. The duration of each meeting between breaks and protocol events - no more than 2 hours.

A brief list and description of the services provided by the organization of the Seminar

The formation and maintenance of a project team.

Formation and Maintenance of an advisory group on the use of co-generation technologies for the distribution of energy systems.

Russian Foundation for educational programs "Economics and Management" A team of consultants from Russia and other economies of APEC to meaningful training seminar. Number of group of consultants - ten (10), details of the consultants listed in this document.

Formed with the support of an international group of consultants, we organized the work on the preliminary analysis of the following issues:

1. State of the underlying technology and the potential development of new technologies of cogeneration.

2. Complexity and risks of innovative modernization of energy systems in developing APEC economies, review priorities, policies and plans for the development of cogeneration in various APEC economies, including also the study of European initiatives, policies and legislation, research and review of "best practices" in the field of cogeneration technologies with emphasis on practical projects.

3. Recommendations for the use of cogeneration technologies in the special conditions (island territories, cold climate), a review of existing international experience of creating and commissioning of cogeneration plants and the implementation of appropriate pilot projects.

4. Possible recommendations for strategies, actions, institutions to reduce risk and cost of the investment in the technology of cogeneration.

In the course of our analysis, we have provided the working contacts between consultants mode mail, video conferencing, and working meetings.

The working group

For the purposes of the project, we formed a project team consisting of:

Name	Position/Role
Julia Dacko	PROJECT TEAM LEADER
Michael Shetinin	PROJECT COORDINATOR
Elena Ignatyeva	PROJECT MANAGER
Nelly Segisova	ACADEMIC ADVISOR
Oksana Boytsova	LEAD CONSULTANT
Dmitri Lifatov	CONSULTANT
Takahiro Nagata	CONSULTANT

The expert group

Please be informed that the formation of a team of consultants, we have in this group included individuals with relevant experience and skills in the field of technology development of cogeneration and its applications. The selection of consultants, we used the following criteria:

- proven experience in execution of public contracts;
- practical experience with regional programs for energy efficiency and their performance;
- knowledge of the regional aspects of the heating market in Russia;
- practical experience working with government agencies APEC;
- developed relations with APEC economies with obligatory presence of bilateral memoranda of cooperation in the field of energy efficiency;
- knowledge of the legal aspects of energy efficiency and the availability of an appropriate legal framework;
- the presence of institutional experience of the All-Russia conference on energy efficiency and heating;

- availability of proven experience in international research on "smart grids" ("Smart Grid").

Each of the presented group of consultants meets at least six of the following criteria, with the conditions for the existence of practical experience working with government agencies and the availability of APEC bilateral memorandums on cooperation in energy efficiency made mandatory. In addition, a team of consultants in general corresponds to at least seven different criteria from a specified list.

Table 8. List of consultants

#	Name	Role in the project	Position
1	Dr. Segisova Nelly	Academic Advisor	Scientific consultant expert, PhD, MBA, Russia, Moscow
2	Ms. Boitsova Oxana	Lead Consultant	Senior Expert, Department of GR and Regional Policy, JSC "RUSNANO", Russia, Moscow
3	Mr. Andreasson Claus	Consultant	Executive Director Wayne Burmeister End Energy A / S (BWE), Denmark, Copenhagen
4	Mr. Nagata Takahiro	Consultant	Senior Coordinator, Division "New and renewable energy sources", Institute of Economy and Energy, Tokyo
5	Mr. Direland Anders	Consultant	Marketing manager of energy and climate, the company Ramboll Denmark, Copenhagen
6	Mr. Chvid Jorgen	Consultant	Leading expert company Ramboll Denmark, Copenhagen
7	Mr. Zviring Albert	Consultant	Scientific expert consultant, project manager, the company «MWH-ICF-Ensat consortium», the Russian Federation, Moscow
8	Ms. Chelnokova Anna	Consultant	Advisor on Energy, the Russian-Danish Energy Efficiency Center, Russia, Moscow
9	Mr. Lifatov Dmitriy	Consultant	Specialist of strategic cooperation, "Russian Energy Agency," Russia, Moscow
10	Mr. Vigura Alexey	Consultant	Consultant of the Department of energy innovation, the company «CJSC Energy Forecasting Agency (APBE)»

Presentation summaries:

At the workshop by the following speakers:

#	The speaker / moderator / Theme
1	Moderator

#	The speaker / moderator / Theme
	Nelly Segisova Academic Advisor of the Conference
2	Efficiency improvement of CHP equipment on the basis of R&D undertaken by the National Research University Moscow Power Engineering Institute (~ 30 min) Vladimir Gribin Head of Department Institute for Mechanical Engineering and Mechanics, Russia
3	CHP Markets & Policies in Japan (~ 20 min) Takahiro Nagata New and Renewable Energy Group The Institute of Energy Economics, Japan
4	Financing CHP (~ 20 min) Zenko Shinoyama Deputy Director General, Power and Water Finance Department, Infrastructure Finance Group Japan Bank for International Cooperation, Japan
5	Electricity Market in Chile (~ 10 min) José Carrasco Benavides Electricity Department The National Energy Commission, Chile
6	EBRD - Financing and Investment in Russian Power Industry (~ 15 min) Alexander Filkine Head of Regional Office EBRD, Far Eastern Federal District, Russia
7	Alternative source of funding for infrastructure projects (~ 15 min) Maxim Krilevevich Economic Research Institute FEB RAS
8	Tavrida Electric - manufacturer and supplier of electrical equipment for cogeneration facilities (~ 15 min) Andrey Korobkov Deputy Director General Tavrida Electric, Russia
9	Kawasaki Heavy Industries (~ 20 min) Masahiro Kita Deputy General Manager Kawasaki Heavy Industries, Ltd., Member Company of JASE-W, Japan
10	Distributed power systems: microturbine-based cogeneration and trigeneration (~ 15 min) Alexander Skorokhodov

#	The speaker / moderator / Theme
	Director General BPC Engineering, Russia
11	Government Policy and Action for CHP in the Russia's Primorye Territory (~ 25 min) Alexey Bondar Director of Russian Far East Branch Russian Energy Agency
12	Advantages & Benefits of Micro-CHP for Local Energy Systems (~ 20 min) Andrey Udod Ministry of Housing & Communal Services of Khabarovsk region, Russia
13	Condition and prospects of energy Far Eastern Federal District, Russia (~ 30 min) Dr. Anatoly Shtym Head of the Department "Thermal Power and Thermal Engineering" Far Eastern Federal University
14	Establishment of energy-saving and energy efficiency information systems in the Russian Far East Regions as an energy management tool in the public sector (~ 15 min) Victor Dyomkin Director of Khabarovsk Scientific and Technical Information Center, Russia
15	CHP plant on the island of RUSSIAN (~ 15 min) Anton Poley Undergraduate department chair "Thermal Power and Thermal Engineering" Far Eastern Federal University
16	Integrated energy solutions in the field of CHP of «Eridan» (~ 15 min) Denis Logvinenko Director of Department of Power Plants Subdivision of "Eridan", Russia

Also in the program of the workshop was provided for an exchange of views on the subject of the project participants:

Discussion points
What are the most promising CHP technologies for near term applications?
What response characteristics are desired for different CHP systems (reliability, cost, size, etc.)?
How does CHP improve power reliability?
What are the advantages and limitations of currently used CHP technologies?
Where is CHP most useful?
What is the shape and size of the market for cogeneration in APEC Member Economies?
How does CHP affect the APEC Member Economies?
How can a CHP system be financed?
What is necessary to achieve a successful CHP project?

What is the typical financial payback for cogeneration projects? What are the most significant factors that contribute to the decision of a private or a public developer to invest in cogeneration?
Discussion points (continued) Should future CHP projects receive special consideration, incentives or other added value? What barriers need to be addressed to overcome difficulties in CHP sector development in APEC region? What additional measures can be taken that would be most useful for cogeneration in APEC region? How can high-level APEC policy-makers support the development of an active market for cogeneration? Are there utility considerations that affect the economics of CHP?
Discussion Points Is there any competition between CHP and other forms of renewable energy generation? Could CHP partially replace some of the big coal-fired power plants that provide baseload power? How could the APEC region benefit if CHP was scaled up? How can cogeneration be improved? What barriers need to be addressed? What are the market trends in cogeneration and what are the implications of energy market changes for future of cogeneration in APEC region? What would make cogeneration easier to consider as an option? What are the collaboration opportunities among APEC Member Economies?

Transitioning into the low-carbon economy will require collaborative effort, which is at the core of the of APEC economies agenda. The two-day workshop which took place in Vladivostok City, Far East region of Russian Federation on 15-16th of November 2012 brought together state representatives of APEC economies, international commercial companies operating on the Russian market and working with cogeneration technologies as well as leading figures in the infrastructure sector of the Far East region of Russia to discuss the key drivers and barriers to the application of cogeneration technologies in the APEC region. The consensus was that business must find new business models, adopt cutting-edge technology, and foster new collaborative partnerships to effective transition to an economy built around low-carbon and energy efficient infrastructure.

Key discussion issues:

Discussion of the workshop focused on two key issues:

What are the most serious drawbacks hindering the development of cogeneration in the APEC region;

How the identified barriers can be addressed.

Participants of the discussion identified specific action steps that regulators, utilities and industrial managers can take to overcome the barriers.

These two issues were discussed in three themes: research and technology, finance and investment, and policy and regulations.

Presentations discussing RESEARCH and TECHNOLOGY aspects of CHP industry development

Kawasaki Gas Turbines

Masahiro Kita

Kawasaki Heavy Industries, Kawasaki Gas Turbines division

This presentation described the product lines of Kawasaki gas turbines division, demonstrating that Gas Turbine & Machinery comprises 16.5% of their total sales. For power generation mostly GPB80D Gas Turbine, L20A 18MW Class are used by its clients. Detailed listing of the product line is introduced, including Gas Turbine Generator Package M1A/M7A/L20A /L30A Engine; GPBXX Package with M1A/M7A/L20A /L30A Engine; and base load models such as

GENSET MODEL	ENGINE MODEL	OUTPUT	EFFICIENCY, e
GPB15D	M1A-13D	1490 kWe	24.0 %
GPB17D	M1A-17D	1690 kWe	26.6 %
GPB70D	M7A-02D	6740 kWe	30.2 %
GPB80D	M7A-03D	7440 kWe	33.1 %
GPB180D	L20A-01D	18420 kWe	34.2 %
GPB300D	L30A-01D	30000 kWe	40 %

Special attention was paid to the Basic Concept of M7,GT Cogen System, leading to the huge reduction of electricity and heat tariff to attract industries and investment. The reason behind this is that this type of the equipment was just installed in Russian Russki Island. The company is reasoning that advantages of this equipment type are the following: Gas turbine cogeneration has highest total, efficiency, which can reach about 80%, it decreases utility cost in half and ensures a stable energy supply. In addition to that it is an environmentally friendly system with the lowest NOX system, cleaner emission, low noise, low vibration, etc.

The company noted government policies accelerating spread of CHP technology in Japan

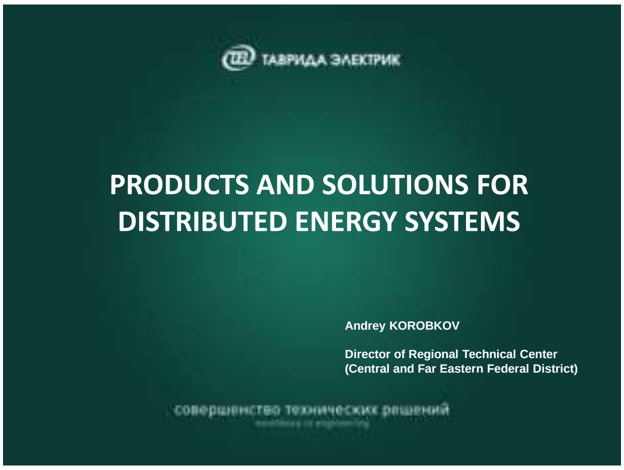
Conclusion:

From the commercial corporation point of view, tax incentive, namely reduction of the corporation income tax on green investments helps reduction of CO_2 emissions. Various subsidies from Government and/or Local Authorities facilitate favorable financing with long term and low interest rates.

Products and solutions for distributed energy systems

A. Korobkov

Regional Technical Center (Central and Far Eastern Federal District)



The presentation described innovative products and services the company provides for distributed energy generation systems in its projects worldwide. It also demonstrated case studies of the micro-grid projects with very short (of 2,5 years) implementation periods and technical characteristics of the equipment.

GAS-PISTON mini-CHP “ZARECHIE” - a co-generation plant, which successfully works since 2010 and is characterised by 6 MW of power from gas-piston machines, 1 MW of backup diesel generators and 6.6 MW of heat energy generated at the same time

Protection of micro-power plants (ПАЭС-2500, Yakutia), which is reached by the installation of a high-speed automatic reclosers by Tavrida Electric preventing depreciation of power plant, frequent accidents in distribution networks 6 kV and large undersupply of electricity and interruptions in the supply of consumers. The automatic outdoor vacuum reclosers were used for electrical networks 6-10 kV with isolated, compensated and impedance earthed neutral to function as automatic shutdown of the damaged line; automatic reclosing (AR); automatic entry of backup power; operative local and remote network reconfiguration; diagnosis states of the elements; measurement of power network parameters; memorizing operational and emergency events in the line and integration in different remote control system

Conclusion:

Typical conditions for building a mini-CHP are as follows: high cost of technical specifications for accession to electricity networks and high costs of meeting associated requirements; high selling price for electric energy (kWh) from electricity networks, expected rapid growth rates for the price of electric energy; need for heat energy; close proximity to a main gas line

Power Efficient Microturbine-based CHP and CCHP Systems

Andrey Skorokhodov

BPC Group Power System

The speaker presented company's projects based on power efficient microturbine-based CHP and CCHP Systems, including a detailed view on industry's challenges, power efficient solutions for industrial and public facilities. Technology solutions of the company are applied in the gas industry, oil production, fuel stations, services sector, machinery, telecom, agriculture, food industry, housing and community amenities, sports and recreational centers

It was stated that various power efficient solutions for industrial facilities is renovation and power efficiency increase through implementation of CHP technologies. It ensures provision of reliable power supply complying with the Category I requirements; reliable power supply of new production lines during expansion of production; provision of high-quality power for complex and sensitive equipment and utilization and recycling of production wastes to generate power and heat.

Advantages of using CHP (cogeneration) / CCHP (trigeneration) for public utilities help to modernise housing and community amenities via implementation of the state-of-the-art generating equipment – microturbines. It helps to increase of energy safety and ensure reliable power supply complying with the Category 1 safety requirements; diverting of excess heat and electrical energy to cover needs of other loads.

Benefits of CHP application in construction works include: reliable and continuous power supply during construction and after commissioning; ensures power supply when utility grid is not available; ease of power generation for construction on undeveloped territories; elimination of construction downtimes due to power outages or power deficit and incremental increase of generating capacities in compliance with the increase of construction volumes.

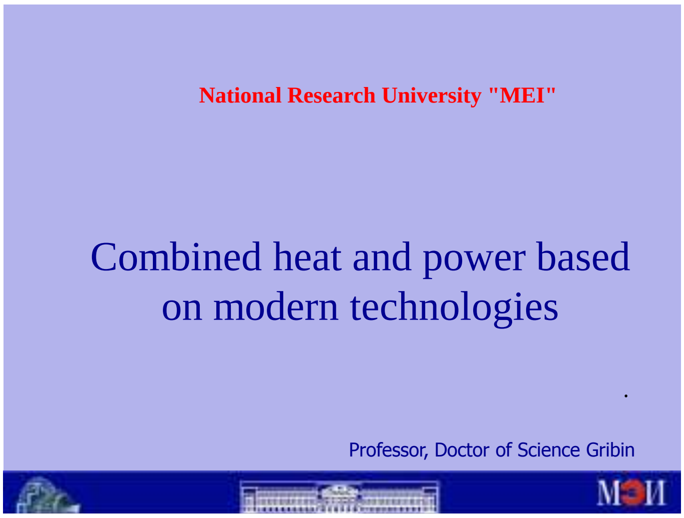
As an exclusive distributor of Capstone Turbine Corporation (USA) in the territory of Russia, the CIS and the Baltic States BPC Engineering described advantages of Capstone C15, C30, C65, C200, C1000 microturbines with the single unit power output 15-1000 kW; WHG125 ORC turbines of single unit power output 125 kW; and the Solutions for hybrid vehicles based on Capstone C30, C65 with the single unit power output 30 and 65 kW pointing out to reliability, controllability; high efficiency: up to 90% in CCHP; low operational costs; ecological features (CO / NOx < 9 ppm); load flexibility (continuous operation at 0-100% power output) and modular design. Numerous case studies of projects implemented in Russia in various geographic locations we re demonstrated.

Conclusion:

Challenges of the industry are explained mainly by such factors as physical and moral deterioration of heating networks and generating equipment (exceeds 60% in Russia on average); increase of emergency outages due to incompliance of housing and community amenities to requirements of energy safety; high power intensity of heat generation due to use of costly and polluting fuels: fuel oil and diesel; increase of electrical and heating tariffs for private and commercial consumers due to low efficiency of local CHP plants; rise of power and heat deficit caused by development of cities and growth of consumers number.

Cogeneration of heat and electricity based on modern technologies

Professor V. Gribin, MEI



This presentation gave a detailed cogeneration technology description for a range of plant sizes and capacity, their advantages and applicability for diverse use. It compares two processes - combined heat and power generation and separate production of electricity, where some energy is rejected as waste heat. Further on various cogeneration types and gas turbines of varied capacity are discussed.

In the report various diagrams of the separate and combined heat and power based on steam-turbine and gas-turbine installations are discussed, efficiency of the Russian and foreign gas-turbine manufacturers' units are compared; typical examples of modern thermal power stations based on gas-turbines technology are demonstrated, and, finally, advantage of gas-turbine CHP technology is discussed.

The project could be recommended as a starting point for creation of joint working groups of APEC economies focused on modernisation of thermal power stations currently existing at various locations.

Increase of efficiency of power equipment for cogeneration processes based on the research of National research university "MEI"

Professor V. Gribin, Far East Federal State University

Professor Gribin presented achievements of young engineers of Moscow Energy Institute, a leading university of Russia for energy engineers education. In the prologue of the presentation professor described university's modern equipment for engineering training and carrying out a research in the field of energy efficiency, namely efficiency increase of cogeneration installations. University owns an experimental thermal power station available for training – a local heat and power generation installation (there is another such station available in the Stuttgart power college, Germany)

Research on efficiency increase of the cogeneration equipment are developing in the following directions:

research of aerodynamics of elements in cogeneration installations

modernisation of the turbine equipment by means of new methods of technical design increase of corrosion stability of construction materials and protection of all functional surfaces of steam-and-water pipes

noise decrease in the power equipment

research on finding harmless methods of use of low quality coals

Conclusion:

The reported results of research demonstrate a high level of research and first class facilities at the national research university. It is recommended to carry out an experts within APEC region. APEC economies could put an objective of synchronising or harmonising scientific research and create joint Study Groups and organisation of professional education centres for engineers.

Cogeneration units on Ruski island

A. Poley

Far East Federal University

In this presentation, a detailed description of mini thermal power station, located on peninsula Sapernyj, near Vladivostok City , including plans and maps of its location, function charts of this thermal power station and heating systems served by it is given. The presentation is richly illustrated by photos of objects and surrounding district.

This initial project can be used for planning further modernisation of stations with similar characteristics by means of the advanced functional elements developed in the APEC region.

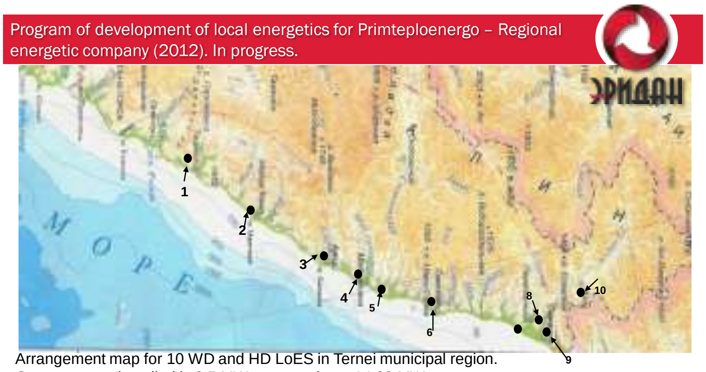
Complex power solutions

A.Logvinenko

JSC Eridan

Complex power solutions

A JSC Eridan was introduced to the audience as an official certificated dealer of Cummins Power Generation distributing gas-piston generators in Russia. The company implemented considerable quantity of effective power solutions in various regions of the Russian Federation: from maintenance of heat - and electric power units of residential housing, communal services and social objects to complex independent power supply of sport facilities and large industrial factories. Case studies of power supply projects such as Power plant for government company «Russian Railways». C1540 N5C genset with heat recycling system and Wind-Diesel LoES "Golovnino" project at Kunashire Island, Kurils islands, Sakhalin Region where basic Wind-Diesel technologies of Danvest Energy, A/S, Denmark were introduced.



Arrangement map for 10 WD and HD LoES in Ternei municipal region.
Current power installed is 6,5 MW, perspective - 14,08 MW

Conclusion:

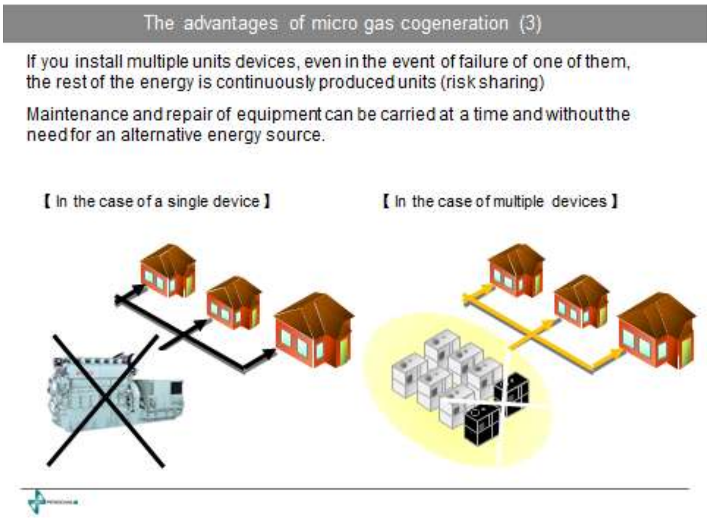
Wind-Diesel LoES technologies have huge opportunities for generation of heat. The main problem in remote settlements is absence of central heating system. A possible solution is to use energy surplus from renewable energy sources such as wind, up to 30% from annual energy production, for needs of heating with low "night" tariff. In big sites, for example Terney, diesels for cogeneration units are very profitable.

Advantages of micro-generation technologies for distributed energy systems

A.Udod

State organisation RegionSnab

The presentation compared fuel gas monogeneration and cogeneration technologies based on the practical experience of this organisation. For residential communities in remote areas the company suggests to build a chain of micro- generation units as an effective method of heat and power supply. The company argues that this method does not require big investment and allows creation of needed power amount in specific locations. This also means that long electricity network are not needed. In addition to that, such a system allows switching off only one or several units for maintenance and lets other units continue functioning as in a case of one big power station.



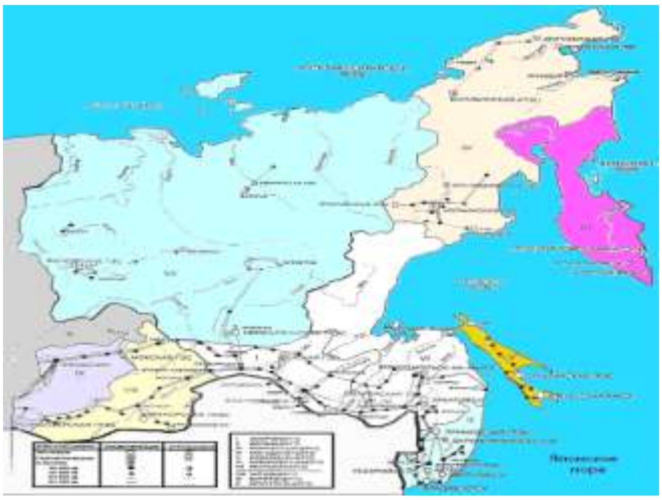
Technical characteristics of various blocks of the micro-grid chain are described and variations of the units and their long distance monitoring systems manufactured in Japan and Russia are compared.

Several case studies of projects implemented in Canada, Japan, Russia and the US are presented.

Strategic planning of CHP application in Far East regions of Russia

Professor A.N. Shtym

Far Eastern Federal University



This presentation described in detail the development of the power industry in the Russian Far East region. Comprehensive characteristics of region's major power plants and high-voltage electricity networks and the companies that operate these assets are provided. Much attention is paid to the current state of isolated power systems in Sakhalin, Kamchatka, Yakutsk, Magadan and

Kolyma areas comprising a list of projects for a potential investment. The report also describes options for the construction of oil and gas pipelines in the Far Eastern Federal region of Russia.

Conclusion:

All of the above presentations combine the idea of developing a comprehensive energy strategy of the Far East and develop its long term economic prospects, which undoubtedly represents a great opportunity for cooperation with the countries - members of APEC

Presentations discussing FINANCE and INVESTMENT aspects of CHP projects development

Possibilities and challenges for realization of CHP projects in the Russian Far East – Discussion from aspects of investment opportunities

Iwao Ohashi

Chief Representative, Nomura Research Institute, Moscow Branch

Based on the fact that the workshop took place in Vladivostok City, Far East of Russia region, this presentation was focused mainly on the Russian market. First of all, the basic concept of smart city was discussed, which included CHP-solutions as integral parts of the successful smart city operation management.

Obviously, the presentation described how the CHP industry is being developed in Japan, what are the main driving factors for its growth and how the technology is promoted within the public and private sectors.

It was noted that there are five points of competitive edge that Japan can offer to Russia for urban and transport infrastructure development:

Security

Ecology

Energy saving

Time saving

Compactness

As a positive characteristic of current market conditions, the audience agreed with the speaker that the gas pipeline network, which is beginning to work in the Russian Far East, provides opportunities for creating modern infrastructure by gasification. The presentation gave a detailed proposal for effective Japan-Russia CHP projects value chain, the roles of partners starting from policy formulation, master planning stage, creating a financial scheme, down to design, procurement, construction, maintenance, operations management and further business administration. It was stressed that in NRI's view, for mutually beneficial, effective cooperation between Russia and Japan in modernizing Russia's urban and industrial infrastructure, it would be better to start partnership and cooperation already in the phases of concept and strategy development, which would lead straight to the possibility to devise successful financial schemes by major Russian banks, encourage Japanese consortium for sending effective and competitive proposals of technology know-how .

This presentation naturally lead to the active conversation on not only how Japan-Russian CHP projects should be initiated but also what are the general methods of setting the CHP industry in motion worldwide.

Conclusion:

The audience agreed that based on practical experience of international project holders CHP helps to:

Save energy (to reduce consumption of fossil fuels);

Reduce emission of CO2;

Optimize costs for energy generation

Guarantee stable supply of energy against demand

To guarantee efficient energy security

Basic directions to promote introduction of CPH in the APEC region for the governments:

Development of policy measures for promoting introduction of CPH

Appraisal of the effects by introduction of CPH – improvement of efficiency in supply-demand relations of energy- and announcement to the public

Support by the state for installation of CPH equipments

Demonstrate how CHP introduction would lead to the fuel price reduction

The barriers to the international joint projects in countries with different technological level are revealed based on a Japan-Russia cooperation experience: Japanese enterprises, which possess efficient technological solutions, are strong in EPC phase. But in Russia currently the planning phase is more important to realize projects for infrastructure building. The market needs to learn specifics of the efficient planning stage of any projects. This was a good lessons learned for the wider audience.

There should be active dialogues and cooperation in the phases of development of policy and strategy initiated to discuss issues and experience exchange within the APEC region:

What are the effective unified tax and subsidy policies for promotion of efficient and clean energy infrastructure

Proved methods for effective tariff formulation

Effective concept and strategy for regional and territorial development

Effective concept and scheme for financing the project by public-private partnership

What are the effective ways for the successful selection and creation of the pilot project concept

Cooperation in the following fields APEC region- wide would lead to the CHP-market growth:

Elaboration of a concept and strategy for regional and territorial economic and social development, that would be clear and logical to potential foreign investors

Clear positioning of the project to be proposed in the concept and strategy, that would be an effective instrument for efficient realization of the targets set in them

Objective analysis and calculation for the economic effects by realizing the project

Creation of a financial scheme and planning of cash flow, that would be clear and understandable to potential foreign investors

Effective international benchmarking and extraction of key factors for success (KFS)

Financing CHP

Zenko Shinoyama

Power and Water Finance Department, Infrastructure Finance Group

Japan Bank for International Cooperation (JBIC)

This presentation also touched potentials for cooperation between Russia and Japan on CHP as well as methods of financing CHP projects. It was said that in case of a large scale CHP where typically, the CHP costs more than USD 50~100 mil, a traditional Two Step Loan or, in case of a company of high credibility subject to credit analysis, Corporate Finance scheme will be applicable. In case of the small CHP, a typical situation is that Small scale CHPs are diversified to towns and villages in regions and each CHP costs less than USD 10 mil. Therefore different ways of financing could be applicable.

Conclusion:

Financing small scale CHP is difficult because it is inefficient to finance each small CHP installation and difficult for financial institutions to take risk for each CHP owner/small business operator. Therefore, it is recommendable to make (or establish) a controlling company to own a group of small CHPs. In this case, a traditional Two Step Loan or, in case of a company of high credibility subject to credit analysis, Corporate Finance will be applicable for such controlling company as with the large scale CHP .

Financing Investments in Russian Power Industry

Alexander Filkine

European Bank for Reconstruction and Development

Presentation of the European Bank for Reconstruction and Development focused on power sector projects the bank financed, being the largest investor in Russia. The bank spent total cumulative volume of financing (1991-2011): €72 bn in more than 3,500 projects, out of which €22 bn in over 700 projects since 1991 were invested in Russia. In 2011 the bank invested €2,9 bn in 74 projects, amounting to 30% of EBRD business volume in 2011. It was specifically pointed out that Renewables represent 15% of total financing today, comprised primarily of wind and hydro, but also including biomass. Special attention was paid to the project case studies in Russia, such as for example Lenenergo (Loan) - €40 million loan to finance capital investments for the completion of a new unit (210MW) at CHP-5; Mosenergo (Loan) - RUB 7.2 billion senior loan (A/B tranches) for the financing of Mosenergo's urgent priority investments for the refurbishment of several CHPs to improve the efficiency of operations;

TGK-9 (Equity) - The Bank acquired 7.88% stake in TGK-9 in 2007. The proceeds of the capital increase are used for reconstruction of CHP-6 (124MW), CHP-9 (165MW) and construction of Novo-Bogoslovskaya (230MW) and Novobereznikovskaya CHPs (230MW); TGK-13 (Loan) - Senior loan of up to USD 75 million to finance the completion of the cogeneration unit at Krasnoyarsk CHP-3 (185MW).

Conclusion:

Key Financing Criteria of the international banks to operate in Russia and similar economies are: projects' transparency, strong financials and reputation, transition impact, clean environment.

This means the company should demonstrate full transparency of the ownership structure and complete disclosure of the end beneficiaries; at least 3 years of financial statements audited and prepared in accordance with IFRS (USGAAP); demonstrate sound business model with a clear return to the Bank from the main operations rather than from alternative sources; ensure high level of integrity of owners and managers with long term vision and high standards of corporate governance; the company should also take care on being able to make impact on the local economy in line with the Bank's mandate to facilitate transition to a market economy and be compliant with EBRD's environmental and social mandates - best international practice

Alternative means of financing for infrastructure improvement projects

Maxim Krivelevich

Institute of economic research, Far East division of the Russian Academy of science

This complex presentation discussed the ways of financing infrastructure projects by means of non-state pension funds' resources. It also explores the viability of creation a financial and stock exchange centre and electronic trading platform in Primorye Territory of Russia during the period of 2013 - 2017 and whether

support mechanism for implementing large infrastructure and industrial projects using the tools of the financial market & regional budgets could be created.

Conclusion:

The growing importance of investment needs for infrastructure projects are recognised. To bridge this "infrastructure gap" institutional investors were identified as one of the most promising candidates; further opportunities and barriers to investment in infrastructure from the standpoint of pension funds should be reviewed. This could be one of the potential fields of cooperation and future research projects for a project holder within APEC economies.

Presentations discussing POLICY and REGULATIONS aspects of CHP industry development

CHP Markets & Policies in Japan

Takahiro Nagata

New and Renewable Energy Group, The Institute of Energy Economics, Japan

The three main issues discussed in this presentation are: Energy Mix Options, CHP Markets in Japan and CHP Policies in Japan.

It was said that experts predict "Energy Mix Options" for 2030 Power Generation Mix the three scenarios where the share of nuclear power is growing at 0%, 15%, 20-25%, respectively and each scenario with CHP at a pre-set 15% market share demonstrates considerable, up to 25% Co2 Emissions Reduction by 2030.

The CHP Cumulative Capacity Growth market in Japan shows that Industrial users represent 79% of CHP capacity but high LNG prices and relatively low electricity prices have reduced the competitiveness of gas-fired CHP. It was stressed that CHP share of total power generation lags far behind EU and USA, which means that there is a large and untapped potential for CHP: out of all EU countries and the US Japan has the smallest CHP share of 3% and Denmark is with the biggest and most advanced heat and power generating capacities of 49%.

CHP capacity is found in various industries, such as chemicals, petrochemicals, machinery, and energy, etc. where chemical & petrochemical industry is a leader with 24% of capacity. It is shown that in Japan, hospitals, shops, DHCs, hotels, public facilities, sport facilities & spas represent more than 80% of commercial CHP capacity, meaning that medium and small enterprises use CHP with bigger enthusiasm, which obviously dictated by market conditions. It is also shown that natural gas and oil represent more than 80% of CHP fuel and as a technology choice gas turbines (43%) are predominant in industrial applications, while gas engines are the most widespread in commercial applications (25%). This CHP capacity development is happening despite the absence of CHP promotion law in Japan, there is no Feed-in-Tariff schemes, and no certificate schemes.

Conclusion:

The audience discussed CHP market characteristics of Japan as one of the very important member of APEC and based on discussions the following conclusions were made: CHP Future Target Markets are industrial, commercial and domestic, where as industrial market potential lie in the large-scale users, applications with high thermal demand; applications with limited experience with CHP (by promoting the use of gas engines with high generation efficiency); penetration into existing markets is needed by introducing adequate evaluation system for CHP environmental benefits.

Commercial market is characterised by large-scale users and their focused approach to DHCs and urban users; increase of thermally-based CHP (through construction of heat network to integrate locally-dispersed heat demand; penetration into users with large thermal demand (hospitals, hotels etc.); utilization of CHP for improvement of key facilities for natural-disaster prevention

Domestic market will grow by the higher penetration of CHP through development of lower priced units and entry into overseas markets.

CHPs need to contribute to the stability of power grid where the Win-win situation for both CHP operators and power grid operators be created through states' policy coordination. This goal should be reached by enhanced support system, use of voluntary negawatt market schemes utilizing CHPs and drawing up of guidelines on negawatt trading as well as, based on the Japanese experience, Reform of Electric Power System including creation of a "Distributed Model Green Electricity Selling Market" and improvement of evaluation for CHP electricity through the electricity power system reform.

Important pillars of CHP promotion policies would be support schemes to induce CHP investment, including capital grant and tax support and capital grant and fuel cost subsidy for new and additional in-house power generators/CHPs as a power peak cutting measure, already introduced in Japan.

Presentations discussing MARKET CONDITIONS aspects of CHP projects development

Chilean Electricity Market: Opportinities for Cogeneration

José Carrasco B.

Cobierno de Chile

This presentation introduced the electricity market development of Chile and the potential of the CHP industry growth. It was said that currently the amount of installed capacity in 2011 in all Chile regions is 16,329 MW, with peak demand of 9,043 MW.

Out of this amount the CHP usage is counted at ≈ 600 MW. The Chilean Electricity Market is characterised by:

Mandatory pool with audited costs

Commodities: Energy, Capacity

Energy and power transactions

Opened only to generators

Financial bilateral contracts with free customers or regulated customers

This presentation gave a good opportunity for the attendees to discuss the international CHP market and compare practical issue of the industry development, such as costs and inclusion of renewables into the national grid.

Conclusion:

Opportunities for the CHP market development are as follows: high marginal cost produce high volume of short term contracts to free consumers; industries should evaluate the CHP, enter the electricity market and avoid high prices (or even trade electricity where the system is not introduced); it is necessary to introduce Renewables Energy Law

Challenges and progress of power infrastructure development in Primorye Territory of Russian Far East

A. Bondar

Russian Energy Agency

This presentation described power sector in Russian Far East Primorye region, dynamics of electricity consumption and peak electric load power. It was stated that currently the structure of the installed capacity of power plants ES Primorye consists from thermal power plants (TPP) - 98.2% and gas turbine plant (GTP) - 1.8%. the stations work mainly on the local coal. Out of 920 boiler rooms, 144 boilers work on mazut fuel, 75- using diesel fuel, 626 stations work on coal, electricity is used for 59 stations and there are 28 mixed fuel stations. This clearly shows that there is a significant potential for transfer of the municipal energy sector to work in cogeneration mode. The main issues of the power sector in Primorye regions are outdated equipment and technology; the dominant share of the state as the owner of the energy infrastructure; low efficiency use of communal and micro-grid energy, which do not employ modern investment vehicles; municipal power depreciation is up to 72 - 86%.

New strategy of Primorye region energy development proposed in accordance with the Energy Strategy of Russia for 2030 (approved by the Government of the Russian Federation of 13.11.2009, № 1715-p) based on the following technology platforms: micro distributed energy platform; smart grid technology platform of the

Russian energy agency; eco-friendly thermo power; renewables energy sources. All these technology platforms operate in Primorye region.

Priority areas of the State Program of Primorsky Krai "Energy efficiency and energy development" are: development of national grid modernisation plan in order to reduce the number of power-hungry areas in the region, especially in areas of the planned grid connections for new consumers; reducing internal costs in energy industry (loss reduction, decommissioning of depreciated equipment); improving the efficiency of energy facilities located in ownership of the regional and municipal authorities; increasing the level of extra- funding from the state budget for modernization projects of regional and municipal property - at least to 70%. Therefore, the goal of the state program on energy efficiency is complete supply of energy resources to ensure positive socio-economic development of Primorsky Krai and sustainable and environmentally responsible use of energy resources.

Objectives of the current short term programme are: building and development of gas supply network; development of new energy sources; Improving energy efficiency in the residential sector; improving energy efficiency of organisations financed from regional and municipal budgets; promote energy efficiency in the public sectors of the regional economy; stimulating investment in energy efficiency; development of renewable energy sources.

State support measures envisaged by the state programme on energy efficiency: co-financing of the development of heat supply schemes for residential communities, which form the basis for the investment programs of power suppliers; co-financing of modernisation programs of communal heat and power network efficiency by the state budgets of different levels; interest rate subsidies for the implementation of energy efficiency projects funded by the domestic financial institutions.

Conclusion:

Particular efforts in encouraging the application of cogeneration technologies in regional utility sector are put by the government of Primorye region. CHP and DHC are both supported by the government through planning policy and tax incentives

The main outcomes of the discussion were as follows:

In the research and technology side of debate all experts agreed that those engineering barriers negatively affecting the expansion of cogeneration in APEC Member Economies are not critical and can be successfully overcome. Generally speaking, the technology as such starting from generation to distribution to end-users in varying geo-physical and climatic conditions of the APEC region cannot be the major barrier to the CHP sector development. In most cases a simple redesign of existing cogeneration equipment is required to make the operation of a CHP system in such conditions possible. The speakers and experts put special emphasis on the technological challenges of the CHP industry development in Russia, where the physical and moral deterioration of heating networks and generating equipment exceeds 60 per cent on average. Another noteworthy suggestion envisaged creation of joint Study Groups and organization of professional education centers for engineers in the APEC economies to synchronize training process.

One expert noted that technologies penetrate the CHP market at different rate of speed, depending on the maturity of the technology and the market. Hence, large cogeneration that is a mature technology and has relatively high market saturation has little room for further expansion. Micro-CHP will reach its maximum penetration rate around 2020. Thus, it is one of the most promising technologies in the future, agreed this side of debate. Another suggestion was that the development of "good quality cogeneration" instead of captive CHP systems should be prioritized by introducing different tax incentives, fines, etc. It

As far as the policy and regulation side of debate is concerned, there were two major points of view expressed by the panelists:

Existing state policies are adequate and do not require any changes. This side of debate pointed out that the existing energy policy in APEC Member Economies is adequate and therefore the CHP sector should be equally treated along with other energy-related sectors in the economy. The panelists from this side argued that both explicit and implicit measures to artificially promote CHP industry could create market distortions which would have a negative impact on the whole energy sector of the economy. It was also believed by this side that

Existing state policies need to be re-thought. On the other hand, some panelists pointed out that the present situation with CHP sector development in the APEC region requires a well-tuned policy approach which will address the specific group of barriers to CHP expansion in the region. This side of debate stated that the development of CHP sector should be prioritized by introducing support schemes such as capital grant and tax support and capital grant and fuel cost subsidy for new and additional in-house power generators/CHPs. It was also believed by this side that there is still a bias towards large-scale conventional centralized energy systems in existing energy policy in the major APEC Member Economies. Therefore, the current national energy policies should be reviewed and re-adjusted in order to stimulate the development of on-site micro-cogeneration systems which are more suitable for the climatic and geo-physical conditions of the APEC region. However, it was also believed by this side that the government incentives sooner or later will give way to the market mechanisms, which with the same rate of efficiency will replace the direct interventions into the market.

However, even the side supporting the present CHP state policy in the APEC region agreed that it could be beneficial for the whole cogeneration sector to elaborate a set of distributed generation and cogeneration policy roadmaps. They also claimed that a standardized approach for the analysis of cogeneration in the major countries of the APEC region should be elaborated to make it possible and easy to compare different CHP statistics and acquire solid data on cogeneration status in APEC Member Economies.

During the finance and investment part of the discussion the panelists expressed a number of valuable considerations:

Any long-term CHP business arrangements must be constructed with reasonable and appropriate financial risks. Present uncertain economic situation in the world makes it difficult to raise funds for CHP financing. Therefore, some panelists saw the government financial assistance as an option to overcome this barrier. However, other experts believed that in order to become economically viable CHP sector should be financed mainly by private investors.

The growing importance of investment needs for infrastructure projects is recognised. To bridge this "infrastructure gap" institutional investors were identified as one of the most promising candidates. Among infrastructure investors, pension funds are a relatively new player in Russia. The audience agreed that further opportunities and barriers to investment in infrastructure from the standpoint of pension funds should be reviewed. This could be one of the potential fields of cooperation and future research projects for a project holder within APEC economies.

Inadequate enabling financial environment for investments in cogeneration (lack of PPAs, inadequate financing mechanism for CHP projects, etc.) hinders the potential for CHP sector development in the APEC region. A number of experts in their presentations independently put forward an initiative to elaborate a joint common platform for cooperation in financial areas among APEC Member Economies to facilitate the financing of new CHP projects.

Also, it was claimed that unattractive prices for cogeneration electricity and long bureaucratic licensing process discourage investments into CHP sector. Panelists discussed types of regulatory and policy support mechanisms encouraging investments into CHP, especially medium to long term support mechanisms already largely implemented in the developed world, such as feed-in-tariff, quota mechanisms for renewable fuels and voluntary mechanisms such as green certificates. It was stressed, that interaction between the mechanisms outlined above and other policy measures in place to support CHP application development will play a vital role in the success of any programme to encourage the deployment of CHP technologies.

It was mentioned that in order to discuss these issues further, a special on-line forum which will be based on the APEC project web-site could be created as a platform for experience and knowledge exchange. The workshop organizers agreed to review this opportunity.

Key financing criteria of the international banks operating in Russia and similar economies such as projects' transparency, strong financials and reputation, and clean environment were also important issues discussed during the workshop. The representative of local regional governments and commercial companies admitted that above mentioned factors are not always to the best international practice standards and should be considered seriously when the project is in the feasibility study stage.

CONCLUSION

Cogeneration is gaining an increasing importance not only in the Asia-Pacific region, but all over the world, as decision-makers become aware of this technology's potential to curb emissions and simultaneously reduce energy costs. However, in the APEC region it has especially plenty of room for development due to the low starting base.

This report as part of Russia's efforts during its 2012 Chairmanship in APEC tried to identify valuable opportunities for CHP development, especially in decentralized energy systems. It includes a thorough analysis of the key market drivers, restraints, competitive scenario, and CHP trends description for each economy that impacts the industry. In this research, we tried to thoroughly examine the main APEC geographic regions.

Among the key findings of the report are:

1. There are several determining factors to the level of CHP development in particular APEC Member Economy, including the level of economic and industrial development, status of power sector in terms of demand versus supply, availability of fuels, electricity pricing, government policies on the role of private sector in energy supply, and local climatic condition;
2. CHP expansion in most APEC economies require even not substancial financial incentives, but rather a well-tuned policy approach regardless wether is is a regulated or liberalized market. This approach should address each CHP sector (e.g. industrial, district energy, commercial, and micro-CHP) and, in so doing, will address each CHP technology;
3. APEC Member Economies should elaborate not only their CHP policy, but also a broader set of approaches towards the wider use of clean energy policy instruments;
4. There several engineering drawbacks that hinder the CHP expansion in the cold-climate and remote territories of APEC region, but all of them can be avoided with simple and low-cost redesign of existing equipment;
5. Case-studies, described in this report, helped to identify real barriers to CHP development. The main are the lack of technical expertise on the part of the technology buyer on technology selection, unavailability of capital, high risk for a FSDP, and lack of local capacity to operate the equipment;
6. Other barriers could be classified into four main categories: regulatory, technical, economic/financial, and awareness issues. The report addresses them by providing specific concrete recommendations;
7. Countries lagging behind in the development of CHP can learn from their neighbors as well as from the best practices and examples around the world. Here the U.S. is undoubtedly leading the way. This country has its own export strategy for renewable energy and energy efficiency. Moreover, the absolute majority of the CHP equipment manufacturers comes from the U.S.;
8. Installation of inefficient and low-pressure CHP systems mainly for captive energy generation severely limit the CHP development potential. Therefore, a special standard for assessing "high efficiency" or "high quality" CHP should be drawn up.
9. Cogeneration is an important tool to optimise energy use among APEC Member Economies. The adherence to the expansion of cogeneration must be explicitly stated in governmental policies to provide long-term perspectives to potential investors. Such policies need to acknowledge regional specificities and differences existing in the APEC region regarding the availability and

possibility of using cogeneration technologies. They should consider and should prioritise expansion and establishment of new cogeneration systems in markets. At the same time, APEC policy-makers should avoid market distortions that could negatively impact the cogeneration industry;

10. APEC national governemnts and private investors should join in an effort to create a dedicated Asia-Pacific platform and to provide improved financial and material basis for joint research activities on new CHP technologies.

The solutions proposed in this report will help to accelerate the process and also reduce the barriers to the CHP technology deployment in the APEC region. In the short term, these solutions will enable easer implementation of the majority of CHP projects. In the medium term, the solutions will enable development of projects that better cater to electricity and heating demand on a larger scale. Finally, reducing the barriers identified during the project is expected to pave the way for the real potential of cogeneration to be realized. In the longer term, by increasing awareness among APEC decision-makers about the benefits of CHP technologies applied to distributed energy systems, the market will be given a clear point of view from which to judge how significant place cogeneration should have in APEC's future energy mix.

Most of the Asian APEC economies were among the "miracle economies". GDP growth rates as well as investor confidence were very high. They were among the low investment risk economies. Nowadays investment decisions are sometimes constrained with the availability of capital but the financial assistance provided by the government had helped accelerate the process. However, these funds need to be properly spended. The lack of available information required to make investment decisions and lack of support for project development does not encourage investments on CHP systems to happen. This study has shown in a systematic way the menu of options for CHP system financing which can be useful for CHP project tdevelopers. Since one type of barriers identified during this project was lack of awareness, not only regarding the benefits of cogeneration but also regarding fund-raising, this report can shed light on mechanisms of CHP financing.

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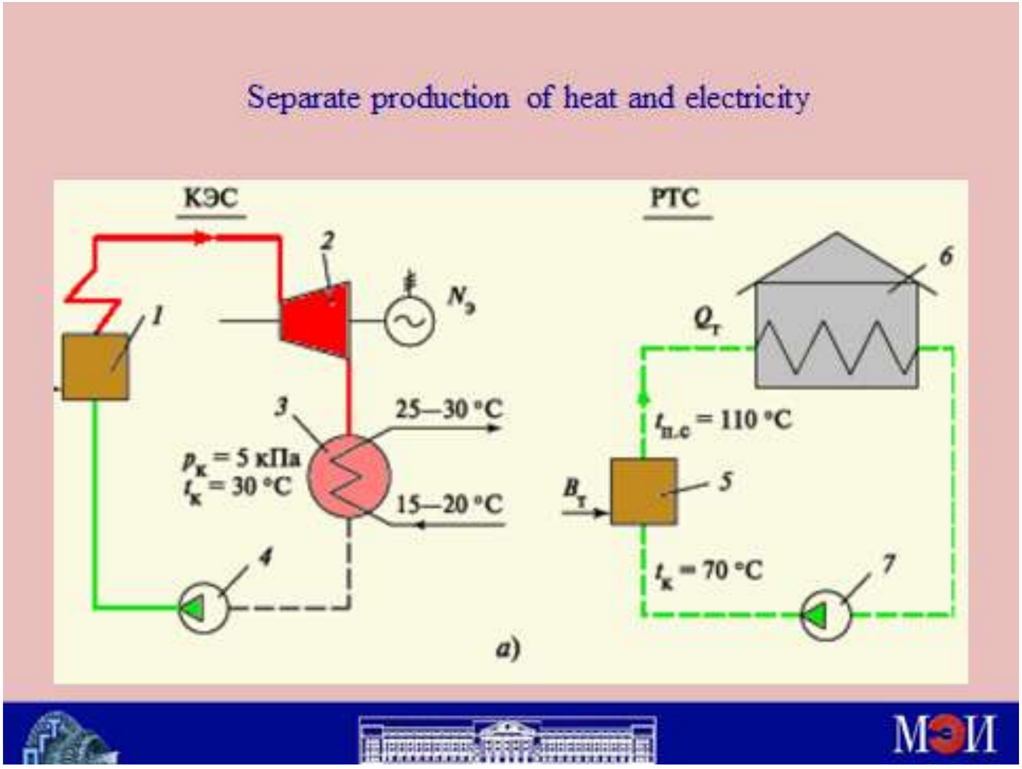
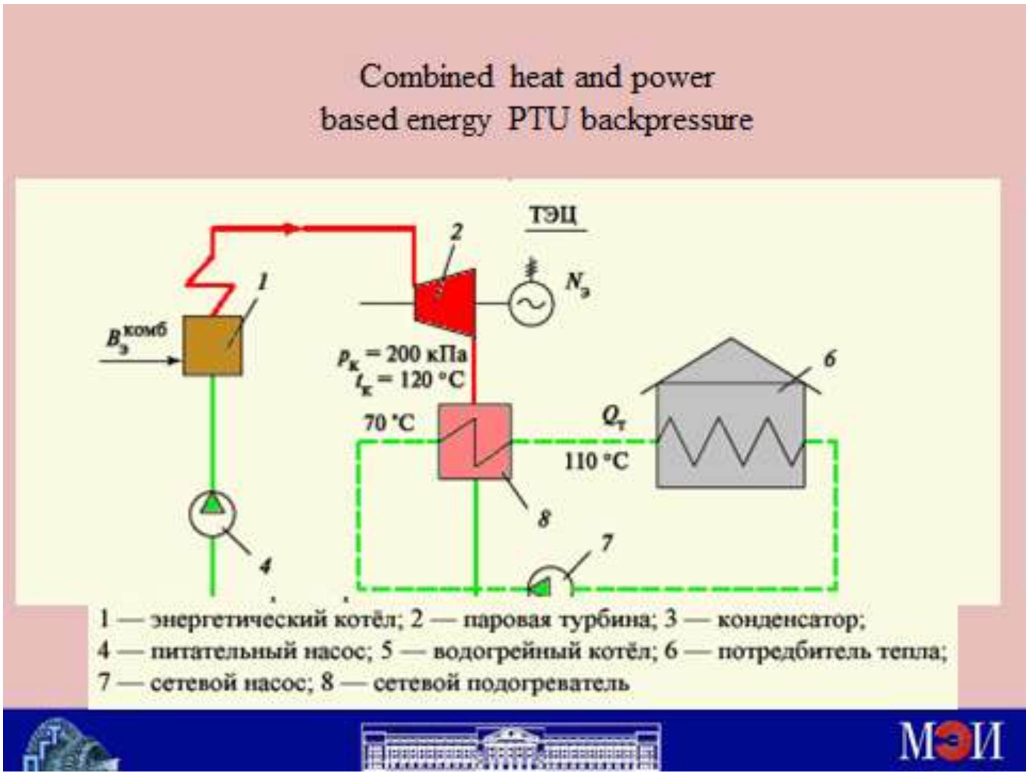
ANNEX 1. Brief excerpts from the presentations of speakers

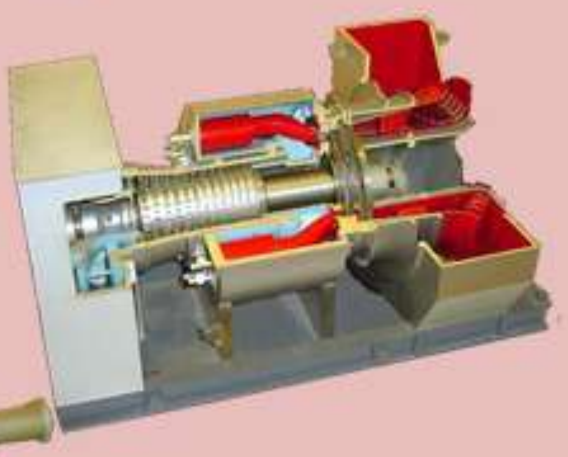
Professor V. Gribin "Gogeneration of heat and electricity based on modern technologies". This persentation gave a detailed cogeneration technology description for a range of plant sizes and capacity, their advantages and applicability for diverse use.

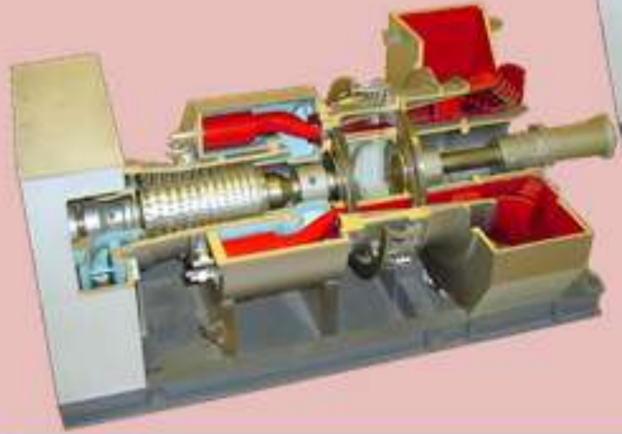




Single-and twin-shaft gas turbine

- Single-shaft gas turbine is usually used as a generator drive
- Twin-shaft gas turbine is used as a mechanical drive





Maintenance of gas turbine aircraft type

Replace the motor LM6000

Shipping container LM2500 (allowing the transport of the aircraft)

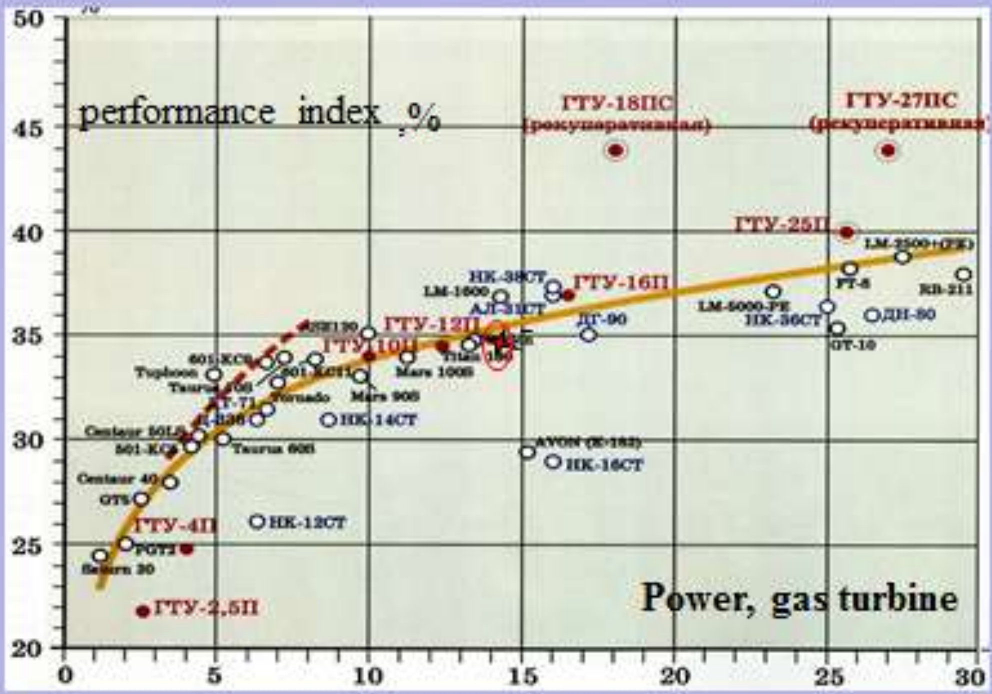
·Boroskopicheskaya check every 6 months. (t / o as)

·Engine dismantled every 25 thousand hours and transported to the service provider in a standard container (including aircraft)

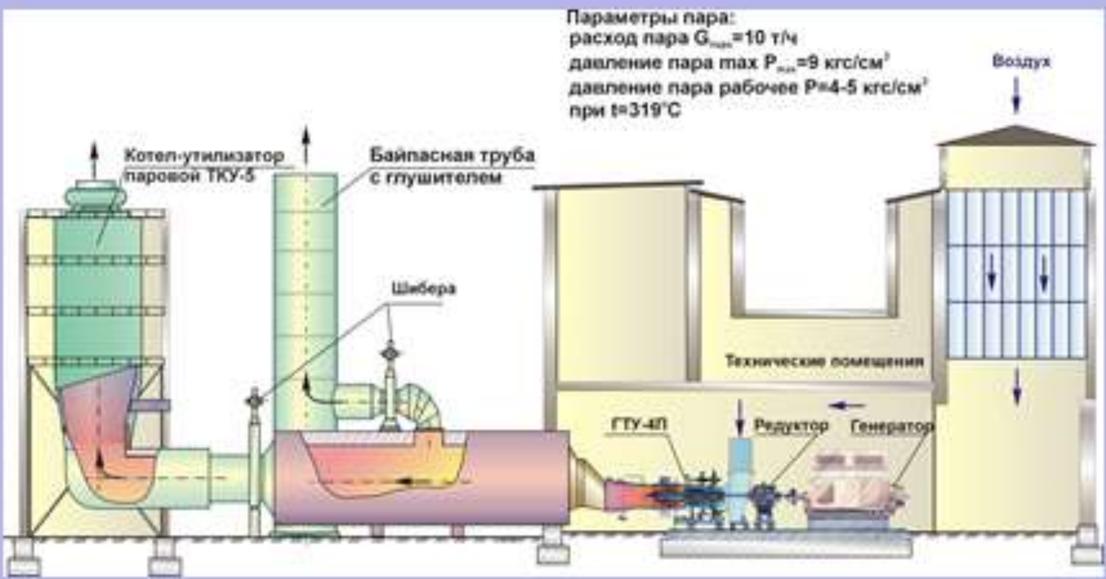
·A program of exchange of engines (engine rotation from the general fund)

·Minimal downtime (engine replaced after 24 hours of cooling)

Efficiency of domestic and foreign drivers GTU



POWER TEC-4000 "Janus"



Gas turbine power plant with a capacity of 2.5 MW
recovery boilers

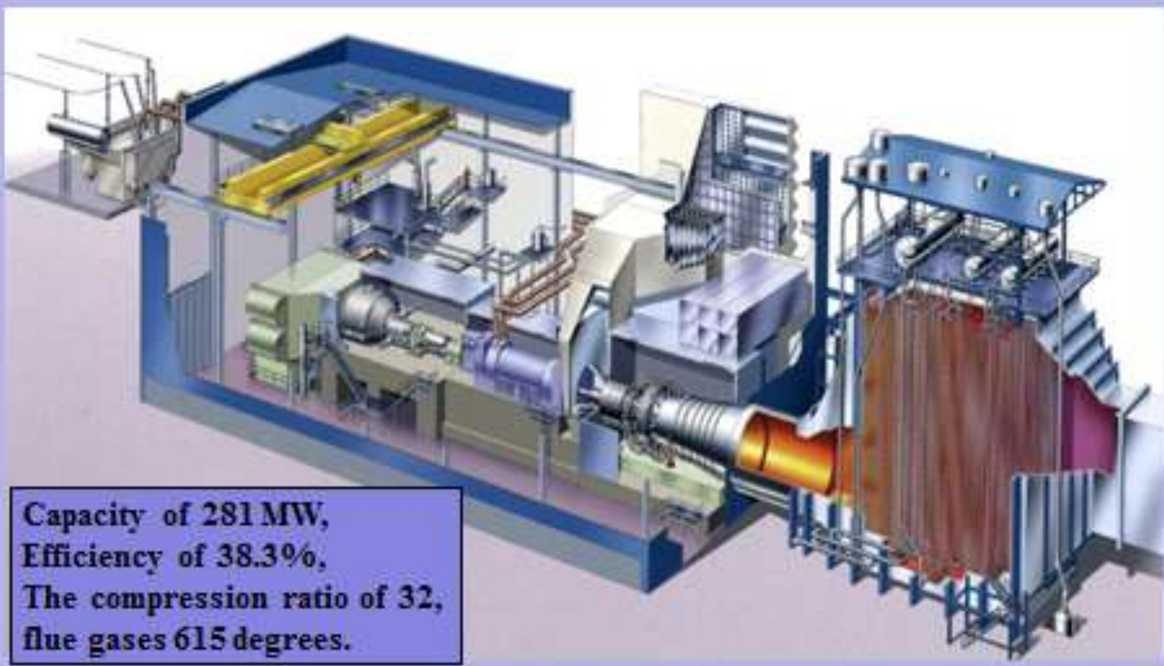
GTU-CHPP "Agidel" E 8 MW thermal - 16 Gcal


GTU-CHPP "Shaksha" E 8 MW thermal - 16 Gcal
МЭИ

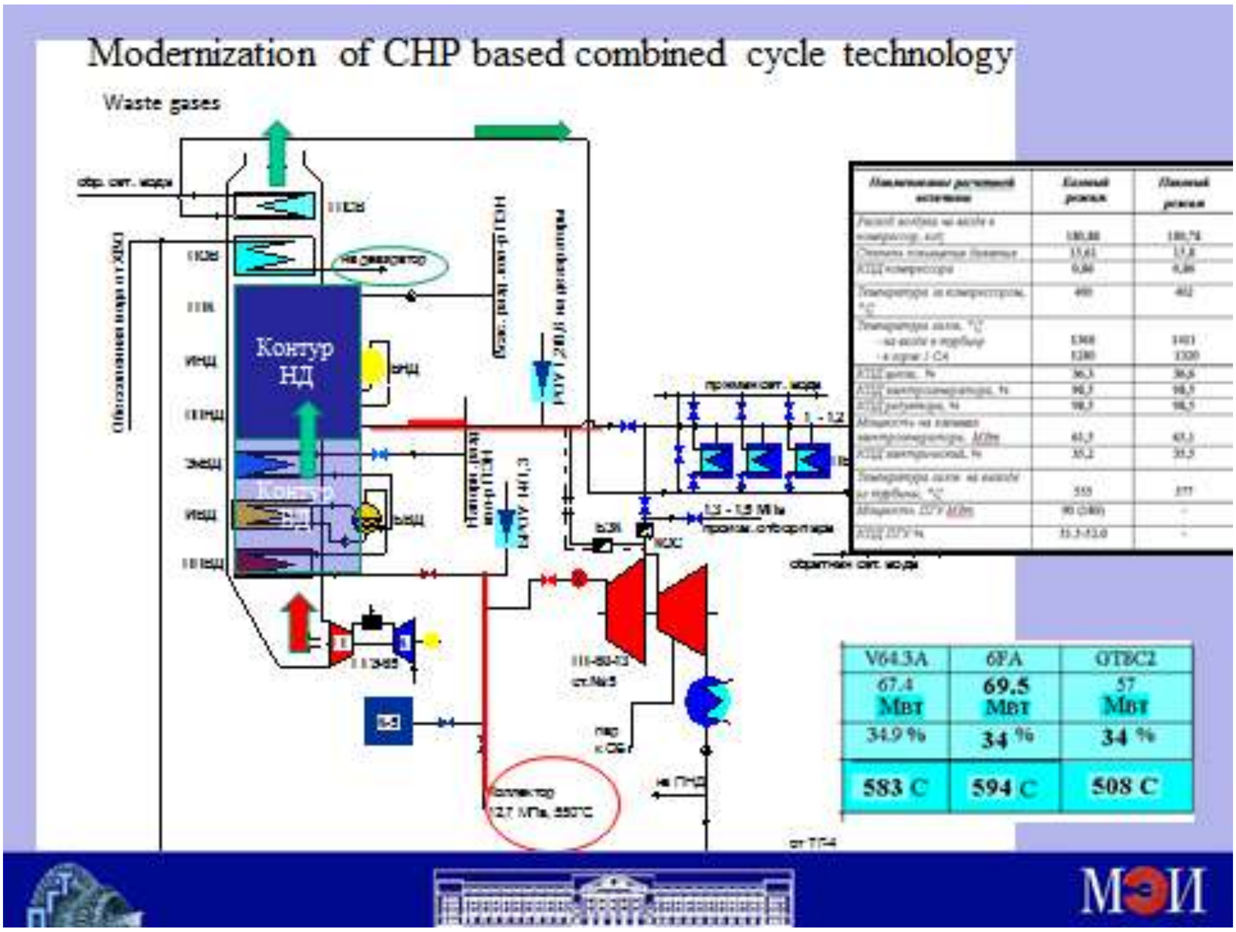

Turbine energy technologies
GTE-110 NPP "Mashproekt" for CCP-325
Промышленная ГТУ фирмы SIEMENS, SGT-700
МЭИ

The layout of the GTU-CHP

Single-shaft arrangement of PSU firm Alstom




МЭИ


Modernization of CHP based combined cycle technology
Waste gases
Контур НД
Контур ВД
V64.3A
6FA
GTBC2
67.4 Мвт
69.5 Мвт
57 Мвт
34.9 %
34 %
34 %
583 C
594 C
508 C
МЭИ

Professor V.Gribin presented achievements of young engineers of Moscow Energy Institute, a leading university of Russia for energy engineers education. This presentation demonstrateted "New methods of efficiency increase for cogeneration power equipment".

Professor Gribin elaborated on higher education in the cogeneration system, described the current situation on the use of material resources of the university, applied teaching methods, practical aspects of learning.


TRAINING AND EXPERIMENTAL CHP MEI TODAY
For 56 years produced more than 300 educational benefits to the operating design, research, and other repair of main and auxiliary power equipment.
CHP tower MEI film and drip types
Machine room CHP MEI twin turbo P-4-35/5 and P-6-35/5
For 56 years apprenticeship in CHP MEI were more than 80 000 students, many of whom are leading or running large factories, design institutes, design offices, universities, thermal and nuclear power plants, repair and other divisions of many ministries and departments of the country.
11
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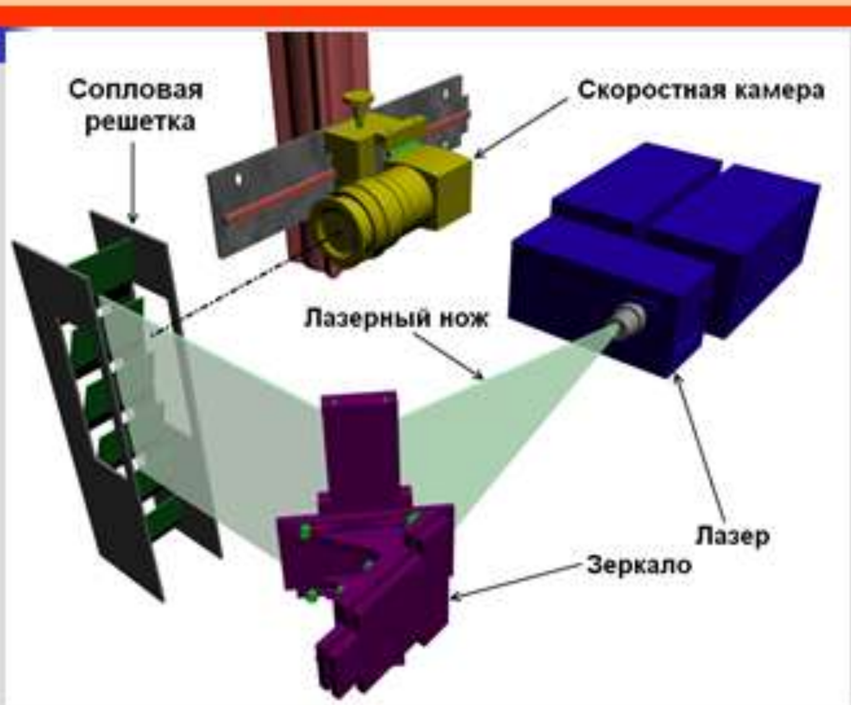
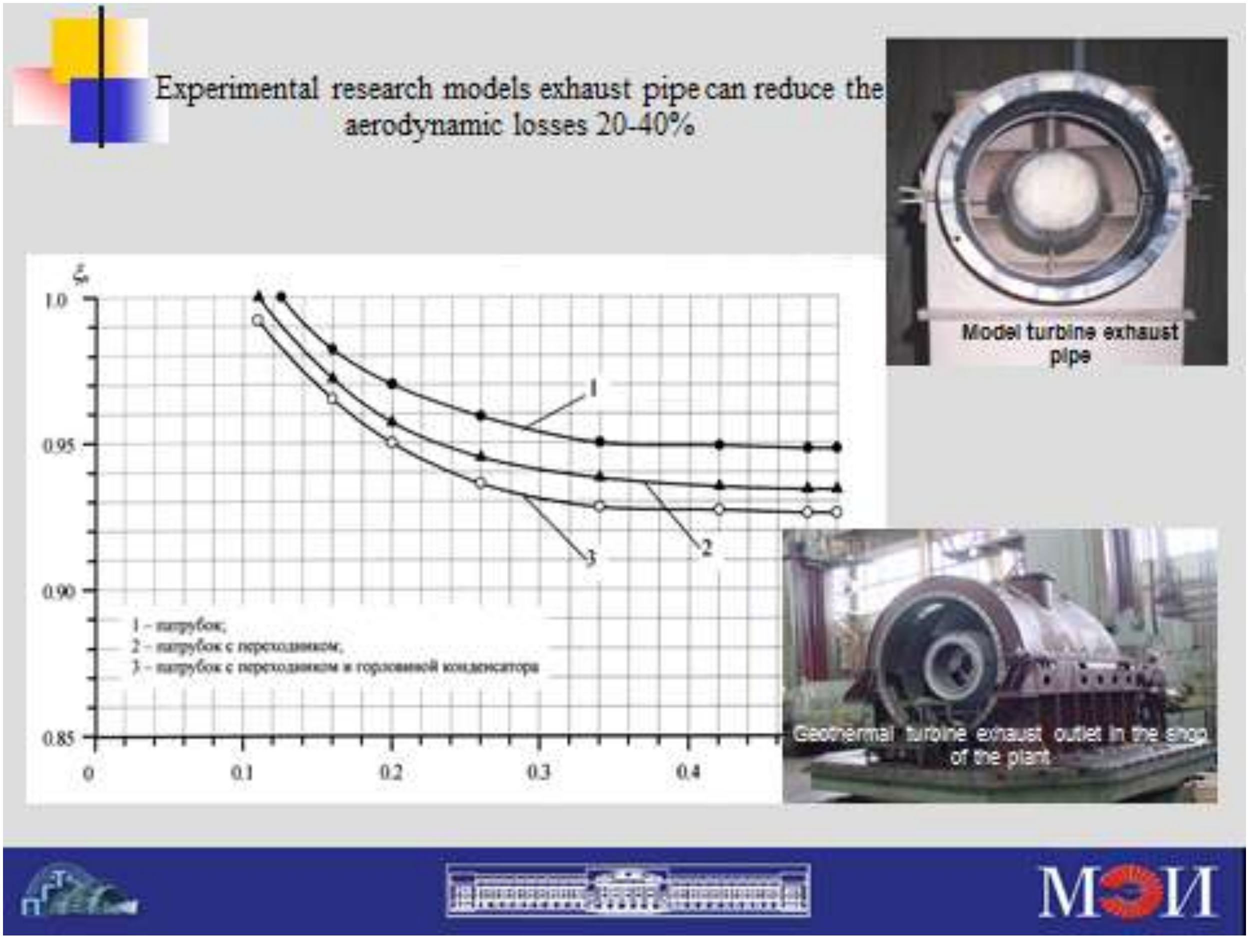
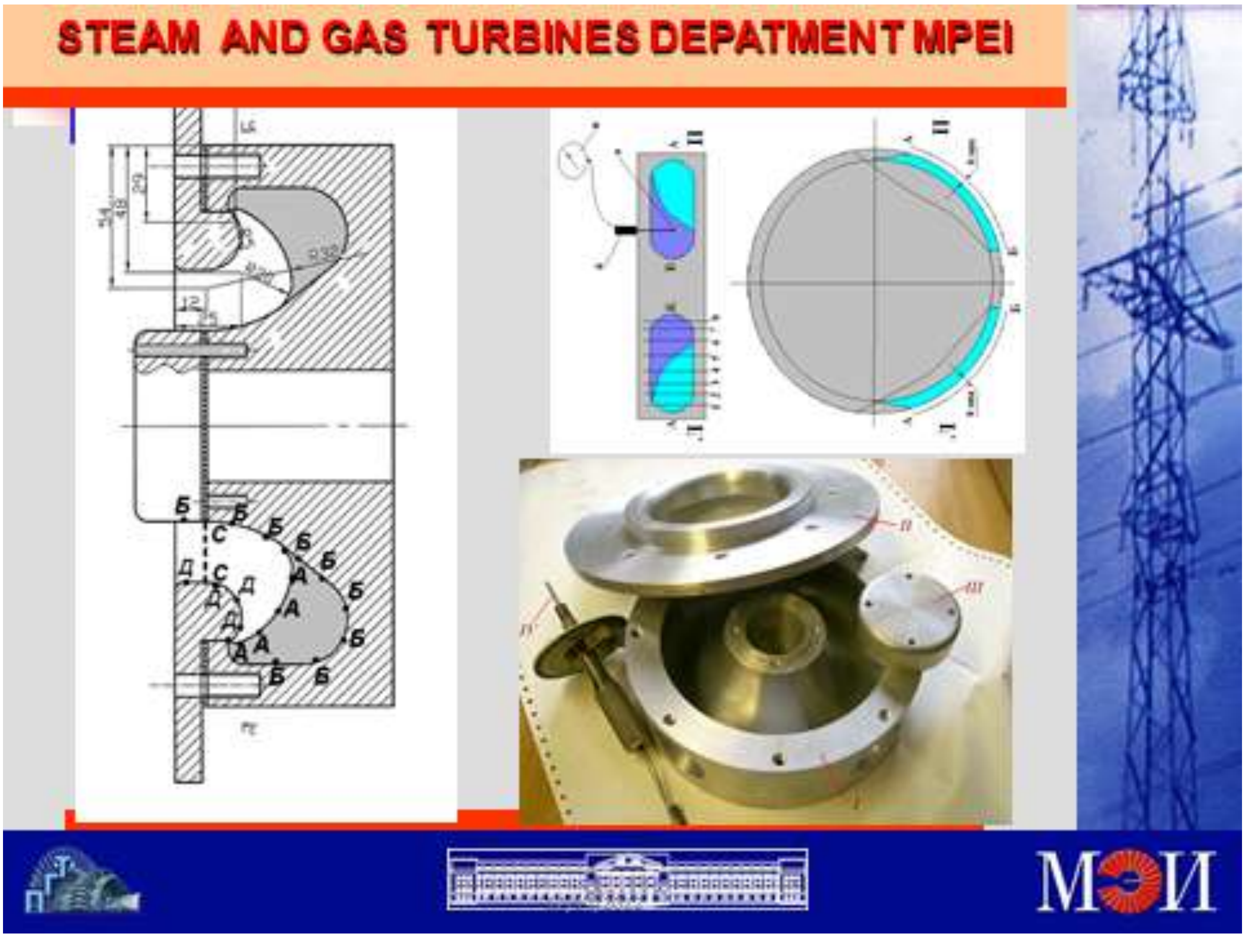
Educational, scientific production Center heating systems
МЭИ

Experimental stands at CHP MEI

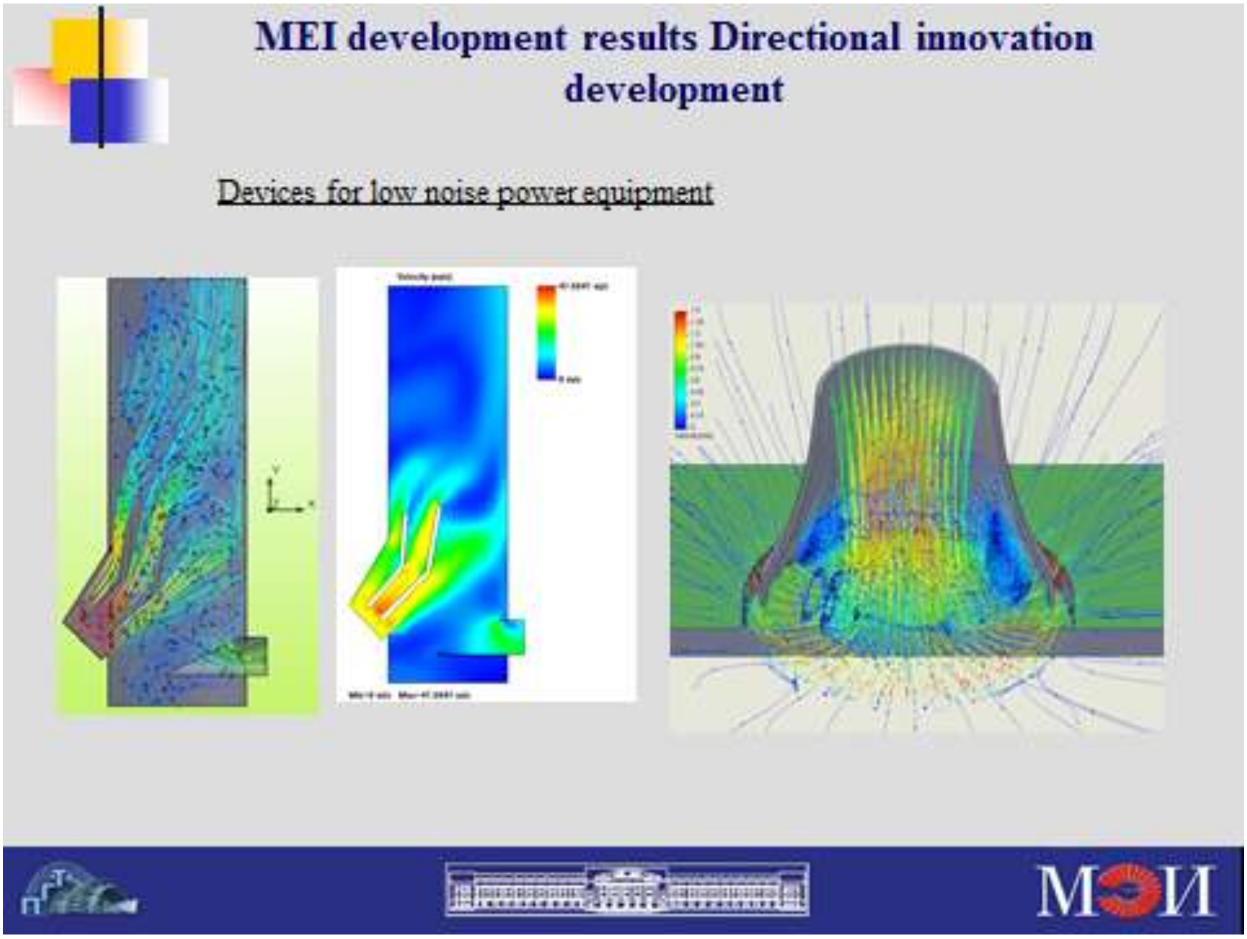
The system of laser diagnostics "POLIS" two-phase flow models turbomachinery flow paths




Experimental research models exhaust pipe can reduce the aerodynamic losses 20-40%
1.0
0.95
0.90
0.85
0
0.1
0.2
0.3
0.4
1
2
3
1 – патрубок;
2 – патрубок с переходником;
3 – патрубок с переходником и горловиной конденсатора
Model turbine exhaust pipe
Geothermal turbine exhaust outlet in the shop of the plant
МЭИ


STEAM AND GAS TURBINES DEPATMENT MPEI
МЭИ


STEAM AND GAS TURBINES DEPATMENT MPEI
Т-12
Diaphragm with slots in nozzle blades for steam injection
МЭИ


MEI development results Directional innovation development
Devices for low noise power equipment
МЭИ

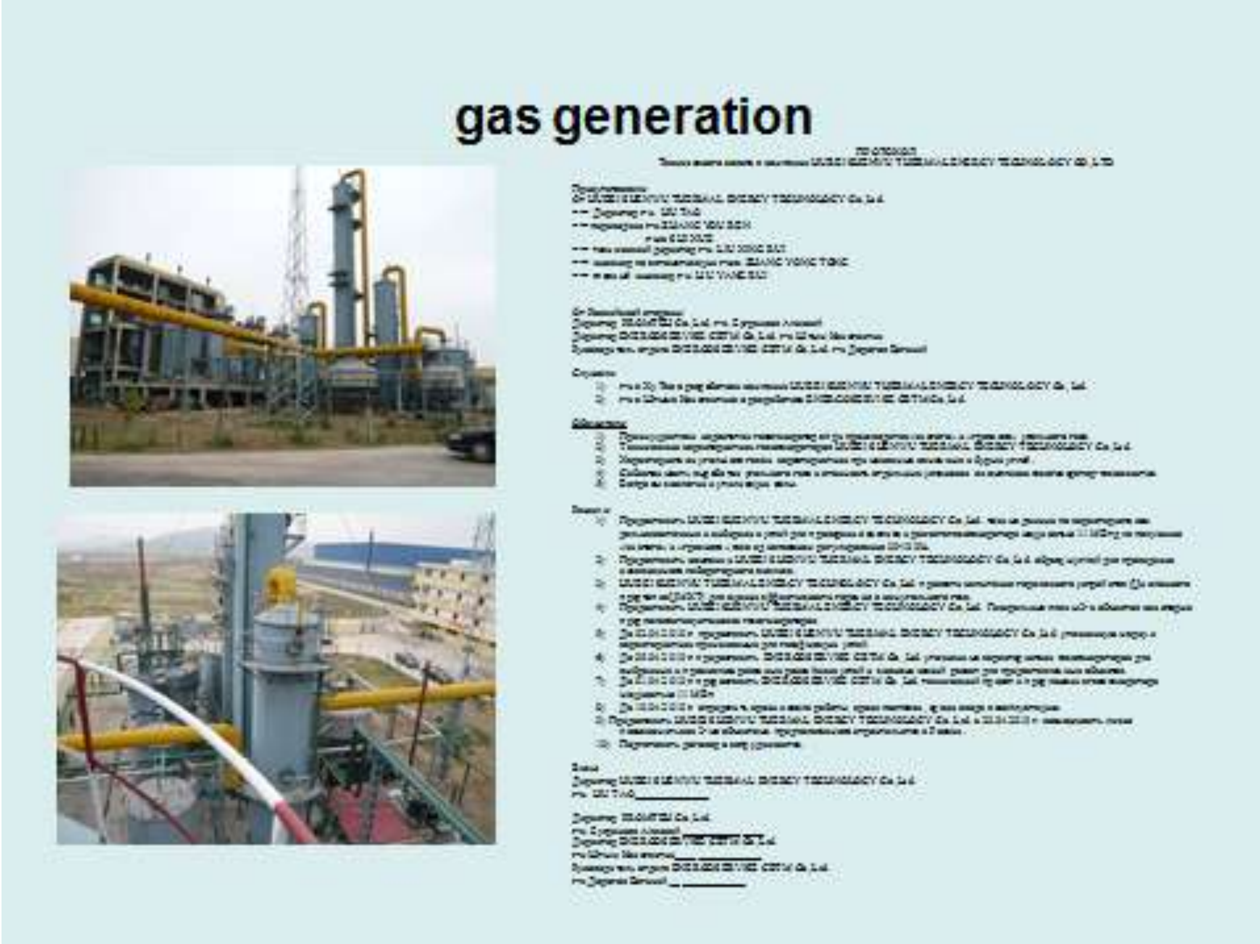
Professor Gribin In conclusion drew conclusions:

Laboratory equipment of the National Research University "MEI" not inferior in features leading research centers and allows the measurement of dynamic and static characteristics of the definition of reliability and efficiency of power equipment for thermal and nuclear power plants.

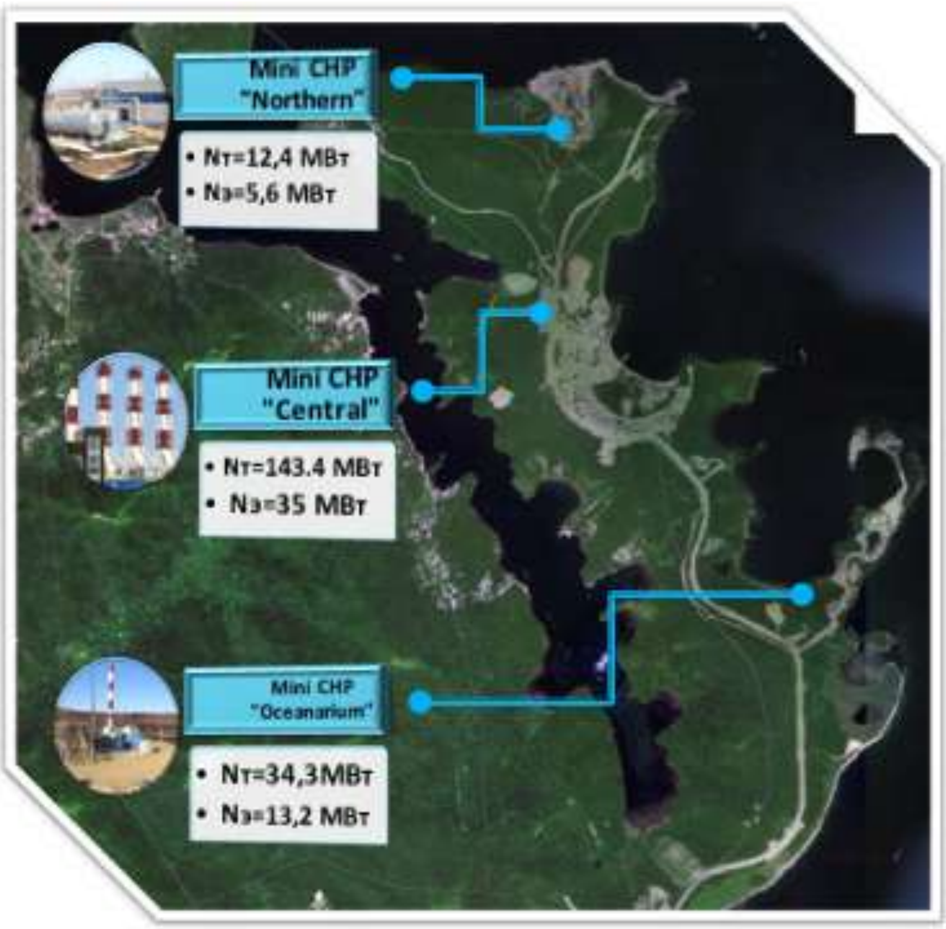
Modernization based on experimentally worked in NIU MEI solution allows up to 10 ... 12% increase in power PTU conditions and reasonable to extend service life.

Results are used to develop the experimental sound design techniques as well as of innovative energy technologies to improve reliability and reduce operating costs

Next two presentations gave overview of current cogeneration projects and established power manufacturing facilities in Far East region of Russia, including the new cogeneration plants on Russki Island where the September 2012 APEC leaders conference took place. The presentations were given by the representatives of Far East Federal State University.

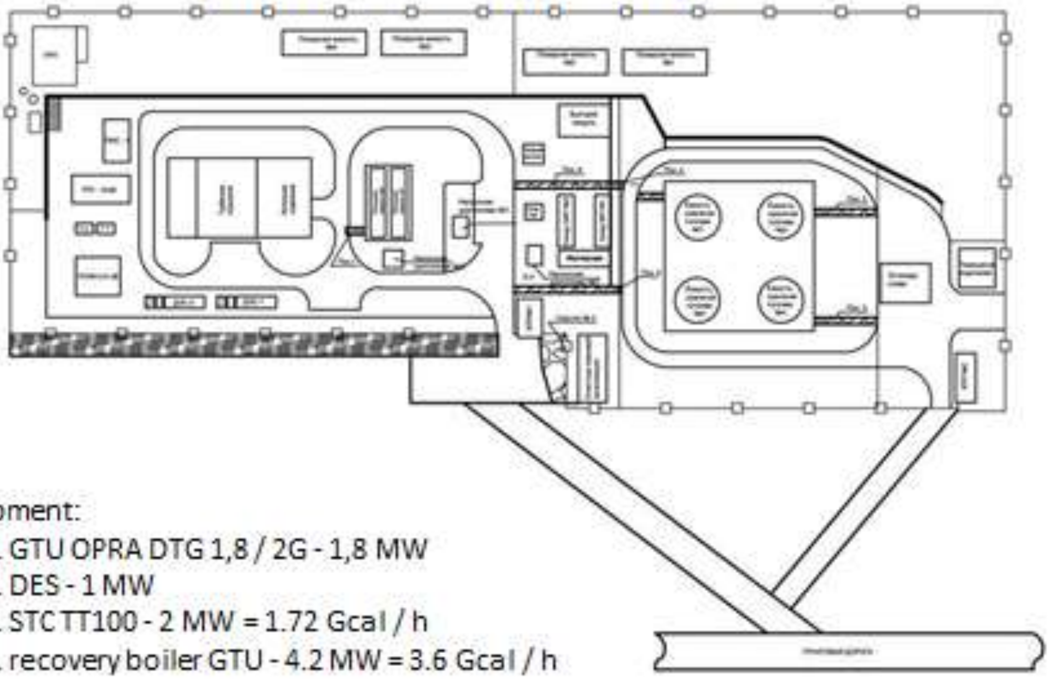

gas generation


ДВФУ
ДАЛЬНЕВОСТОЧНЫЙ
ФЕДЕРАЛЬНЫЙ
УНИВЕРСИТЕТ
Cogeneration RQ. Russian



ДВФУ
ДАЛЬНЕВОСТОЧНЫЙ ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ

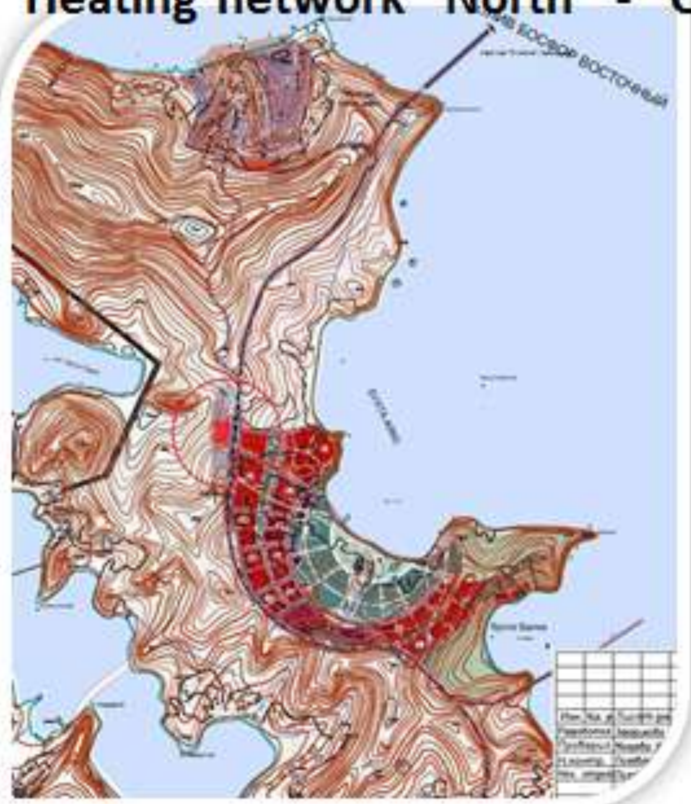
Mini CHP "Northern"

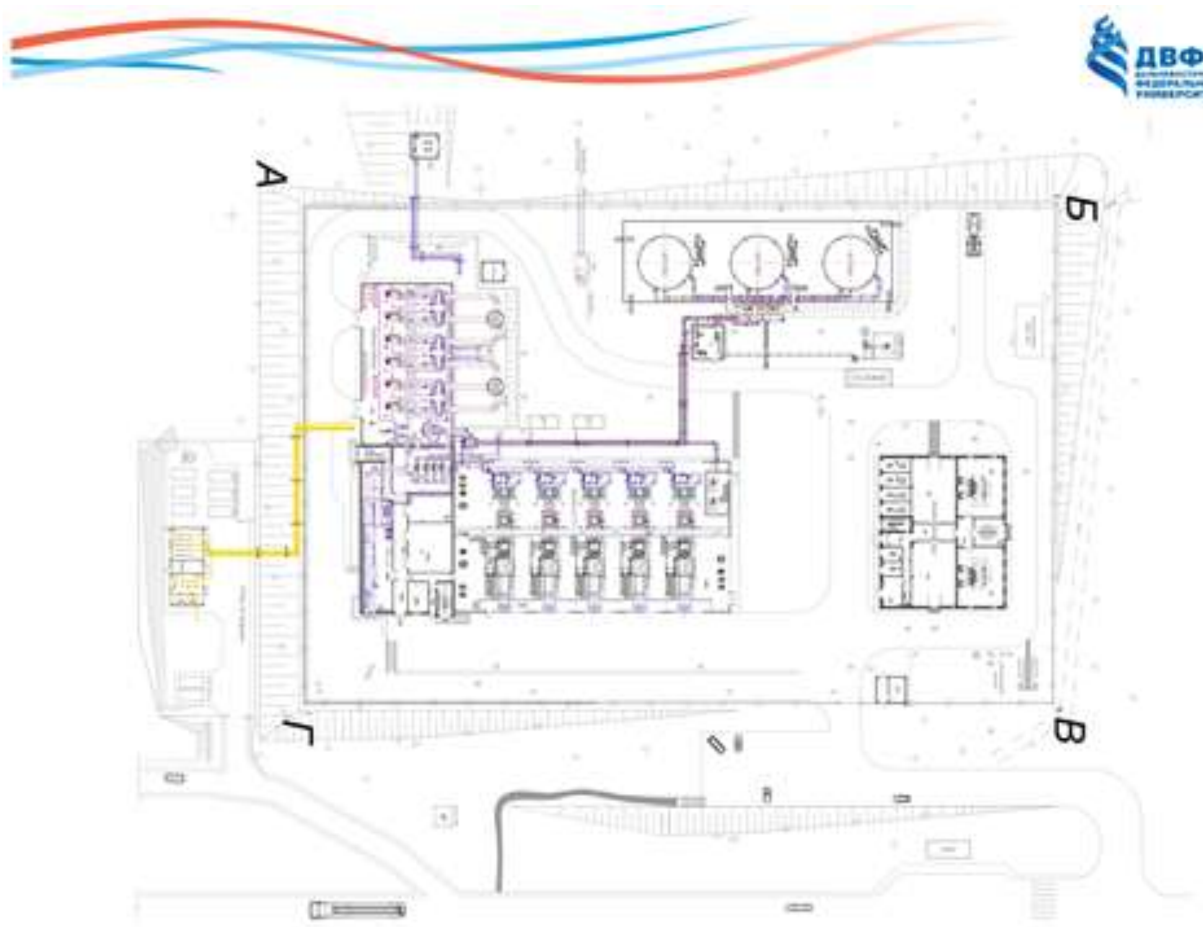


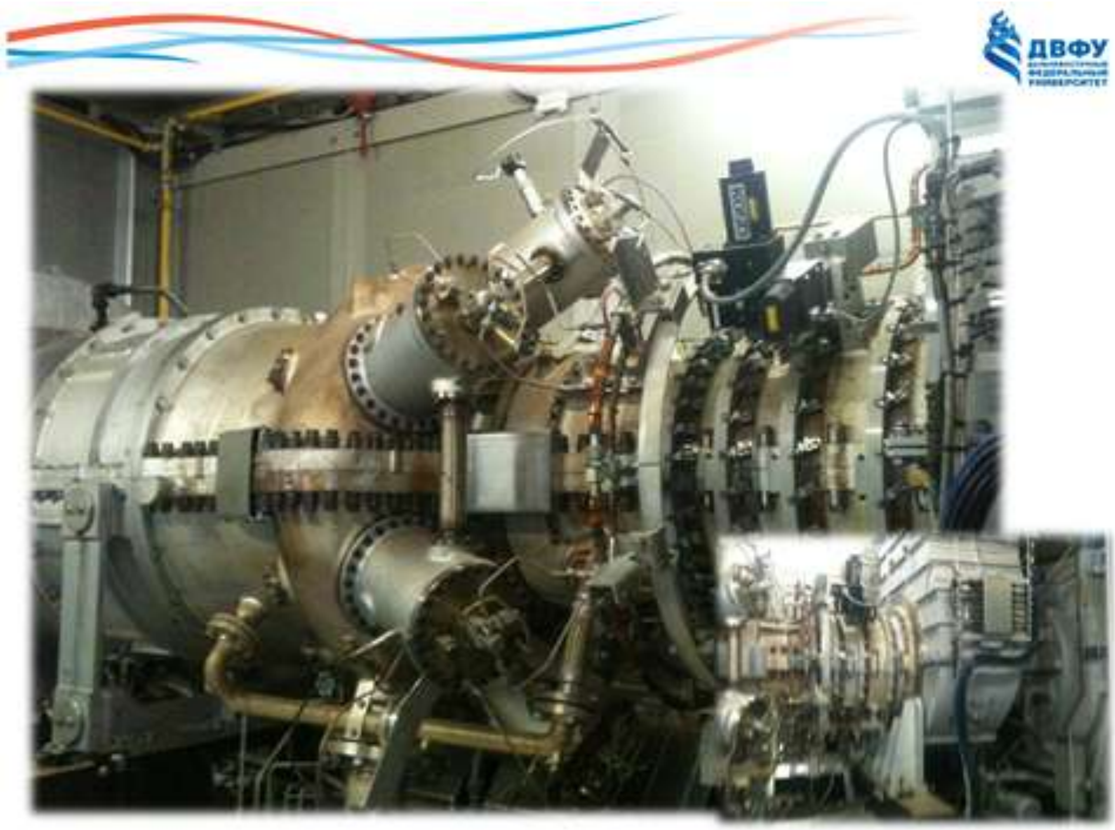
equipment:
2 pcs. GTU OPRA DTG 1,8 / 2G - 1,8 MW
2 pcs. DES - 1 MW
2 pcs. STC TT100 - 2 MW = 1.72 Gcal / h
2 pcs. recovery boiler GTU - 4.2 MW = 3.6 Gcal / h

Management of all processes on the mini CHP is with the control tower, including:
Starting, stopping, SC;
Start, stop, synchronization with a network of gas turbine and diesel power plants;
The work of pumping equipment and electrical. reinforcement.

Heating network "North" - "Central"

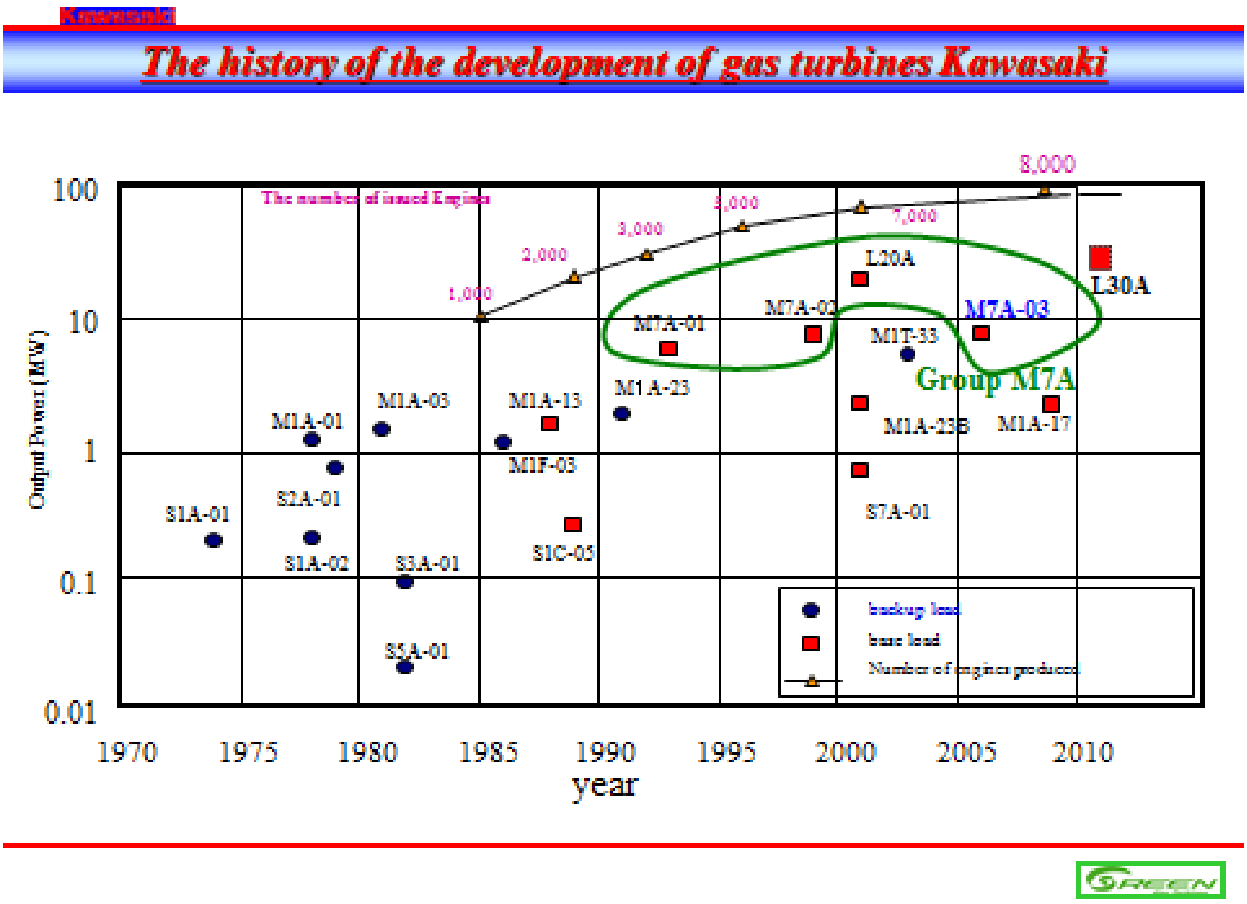




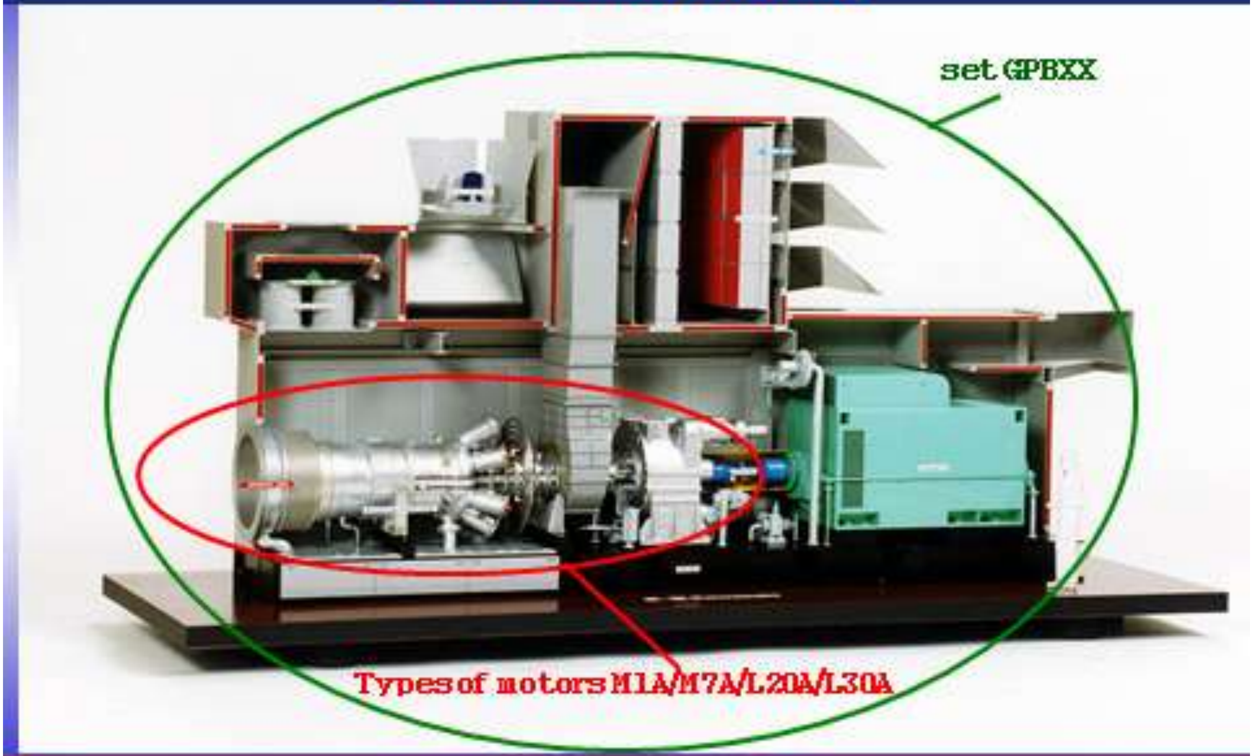


Following the previous presentations, Mr. Kita from Kawasaki Gas Turbine & Machinery Division presented gas turbine equipment for distributed power generation.

This company's equipment is currently working on Russia Island generating heat and electricity for the Far East Federal State University needs.



GT kit Kawasaki Generator



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GTP model Kawasaki

MODEL		POWER EFFICIENCY,	TG ENGINE
GPB15D	M1A-13D	1490 kW	24.0 %
GPB17D	M1A-17D	1690 kW	26.6 %
GPB70D	M7A-02D	6740 kW	30.2 %
GPB80D	M7A-03D	7440 kW	33.1 %
GPB180D	L20A-01D	18420 kW	34.2 %
GPB300D	L30A-01D	30000 kW	40 %

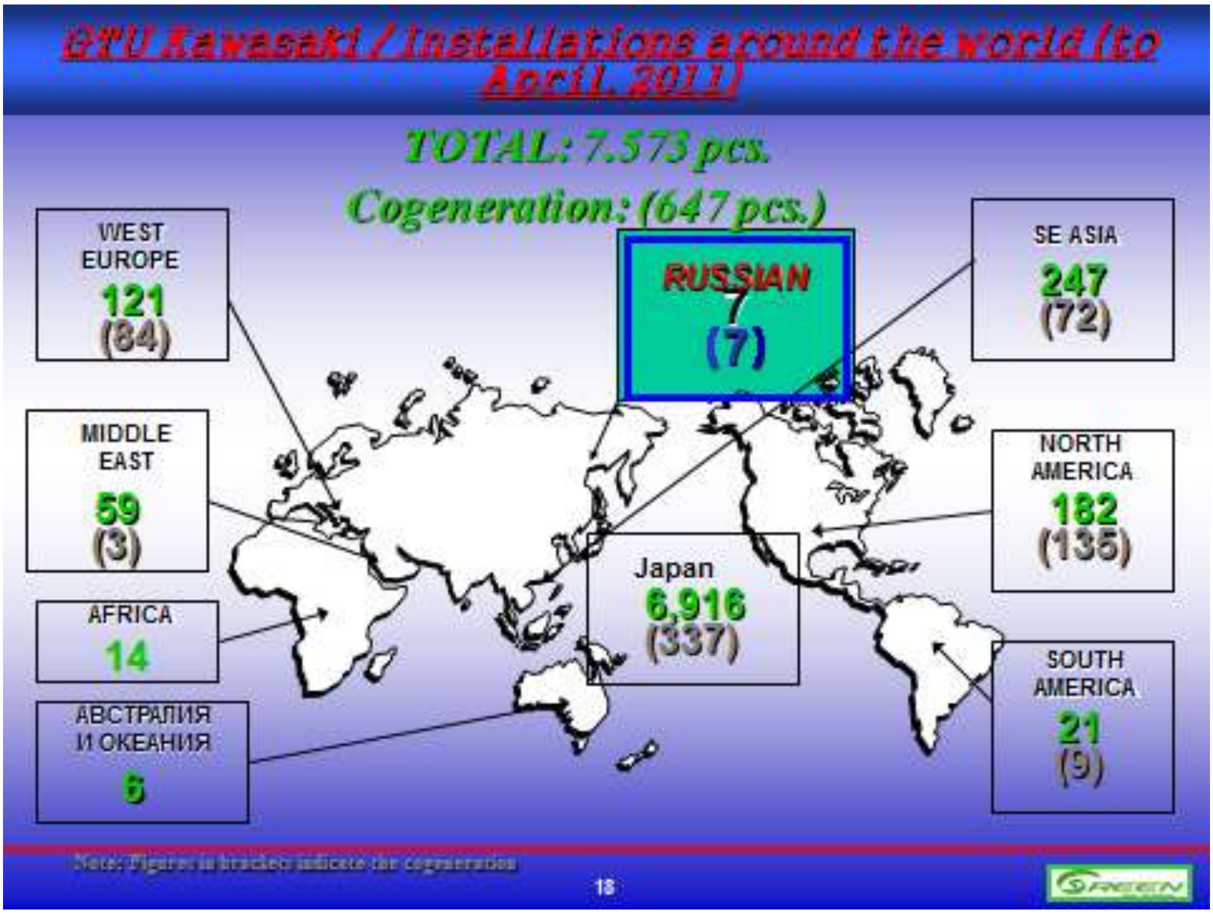
14

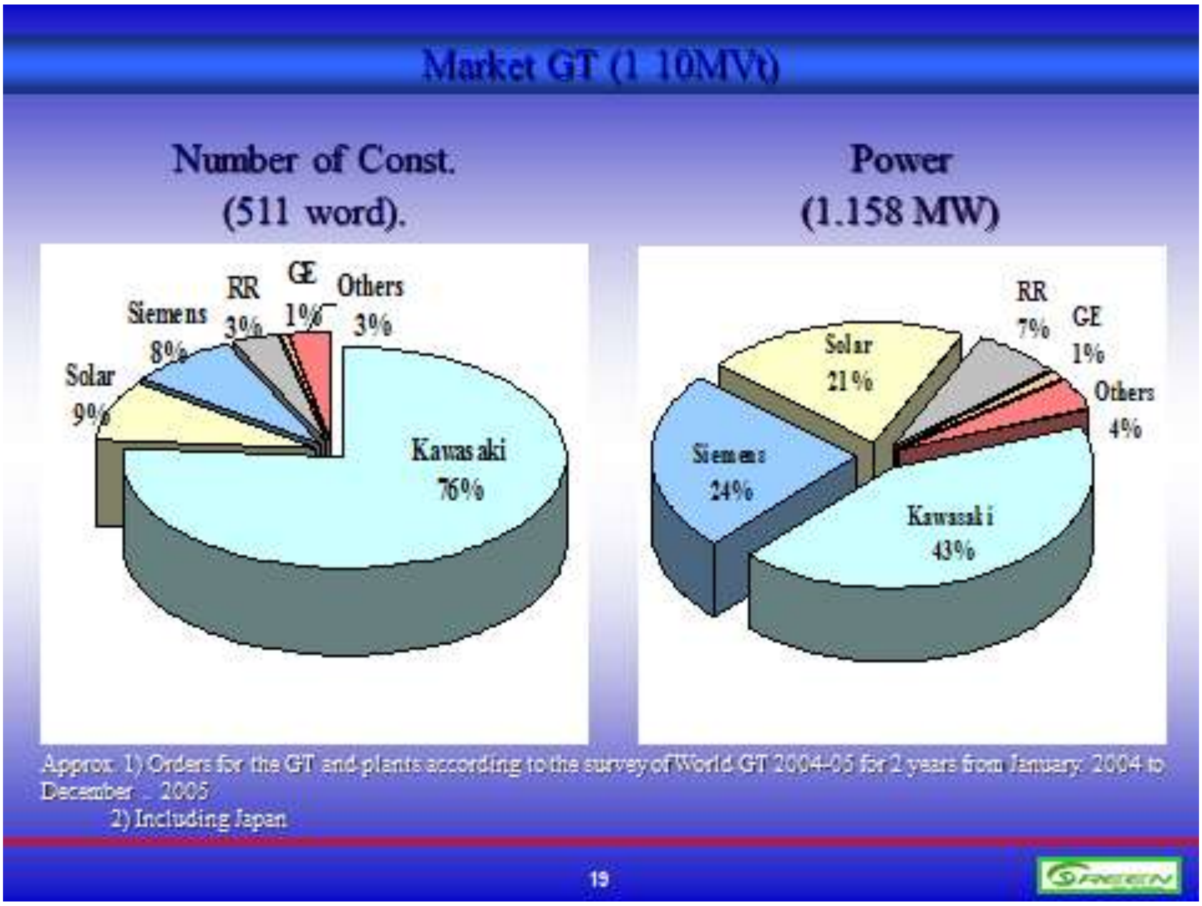
Rapporteur drew attention to policies to accelerate the introduction of kogeneratsionnroy system in Japan:

tax incentives (Reducing the income tax on the green investment helps reduce emissions of CO_2);

Various subsidies from the central government and / or local authorities;

Financing long-termand a low percentage.





Speaker gave examples of large and well-known customer products Kawasaki.

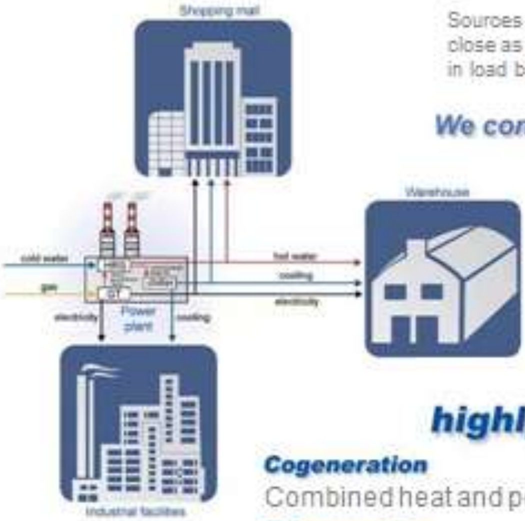
A.Skorokhodov, General director of BPC Group Power System, presented company's projects based on Power Efficient Microturbine-based CHP and CCHP Systems. The presentation also included a detailed view on industry's challenges, power efficient solutions for industrial and public facilities.

Innovative Technologies

Distributed generation concept is the core of our solutions

Sources of power and heat are situated as close as possible to consumers and operate in load balancing mode

We construct microturbine-based power plants



The state-of-the-art, reliable and environmentally-friendly power generating equipment

We use highly efficient technologies

Cogeneration

Combined heat and power production

Trigeneration

Combined cooling, heat and power production

Industry's Challenges

- Physical and moral deterioration of heating networks and generating equipment (exceeds 60% in Russia on average).
- Increase of emergency outages due to incompliance of housing and community amenities to requirements of energy safety.
- High power intensity of heat generation due to use of costly and polluting fuels: fuel oil and diesel.
- Increase of electrical and heating tariffs for private and commercial consumers due to low efficiency of local CHP plants.
- Rise of power and heat deficit caused by development of cities and growth of consumers number.

Power Efficient Solutions for Industrial Facilities

- Renovation and power efficiency increase through implementation of CHP technologies
- Provision of reliable power supply complying with the Category I requirements
- Reliable power supply of new production lines during expansion of production
- Provision of high-quality power for complex and sensitive equipment
- Utilization and recycling of production wastes to generate power and heat

Benefits: Optimization of a facility's energy costs and decrease of production costs due to decrease of power intensity of the production process

Power Efficient Solutions for Public Utilities

- ✓ Modernization of housing and community amenities via implementation of the state-of-the-art generating equipment – microturbines
- ✓ Power efficient technologies: CHP (cogeneration) / CCHP (trigeneration)
- ✓ Increase of energy safety: reliable power supply complying with the Category 1 safety requirements
- ✓ Grid Connected mode: diverting of excess heat and electrical energy to cover needs of other loads

Power Efficient Solutions for Oil and Gas Sector

- Power and heat supply for oil and gas fields
- Associated gas utilization
- Power and heat supply for gas transportation systems

Distributed power plants for construction works

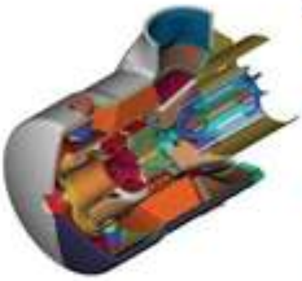
Construction sites

Large-scale construction

Benefits

- Reliable and continuous power supply during construction and after commissioning
- Power supply in conditions of utility grid unavailability
- Organization of construction in undeveloped territories
- Elimination of construction downtimes due to power outages or power deficit
- Incremental increase of generating capacities in compliance with the increase of construction volumes

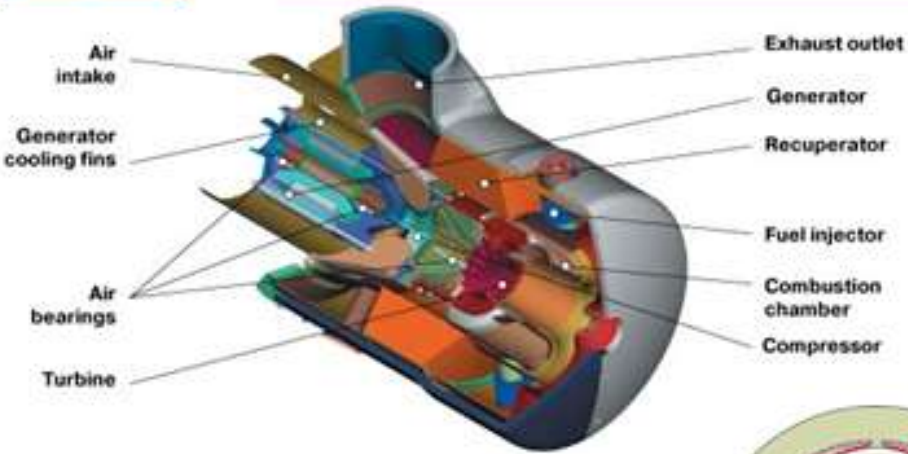
Technological Base – Capstone Microturbines

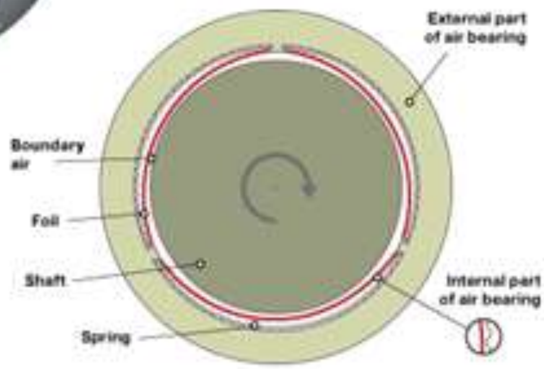


Modular microturbine engines
Capstone C15, C30, C65, C200, C1000

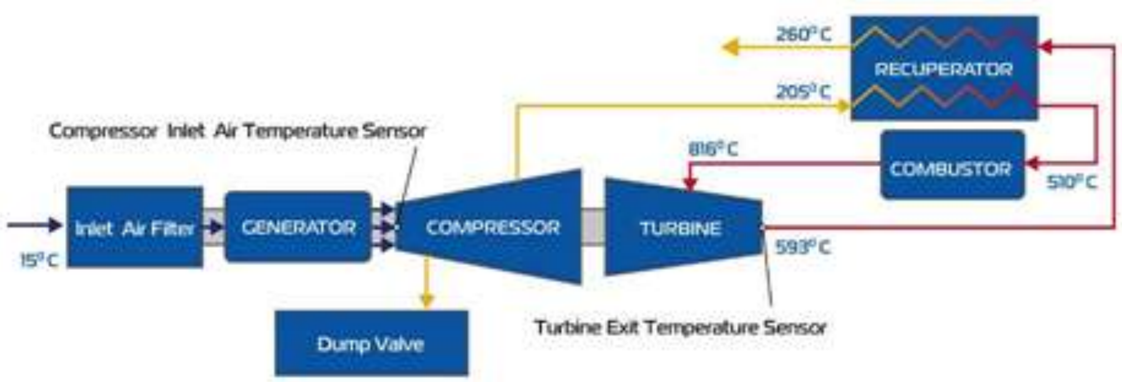
- 15, 30, 65, 200, 600, 800, 1000-kW electrical output
- Fuel: natural gas, associated gas, biogas, liquid fuels (kerosene, diesel), propane-butane mixes, liquefied gas
- Reliability, controllability
- High efficiency: up to 90% in CCHP
- Low operational costs
- Ecological features (CO / NOx < 9 ppm)
- Load flexibility (continuous operation at 0-100% power output)
- Modular design
- More than 700 units in operation in Russia
- Certificates and permissions: UL, CE, ISO 9001:2000, GOST R 9001 – 2001, Rostekhnadzor

Capstone Microturbine Engine

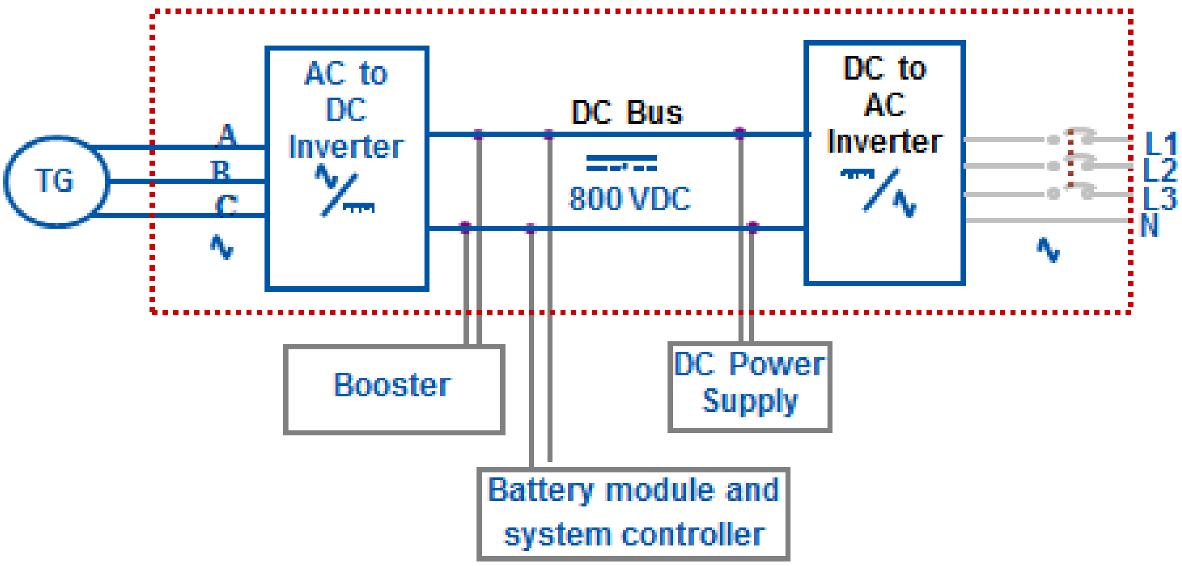




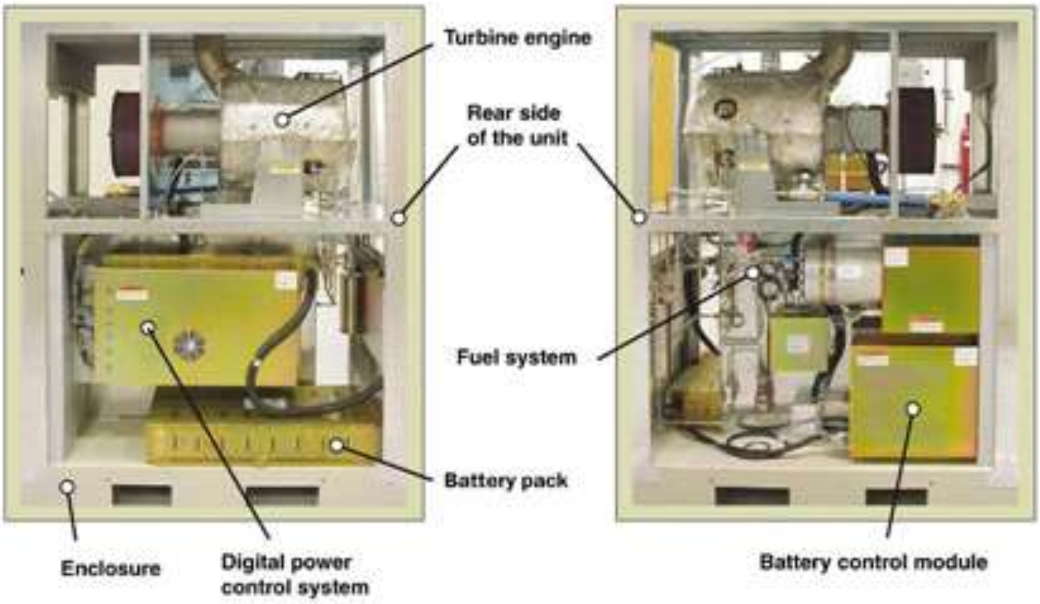
Capstone Microturbine Engine Cycle



Electric Diagram



Key Components of Microturbine (Capstone C30 is shown)



Capstone C1000 Series Microturbine Systems

Models:

C600 – power output 600 kW

C800 – power output 800 kW

C1000 – power output 1000 kW

Capstone C1000 Series microturbine systems

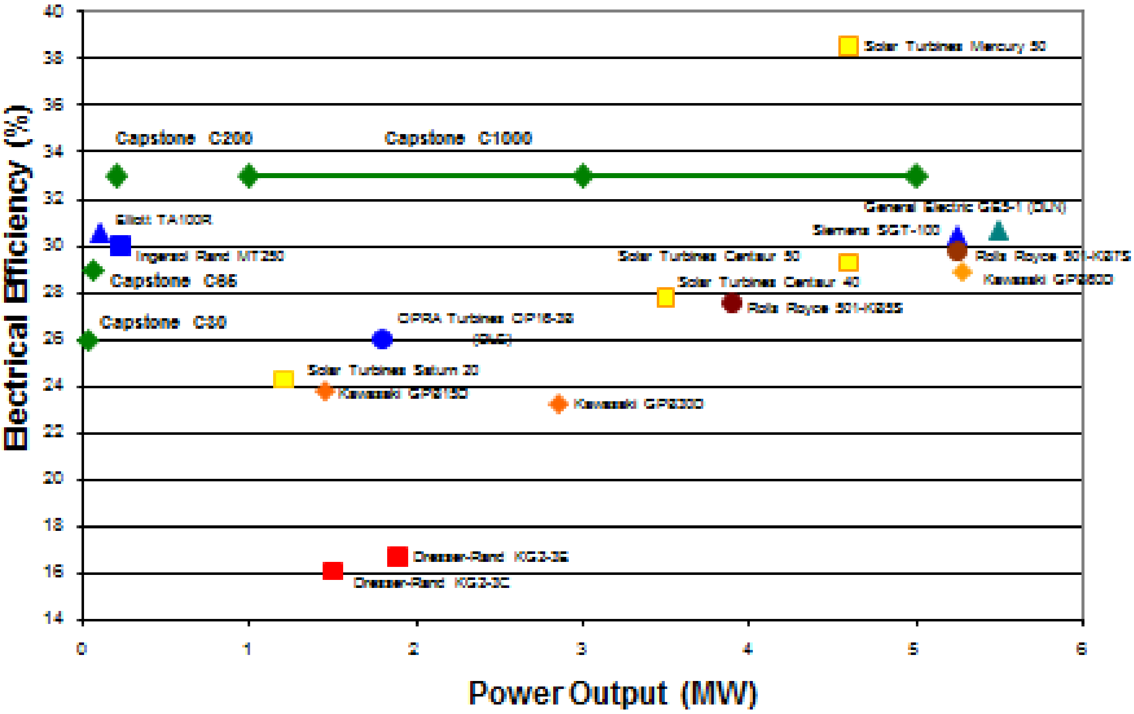
- Electrical efficiency – up to 35%
- Easy independent maintenance of each C200 power module
- High degree of internal redundancy
- Capability to size power output through installing 3 to 5 C200 power modules
- Capability to stack several Capstone C1000 Series microturbine systems

Capstone C1000 systems are equipped with C200 microturbine engines:

- Bearing is located in cold zone
- Increased space between bearings and rotor shaft
- Increased recuperator

Reliability
Efficiency
Economy

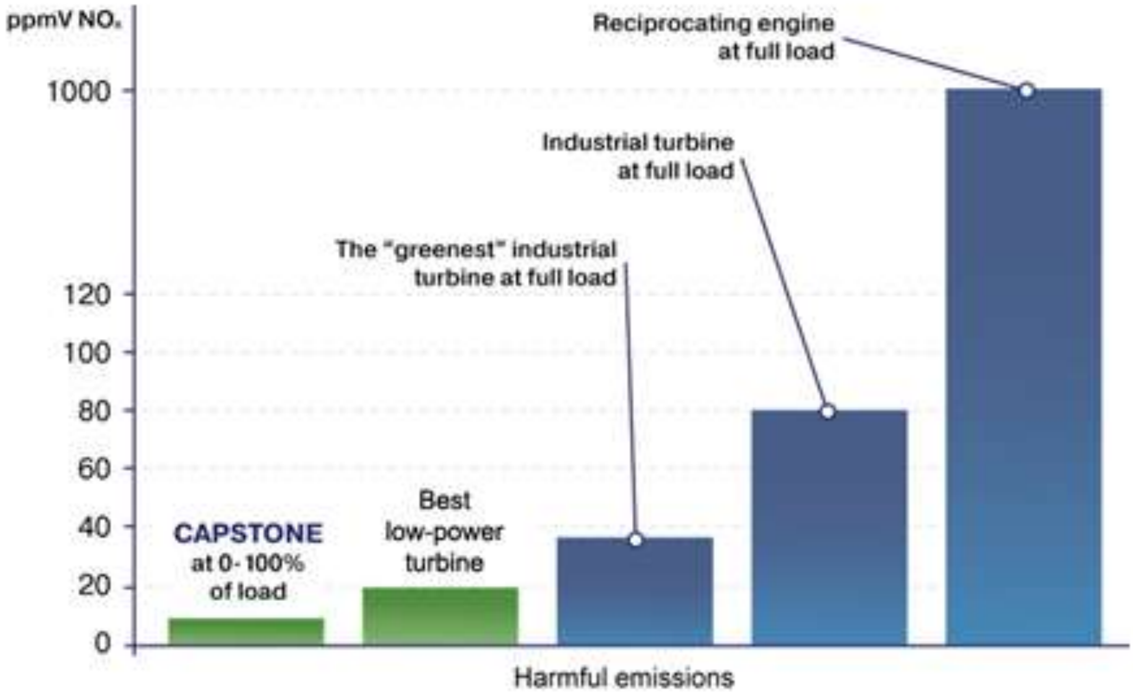
Electrical Efficiency. Capstone vs Other Gas Turbine Units



Capstone Microturbines vs Gas Turbines (GT) vs Gas Reciprocating Engines (GRE)

	Capstone microturbine	GT	GRE
Electrical efficiency	+	–	+
CHP efficiency	+	–	–
Reliability of power supply and redundancy	+	–	–
Load flexibility, ability of continuous operation at 0-100% range of load	+	–	–
Lifecycle	+	–	–
Intervals between maintenance	+	–	–
Production cost of 1kWh of electricity	+	–	–
Fuel consumption	+	–	–
Operational and maintenance costs	+	–	–
Experience in application in Russia	+	+	+
Ecological features	+	–	–

Ecological Features: Emissions. Capstone vs GT vs GRE



Economic Parameters

Fuel costs (cost of gas)
0,03 USD/kW

+

Cost of Capstone MT maintenance and service
0,008-0,009 USD/kW·h

➡

Net cost of 1 kW·h of electrical power
0,04 USD/kW·h

+2 kW·h of heat for free

Conventional electric power rate
0,12 USD/1 kW·h

Conventional heating rate
43 USD/Gcal

➡

Energy cost savings
~ 4 times

Terms of turnkey project execution

6 – 18 months

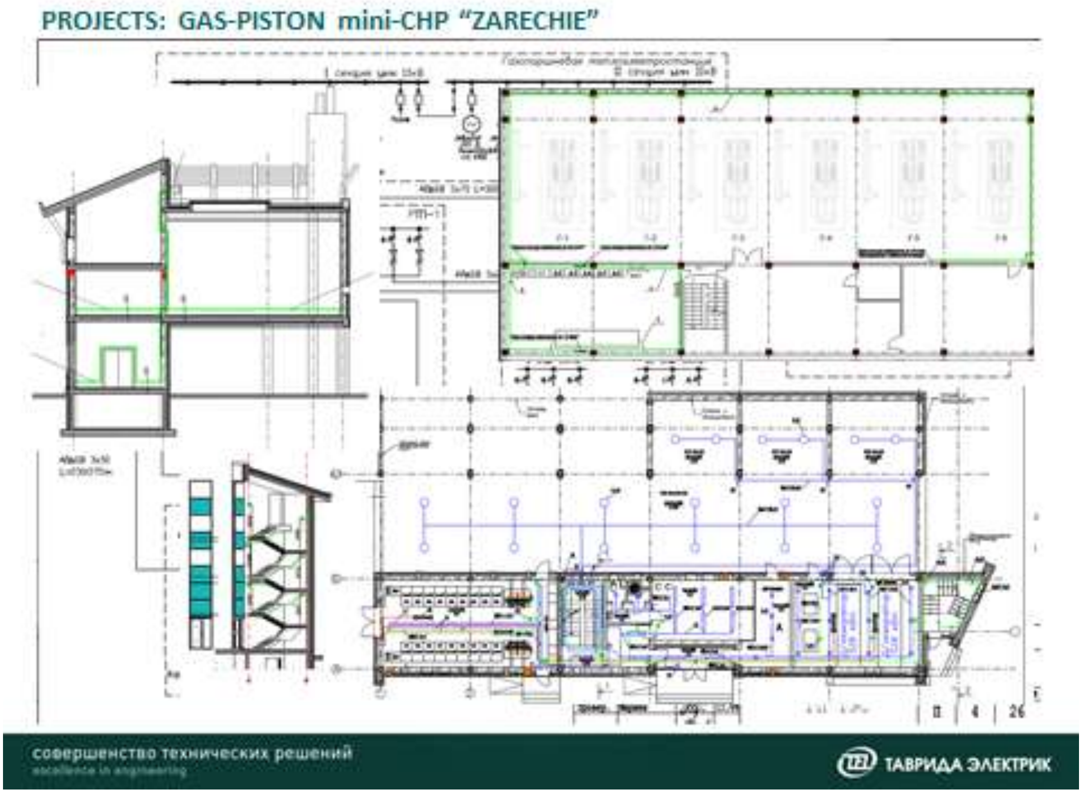
*Depends on model

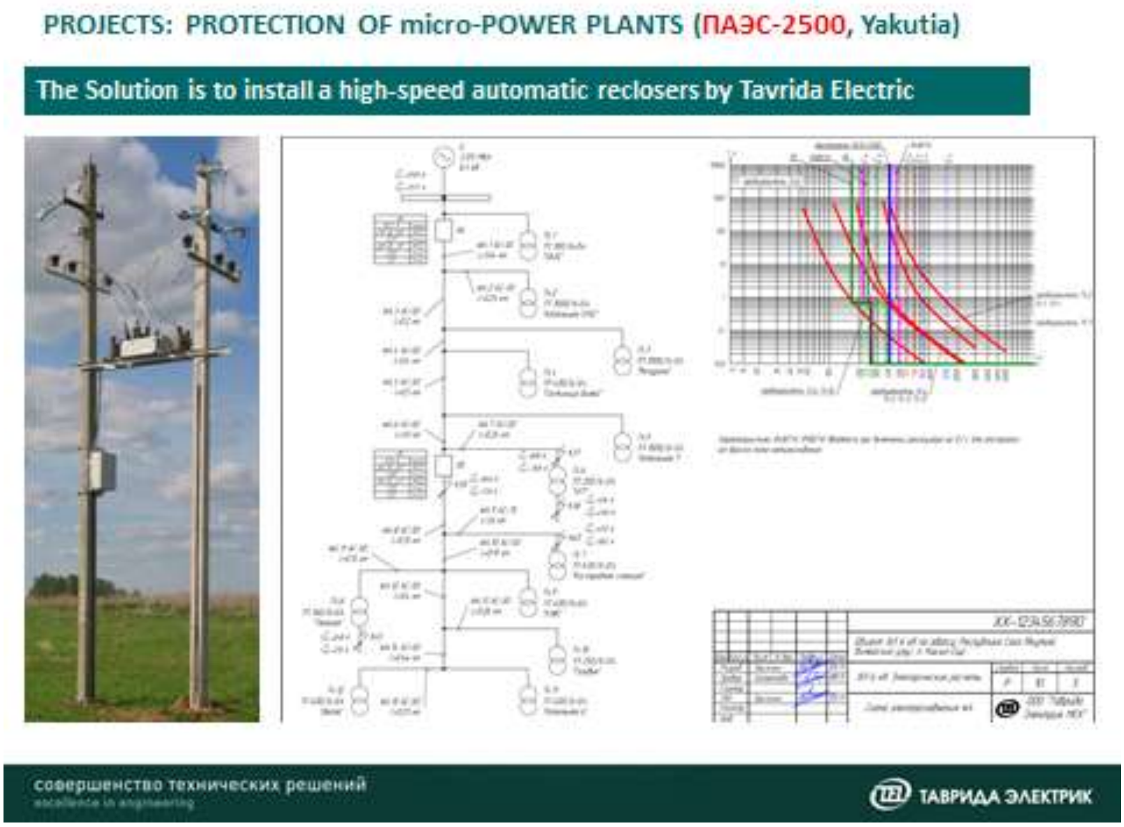
Payback period

■ Power generation	3–5 years
■ Cogeneration / Trigeneration (power / heat / cooling)	3-4 years
■ If connected to power grid	2-3 years

Rapporteur cited numerous examples of projects.

A. Korobkov, Director of Regional Technical Center (Central and Far Eastern Federal District) made a presentation about Products and Solutions for Distributed Energy Systems, as well as several case studies for micro-CHP projects





Next several presentations were dedicated to the financial aspects of conegeration projects implementation:

Z. Shinoyama from Japan Bank for International Cooperation presented the bank's activities in power generation sector, methods of financing for cogeneration projects as well as Prospects of cooperation between Japan and Russia in the field of project financing CHP.

M.Krivelevich, Institute of Economic Research of Far East Federal State University, presented his view on alternative ways of infrastructure projects financing.

Speaker described the current situation of project financing CHP in the region, pointed to new sources of funding, it is concluded:

Establishment of a mechanism to support the regional budget of major infrastructure and industrial projects using money market instruments

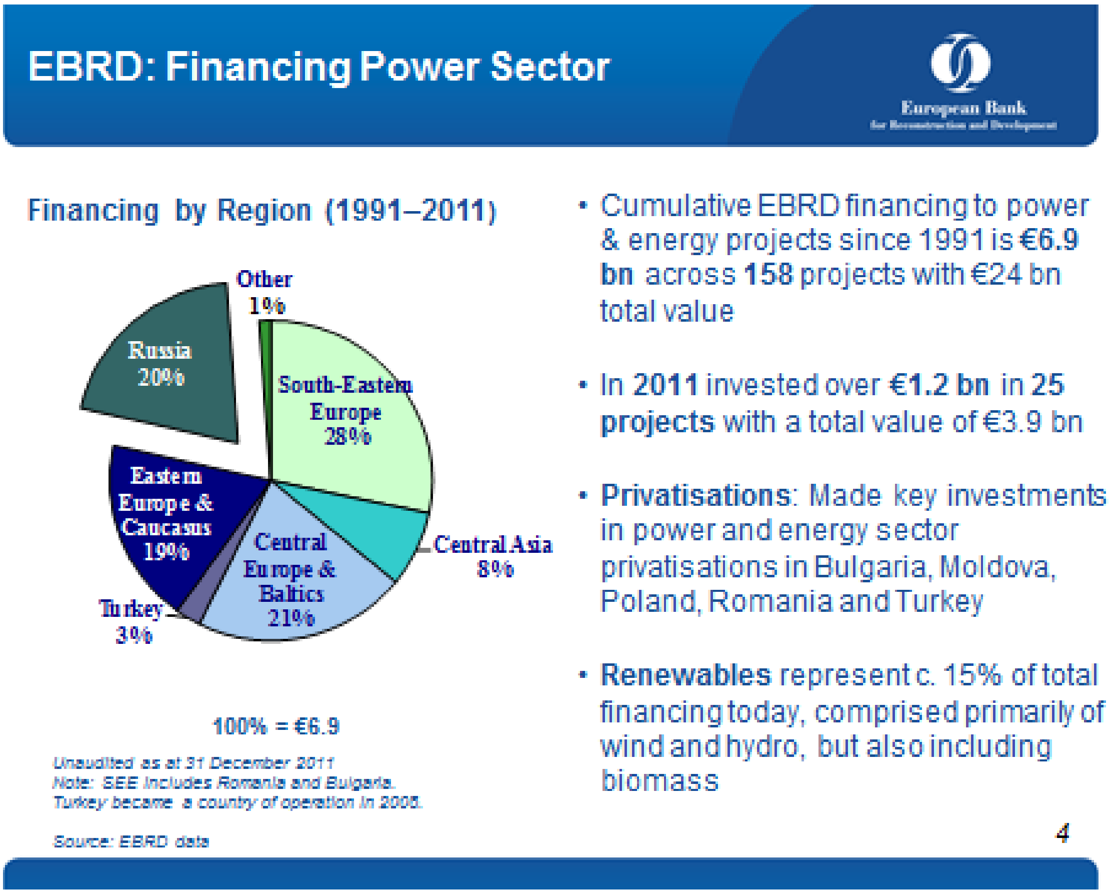
Development of a modern financial infrastructure in order to achieve a multiplier effect of GRP growth

The development of effective interaction with an electronic trading platform, on which the placement of orders, with a view to bringing proven technology solutions to the economic life of the region

Creating conditions for effective public debt management entity of the Russian Federation through the bond issue and circulation of Primorsky Krai

The introduction of the electronic trading platform for derivatives.

A.Filkine, European Bank of Reconstruction and Development talked about Financing and Investment in Russian Power Industry by regions and key projects in the Russian power sector in partnership with major Russian power players.



EBRD in the Russian Power Sector

- Support for power sector reform
- Total volume of direct financing for the Russian energy sector – **€1.6 bn**
- Total volume of mobilised funds (including syndication) – **€2.7 bn**
- **18 large transactions** with the leading power and energy companies
- The first long-term loans in roubles in the sector (Mosenergo, FGC, RusHydro)
- The first ever IFI shareholder in reorganised generating companies (OGK-5, TGK-9)
- Participation in long-term rouble bond issues (RusHydro – 5 year, Federal Grid – 7 and 10 years)

5

EBRD Financing Solutions

	Debt	Equity	Guarantees
Typical size	Min €10m	Min €5-7m, minority stake	€50k– €50m
Term	5-7 (up to 12) years	Typically from 3-7 years	1.5-2 (up to 3) years
Currency	Rubles and major foreign currencies		
Approach	Finance up to 35% of the project (60% with syndication)	Usually up to 35% share, minority stake	Mainly through Trade Facilitation Programme
Options	► Senior, subordinated or convertible ► Floating or fixed rates	► Portage equity finance ► Risk equity	► Import/export operations ► Pure guarantees, cash advance trade finance
Applications	► Greenfield or Brownfield ► Modernisation and energy efficiency ► Acquisition and consolidation ► Privatisation		► Issued to international banks ► EBRD takes the risk of transactions of local banks

Exact terms depend on specific needs and market conditions

8

Key Financing Criteria

European Bank for Reconstruction and Development

Transparent	▪ Full transparency of the ownership structure and complete disclosure of the end beneficiaries ▪ At least 3 years of financial statements audited and prepared in accordance with IFRS (USGAAP)
Strong Financials and Reputation	▪ Sound business model with a clear return to the Bank from the main operations rather than from alternative sources ▪ High level of integrity of owners and managers with long term vision and high standards of corporate governance
Transition Impact	▪ Impact on the local economy in line with the Bank's mandate to facilitate transition to a market economy
Clean Environment	▪ Compliance with EBRD's environmental and social mandates - best international practice

9

Examples of Co-Generation Projects in Russia

European Bank for Reconstruction and Development

Lenenergo (Loan)

- €40 million loan to finance capital investments for the completion of a new unit (210MW) at CHP-5.

Mosenergo (Loan)

- RUB 7.2 billion senior loan (A/B tranches) for the financing of Mosenergo's urgent priority investments for the refurbishment of several CHPs to improve the efficiency of operations.

TGK-9 (Equity)

- The Bank acquired 7.88% stake in TGK-9 in 2007. The proceeds of the capital increase are used for reconstruction of CHP-6 (124MW), CHP-9 (165MW) and construction of Novo-Bogoslovskaya (230MW) and Novobereznikovskaya CHPs (230MW).

TGK-13 (Loan)

- Senior loan of up to USD 75 million to finance the completion of the cogeneration unit at Krasnoyarsk CHP-3 (185MW).

10

I.Ohashi, Chief Representative Nomura Research Institute Moscow Branch made a presentation on Possibilities and challenges for realization of CHP projects in the Russian Far East. This discussion was led from the aspects of investment opportunities and points of competitive edge that Japan can offer to Russia for urban and transport infrastructure development.

José Carrasco B., Chili, «Chilean Electricity Market: Opportinities for Cogeneration».

The reporter described the situation with the generation and consumption of electricity in Chile.

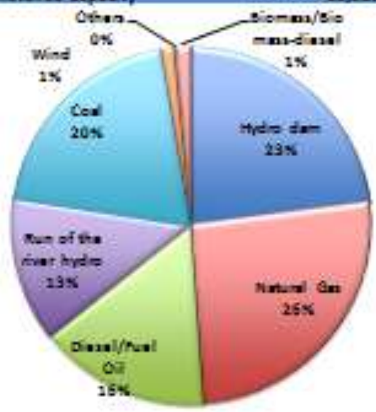
I. Installed capacity 2011

SING	24.1%	3,964 MW
SIC	75.0%	12,365 MW
Aysén	0.3%	52 MW
Magallanes	0.6%	100 MW

Total MW 16,481

II. Installed capacity and peak demand **2011**

TYPE	Capacity (MW)
Hydro dam	3,749
Natural Gas	4,232
Diesel/Fuel Oil	2,539
Run of the river Hydro	2,125
Coal	3,242
Wind	197
Others	27
Biomass/Biomass-diesel	219
Total Installed Capacity	16,329



Installed capacity
16,329 MW
Peak demand
9,043 MW
(CHP to the system ≈ 300 MW)
(Total CHP ≈ 600 MW)

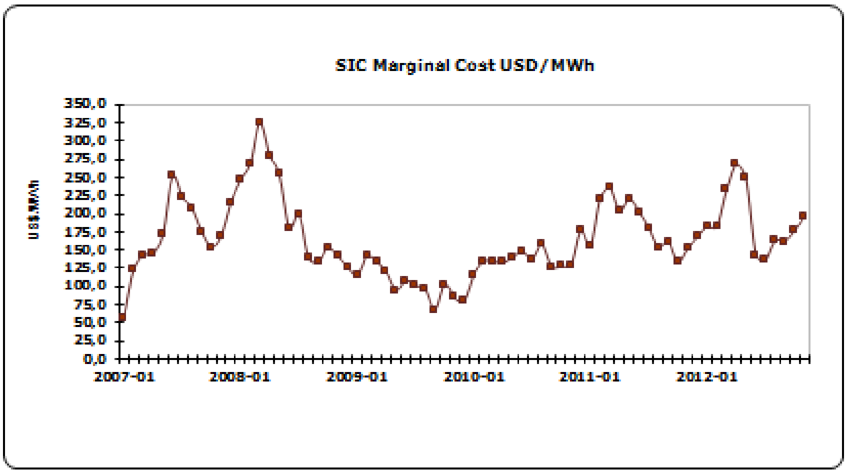
3

III. Chilean Electricity Market:

- Mandatory pool with audited costs
- Commodities: Energy, Capacity
- Energy and power transactions
- Opened only to generators
- Financial bilateral contracts with free customers or regulated customers.

4

IV. SIC Marginal Cost 2007-2012



5

Speaker explained the main features of the region:

Eventually, high marginal cost produces high short term contracts to free costumers (> 2MW)

Industries should evaluate the CHP, enter in the electricity market and avoid high prices (or even trade electricity).

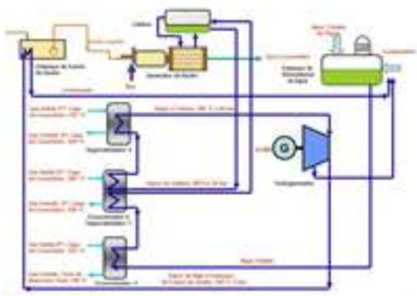
Renewables Energy Law: 5% of all the generation must be supplied by NCRE (with increases of 05.% from 2014, to reach 10% in 2024) -> Market for CHP (biomass)

Forest resourses, mining, industry (2011 ≈ 800-1000 MW)

VI. CHP Chile: 2 examples

- Arauco: 569 MW (≈ 200 to the grid)
- Forestry.

- Noracid: 24 MW (≈ 18 to the grid)
- Sulfuric Acid



7

Takahiro Nagata, New and Renewable Energy Group, The Institute of Energy Economics, Japan «CHP Markets & Policies in Japan».

Speaker elaborated on the following issues:

Energy Mix Options

CHP Markets in Japan

CHP Policies in Japan

"Energy Mix Options"
Options for 2030 Power Generation Mix

IEE JAPAN

- Three scenarios with nuclear power at 0%, 15%, 20-25%, respectively
- Each scenario with CHP at a pre-set 15%

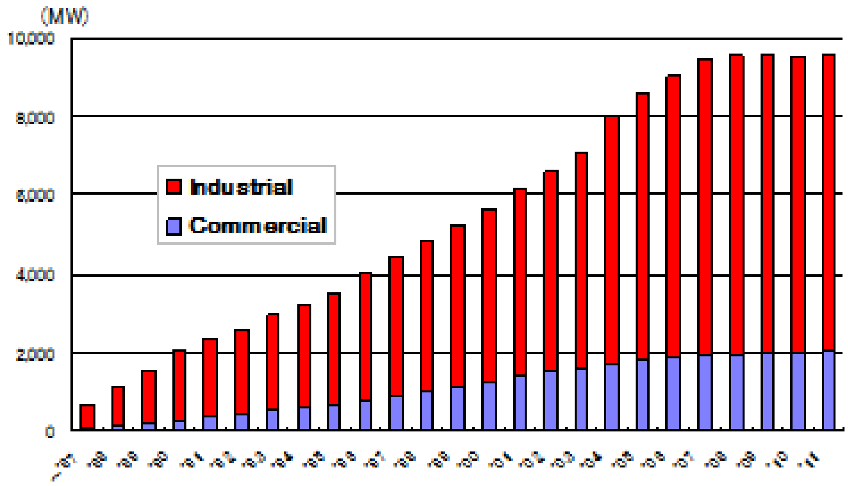
	Nuclear	Renew-ables	Thermal	CHP	C02 Emissions Reduction
FY2010 (benchmark)	26%	10%	60%	3%	-0.3%
Option 1	0%	35%	50%	15%	-16%
Option 2	15%	30%	40%	15%	-23%
Option 3	20-25%	25-30%	35%	15%	-25%

Source: Energy and Environment Council (29th June, 2012)

CHP Cumulative Capacity Growth

IEE JAPAN

- 2011 Existing CHP: 9.5 GW (8,783 sites)
- Industrial users represent 79% of CHP capacity



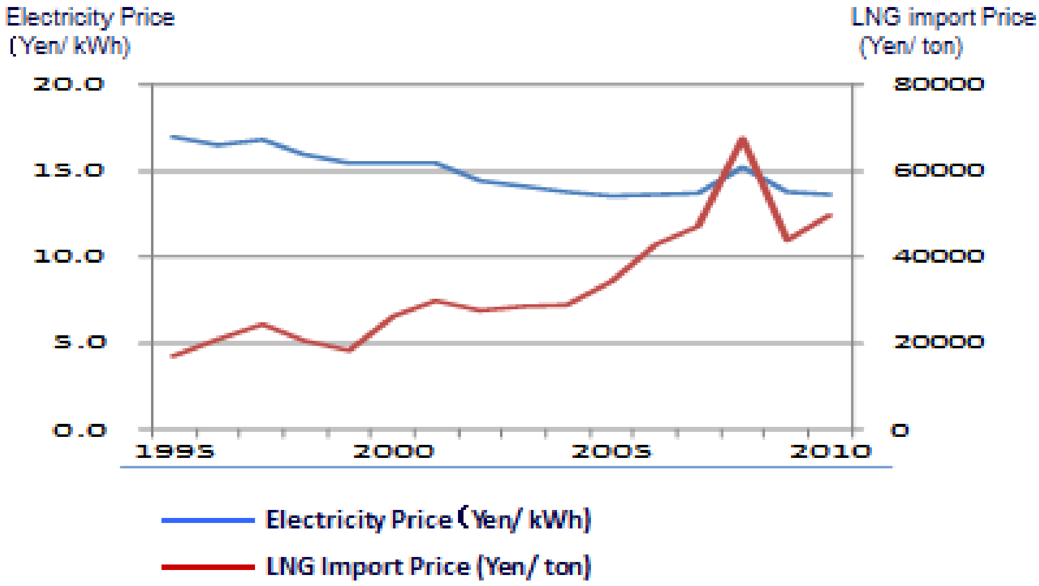
Source: ACEJ

4

Electricity Price vs. LNG Import Price

IEE JAPAN

- High LNG prices and relatively low electricity prices has reduced the competitiveness of gas-fired CHP



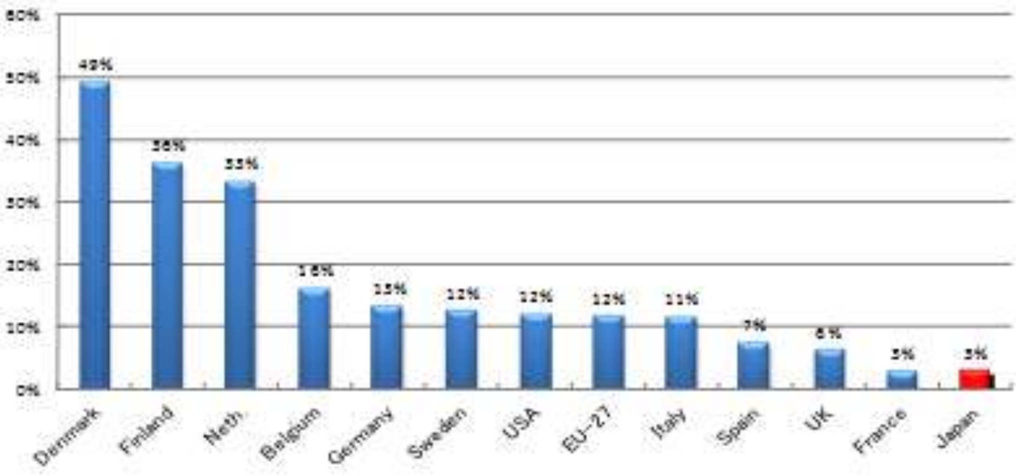
Source: METI

5

CHP Share of Total National Power Generation

IEE JAPAN

- CHP share of total power generation lags far behind EU and USA
- In other words, it has a large and untapped potential for CHP.

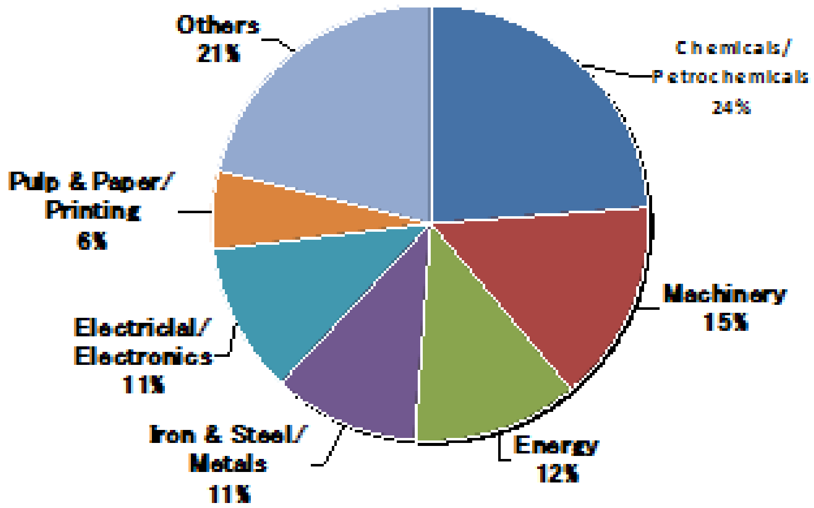


Source: Eurostat, etc.

6

2011 Existing CHP Capacity by Application - Industrial

- CHP capacity is found in various industries, such as chemicals, petrochemicals, machinery, and energy, etc.

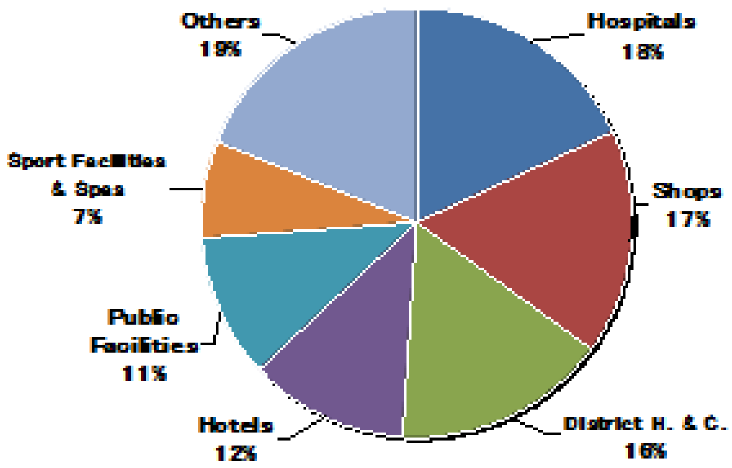


Source: ACEJ

7

2011 Existing CHP Capacity by Application -Commercial

- Hospitals, shops, DHCs, hotels, public facilities, sport facilities & spas represent more than 80% of commercial CHP capacity

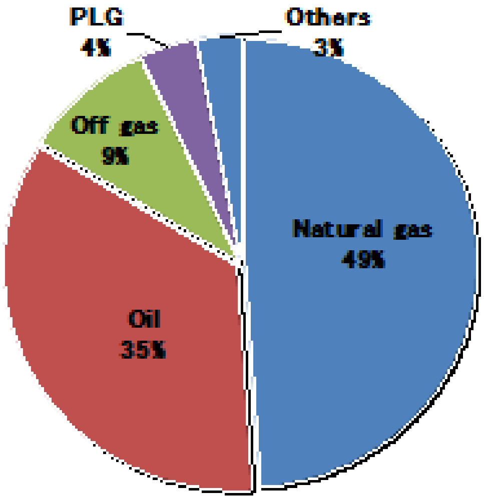


Source: ACEJ

8

2011 Existing CHP Capacity by Fuel Type

- Natural gas and oil represent more than 80% of CHP fuel

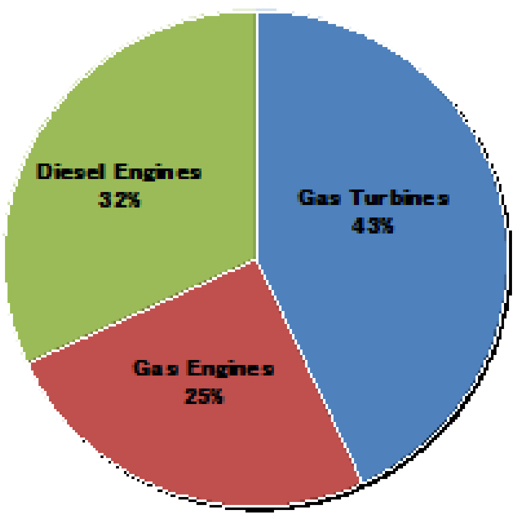


Source: ACEJ

9

2011 Existing CHP Capacity by System Type

- Gas turbines are predominant in industrial applications, while gas engines are the most widespread in commercial applications



Source: ACEJ

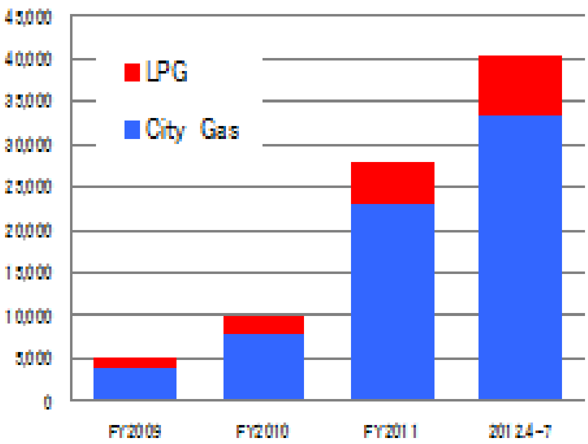
10

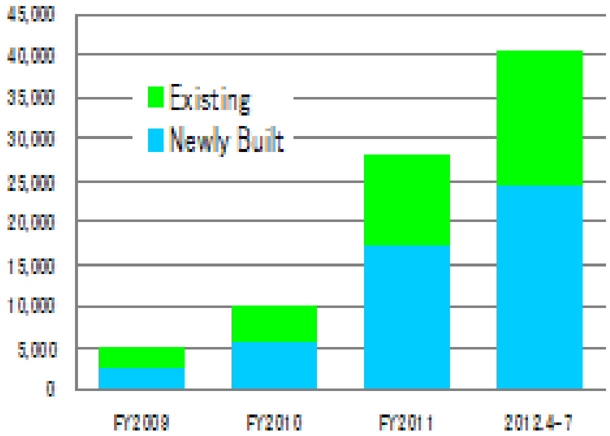
"ENE- FARM" (Residential Fuel Cell) Annual Installation

-Subsidy Application Accepted by FCA* basis

*FCA: Fuel Cell Association

- **ENE- FARM, commercialized in 2009, has been accelerating the pace of introduction and development**





Source: ACEJ

11

CHP Future Target Markets

Industrial

- Large-scale users, applications with high thermal demand
- Applications with limited experience with CHP (by promoting the use of gas engines with high generation efficiency)
- Penetration into existing markets (by introducing adequate evaluation system for CHP environmental benefits)

Commercial

- Large-scale users, focused approach to DHCs and urban users
- Increase of thermally-based CHP (through construction of heat network to integrate locally-dispersed heat demand)
- Penetration into users with large thermal demand (hospitals, hotels etc.)
- Utilization of CHP for improvement of key facilities for natural-disaster prevention

Domestic

- Penetration into domestic market through development of lower priced units
- Entry into overseas market

Overview of CHP Support Schemes in Japan

- No CHP promotion law, no FiT schemes, no certificate schemes

	Japan	Belgium	German	UK
Legal Framework		CHP promotion law (regionally issued)	· CHP law · Renewable energy heat law	Energy Act 2008
Feed in Tariff			●	● (micro-CHP)
Certificate schemes		●		
Capital grant	●		● (micro-CHP)	

*The above schemes are for fossil fuel based CHP, and other support schemes do exist for renewable CHP.

CHP Target for 2030

- METI's Fundamental Issues Subcommittee has set a target for 15% (150 TWh) of gross power generation to come from CHP by 2030

- Need about 30GW of total CHP capacity (assuming 5,000 full load hours per annum)
- An estimate indicates about 10 GW be exported to the grid

- CHPs need to contribute to the stability of power grid
- Win-win situation for both CHP operators and power grid operators be created through policy coordination

Four(4) Pillars of CHP Promotion Policies

- In July of 2012, the Japanese government (METI) showed four policy pillars to be addressed for further CHP promotion

Policy 1	**Enhanced Support System (since Aug. 2012)** ・Establishment of "Cogeneration Promotion Office" in METI (Agency for Natural Resources and Energy) ・ assignment of personnel in charge of CHP in each regional bureau of Economy, Trade and Industry
Policy 2	**Use of Negawatt Market Schemes** ・Use of voluntary negawatt market schemes utilizing CHPs ・Drawing up of guidelines on negawatt trading **Reform of Electric Power System** ・Creation of a "Distributed Model Green Electricity Selling Market"(since June 18, 2012) ・Improvement of evaluation for CHP electricity through the electricity power system reform

Four(4) Pillars of CHP Promotion Policies

Policy 3	**Support schemes to induce CHP investment** ・Capital grant and tax support (already introduced) ・Capital grant and fuel cost subsidy for new and additional in-house power generators/CHPs as a power peak cutting measure (already introduced)
Policy 4	**Reduction of fuel prices** ・Improved natural gas supply infrastructure (construction of national natural gas supply networks) ・ Reform of LNG supply structure through import from US, launch of LNG projects by Japanese firms, and reinforcement of bargaining power with energy majors and gas producing countries

A. Bondar, Director of Far East Federal region Russian Energy Agency made three presentations, including

"Challemges and progress of power infrastructure development in Primorye Territory of Russian Far East"

"State programme on energy efficiency"

"State support and cofinancing of municipal power facilities modernization projects and increase of energy efficiency"

Energy complex of the Far East.

Power System (ES) Primorye operates in the United Energy System (UES) of the East. Today, East IPS redundant power and energy in connection with the introduction of a major new source of energy Unification - Bureiskaya HPP installed capacity in 2011 was 2010 MW power generation for the year 5.07 billion kWh, the yield on the design performance in 2012 the balance of power in East IPS was formed in 2011 with a reserve of 58% of the maximum load with the system constraints on the transfer of power.

ECO East today redundant power and electricity due to the launch of a new large source of energy - Bureiskaya HPP installed capacity in 2011 was 2010 MW. electricity production (E cuttings.) for the year - 5.07 billion kWh, reaching its design parameters - in 2012, and the construction of the Lower Bureya hydroelectric installed capacity of 320 MW output at full performance - in 2016

The balance of power in East IPS was formed in 2011 with a reserve of 58% of the maximum load with the system constraints on the transfer of power.

Energy complex of Primorsky Krai. Power flow.

Cover the power deficit in the EC Primorye provided ECO flow from East to 25% of peak load. To improve the efficiency of the electric power system of Primorye and simultaneously increasing its energy security in the development of appropriate systems to provide the necessary volume of input shifting capacities, as well as optimize the cogeneration turbines and the pairing peak of heat.

Energy complex of Primorsky Krai. Dynamics of consumption.

Electric power consumption Primorye annual growth of 3-3.5%. Slower growth was observed only in 2008, during the crisis, but in subsequent years the dynamics of consumption growth was restored.

In the structure of the installed capacity of electric power energy systems Primorye thermal power plant (TPP) is - 98.2%, the share of gas turbines at the moment is - 1.8%.

Bear in mind that at present in the Primorsky Krai gasification plans may increase by 2025 gas turbines up to 30% (about 1 GW) of installed capacity in the power structure of the Primorsky Territory.

Over the last 5 years installed capacity of the Primorsky Territory increased by 190 MW. Occurred due to the reconstruction and re-marking of equipment and commissioning of TPP mobile gas-turbine power plants.

The main problems of power systems of Primorye:

The outdated equipment and technology - generation, networks, supervisory control were built 20-30 years ago and have developed their own moral and park resources. Growing reliability problems require a lot of investment in the short term.

The dominant share of the state as the owner of the energy infrastructure, leading to a conflict of interests of the state as a business owner and an advocate for civil and commercial customers.

Low efficiency of use of community and small-scale power. Do not use modern investment vehicles. Depreciation of municipal energy up to 72 - 86%

Prospects of development of energy sector Primorye

Formation of a new model of energy development Primorye requested, pursuant to the Energy Strategy of Russia until 2030, which was approved by the RF Government Decree № 1715-r of 13.11.2009

The new model is based on the following technology platforms, which is responsible for the implementation of the Ministry of Energy of Russia, including:

1. Small distributed energy;

2. Environmentally friendly thermal power efficiency;

3. Promising renewable energy technologies;

4. Intelligent Energy System of Russia.

The new business model of energy development of Primorsky Krai is described as "Distributed Energy" and is aimed at improving the efficiency of the municipal boundary of the property and carrying out the production or delivery of energy to the consumer, reducing wear and tear and improve the technical condition of the property, as well as improving the quality and accessibility of public and commercial users of energy services.

Power System (ES) Primorye operates in the United Energy System (UES) of the East. Today, East IPS redundant power and energy in connection with the introduction of a major new source of energy Unification - Bureiskaya HPP installed capacity in 2011 was 2010 MW power generation for the year 5.07 billion kWh, the yield on the design performance in 2012 the balance of power in East IPS was formed in 2011 with a reserve of 58% of the maximum load with the system constraints on the transfer of power.

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Electric power consumption Primorye annual growth of 3-3.5%. Slower growth was observed only in 2008, during the crisis, but in subsequent years the dynamics of consumption growth was restored. This we can see in the chart.

In the structure of the installed capacity of electric power energy systems Primorye thermal power plant (TPP) is - 98.2%, the share of gas turbines at the moment is - 1.8%.

Bear in mind that at present in the Primorsky Krai gasification plans may increase by 2025 gas turbines up to 30% (about 1 GW) of installed capacity in the power structure of the Primorsky Territory.

TPPs power Primorye is mainly coal fuel, its share was in 2011 - 82.6%. The share of fuel oil in the balance of 15%, 1% diesel fuel and natural gas, 2%. The structure is dominated by coal used coal deposits in the Primorsky Territory 72.9%, coal imported from other fields are 27.1%.

In a communal energy at the moment, there are 920 boilers. The largest of them work primarily on fuel oil - 144 boilers produce 3,311 thousand Gcal, 626 coal-fired boilers operate and produce 2,368 thousand Gcal, as well as diesel and mixed fuel employed 122 boilers and produce 346 thousand Gcal.

In a communal energy has great potential for projects with the production of energy in cogeneration mode.

The priority areas of the State Program of Primorsky Krai "Energy efficiency and energy development" are:

Development of network management to reduce the deficit areas, especially in areas of the planned connection of new consumers.

Reduce internal costs in energy complex (loss reduction, decommissioning of Waste Equipment);

Improving the efficiency of energy facilities, located in the regional and municipal authorities;

Budget financing of modernization projects of regional and municipal property not less than 70%.

The purpose of the state program is - complex supply energy resources of socio-economic development of Primorsky Krai and ensure sustainable and environmentally responsible use of energy resources

Objectives:

- Creation and development of gas supply;

- Development of new energy;

- Improving energy efficiency in the residential sector.

- Improving energy efficiency organizations, financed from the regional and municipal budgets;

- Promote energy efficiency in the public sectors of the regional economy;

- Promote investment in energy efficiency;

- The development of renewable energy sources.

Implementation of the goals and objectives is provided by:

Creating the conditions for the achievement of technical modernization of power supply systems, gas supply systems, heating systems in towns Primorye their own and extra-budgetary funds operating in the Far East development institutions;

State support of projects:

1. Co-financing of the development of heat supply schemes of settlements, which are the basis for the formation of investment programs resursosnabzhayuschih organizations.

2. Co-financing of projects for modernization of communal power and energy efficiency of the budgets of different levels.

3. Interest rate subsidies for the implementation of energy efficiency projects funded domestic financial institutions.

V.Demkin, Director of Khabarovsk scientific and technical information center, presented activities of the local Centre for energy efficiency, including power generation projects initiation and support as well as described the goals of the State Information System development.

The purpose of the Energy Efficiency Centre in DFO is to build skills in all areas of energy conservation and energy efficiency and centralized management of regional systems for energy efficiency, housing and communal services, fuel and energy complex, which is a priority in the development of the Far East, in accordance with the instructions of the Ministry of for the development of IR and Development Committee of the fuel and energy complex of the Khabarovsk Territory.

Energy Efficiency Center DFO intends to develop cooperation in the field of energy conservation and energy efficiency:

The federal and regional authorities, major Russian and foreign companies, research organizations:

• Ministry for the development of the Far East

• Ministry of Education and Science of the Russian Federation

• The Ministry of Energy of the Russian Federation

• Staff embassy in DFO

• FGBU "Russian Energy Agency"

• Fund "Skolkovo"

• The largest Russian and foreign partners - suppliers of energy-saving technologies and equipment

Administrations of the Russian Far Eastern Federal District and Municipalities

Conducting effective HR policies to attract skilled employees, increase their professional level, providing staff decent wages and social guarantees is critical of the Centre for Energy Efficiency DFO.

Principles to guide the center of social and personnel policies are equal and equally important, that allows you to create a team of professionals, and fully identify and unlock the potential of workers. We strive to ensure that all staff were aware that the effectiveness of the work and responsibilities of each term depends on the successful implementation of priority national projects.

The main directions of personnel policy for 2012 2013gody:

• implementation of recruitment and the formation of a stable working team;

• formation of personnel reserve;

• The development and formation of a unified corporate culture;

• implementation of training programs and training of employees;

• Training and certification of managers, professionals, working in accordance with the modern professional educational standards;

• Improving the system of remuneration;

• improve working conditions;

• compliance and safety requirements of working.

The purpose of the Centre personnel policy - the optimal use of human resources to meet strategic objectives.

Among the tasks performed by the center is currently:

Provide training in the field of energy efficiency, energy saving and energy

In order to improve the knowledge of responsible experts in energy conservation and energy efficiency Energy Efficiency Center DFO implements comprehensive educational programs for different target groups:

• government agencies, at the federal, regional and municipal level;

• responsible for energy efficiency;

• industry, budget and local government agencies;

• HCS-sector (UK, HBC, HOA);

• power generation and utility companies;

• small and medium enterprises (including in the services and trade).

Development and support innovation and research activities in the field of energy efficiency

• Support and foster innovation, the collection and analysis of innovative proposals in the energy sector and energy efficiency, guidance and advisory support to the preparation of innovative projects

• Promotion of technology: support industrial development, stimulate demand for innovative products

• Participation in the organization of innovative energy efficient products in the Russian Federation

• Promotion of scientific and technological developments, innovative products and solutions in the field of energy efficiency

• Database of products, technologies and solutions: data collection, analysis and dissemination of scientific and technical information in the field of energy efficiency

Methodological support for energy efficiency activities

• Development and implementation of methodological approaches, standards and regulations in the field of energy efficiency

• Monitor and support implementation of the Federal Law "On energy saving and energy efficiency" (consolidation of information on the implementation of mandatory measures, control deviations, consulting)

• Support the implementation of energy efficiency measures (design, printing, consulting, promotion)

• regulatory and methodological work in the field of energy management;

• Implementation and certification of energy management systems

Support the implementation of energy efficiency projects

• Create incubators projects: assistance, counseling, support, development and implementation of priority projects in the field of innovative energy efficiency

• Develop mechanisms to promote the implementation of energy efficiency projects

• Forming the base of potential projects, coordination of the participants (energy consumers, investors, developers, artists). Promote the protection of the projects to investors

• Assistance in attracting international finance (banks, private investors, export credit agencies)

• Promotion of cooperation between business and the state

• Examination of projects and programs to improve energy efficiency for external financing (including the public)

The organization of activities to promote energy efficiency

• Initiation, preparation and support of international agreements in the field of energy efficiency and renewable energy

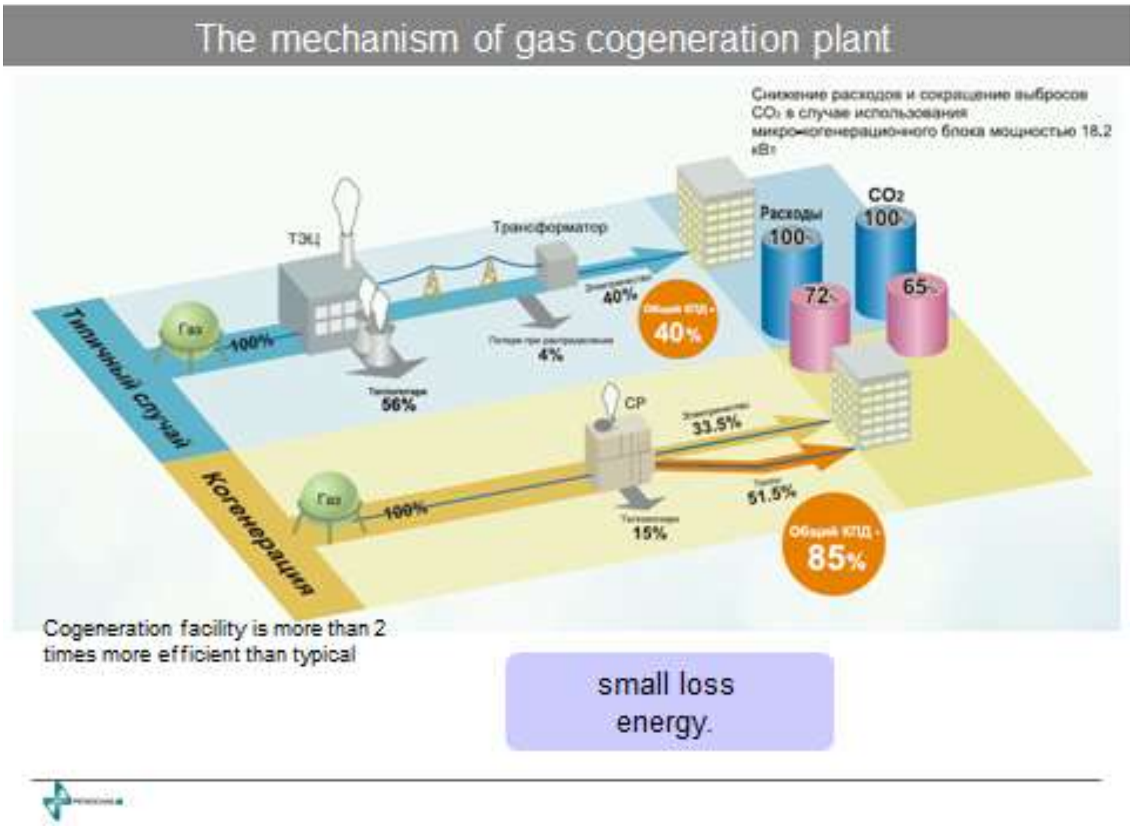
• Information-analytical and organizational support of international agreements in the field of EE

• Analysis of information on technologies and innovations in the field of energy efficiency and renewable energy sources, promoting the adaptation and implementation of the most effective solutions in Russia

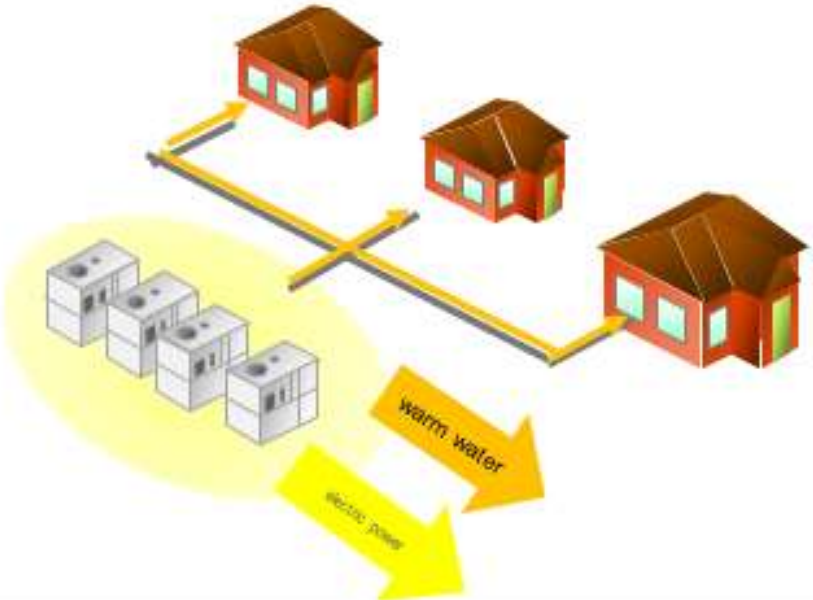
• Cooperation with foreign investors and manufacturers in the implementation of energy efficiency projects in Russia

• The advancement of Russian innovative technologies in the energy sector and energy efficiency in the world market.

A.Udod from State organisation RegionSnab described the ways how the local municipality initiates micro-generation projects and their advantages for building local distributed energy network.



Energy production and distribution by combining micro-CHP units.



The advantages of micro gas cogeneration (1)

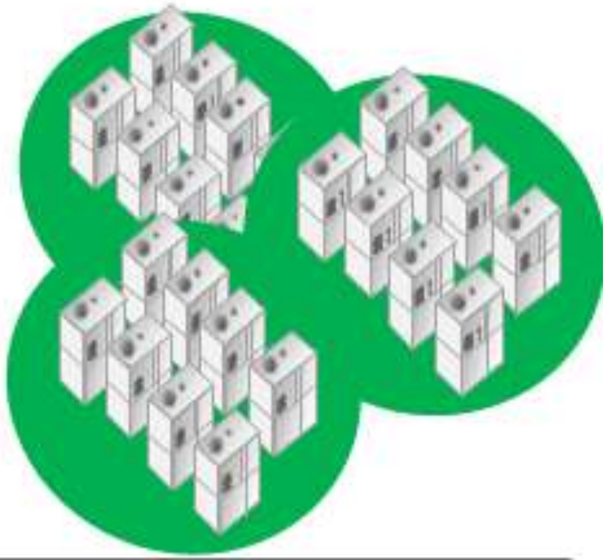
Power plant (eg DES)

The large amount of capital complicate new construction

Compact (dispersed) energy system

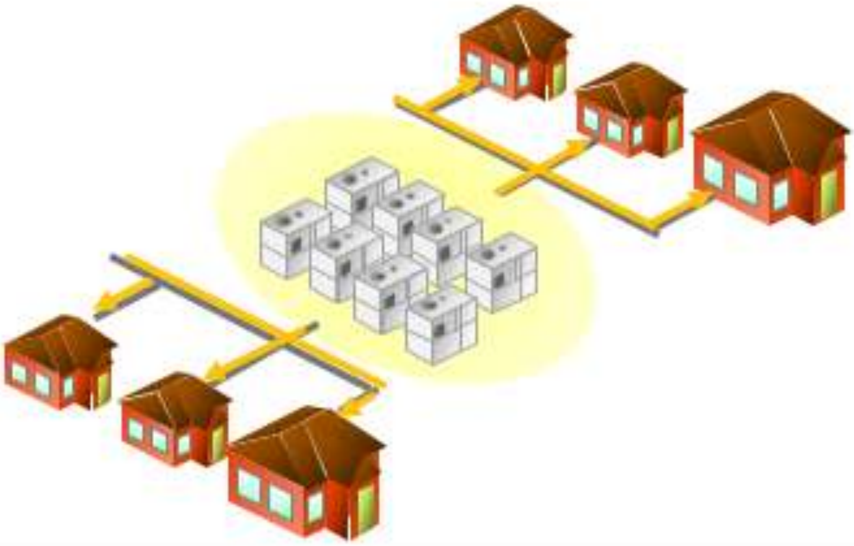
Does not require large-scale investments.

Creating the necessary capacity in the right places.



The advantages of micro gas cogeneration (2)

Possible to generate electricity and heat near the location of the end-users and distribute the right amount in each house.

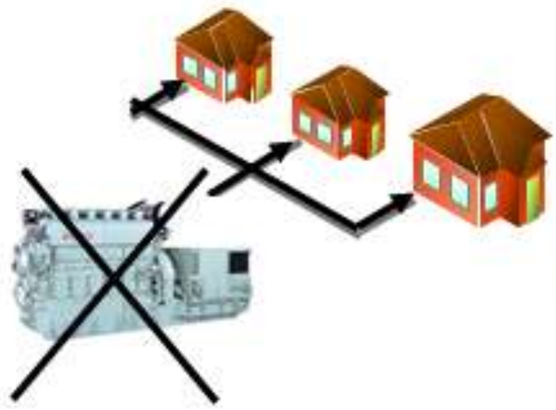


The advantages of micro gas cogeneration (3)

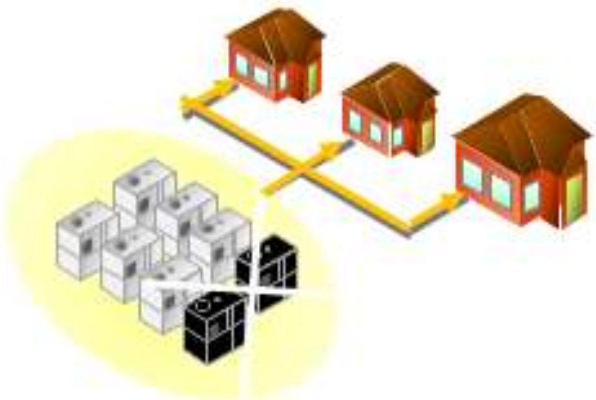
If you install multiple units devices, even in the event of failure of one of them, the rest of the energy is continuously produced units (risk sharing)

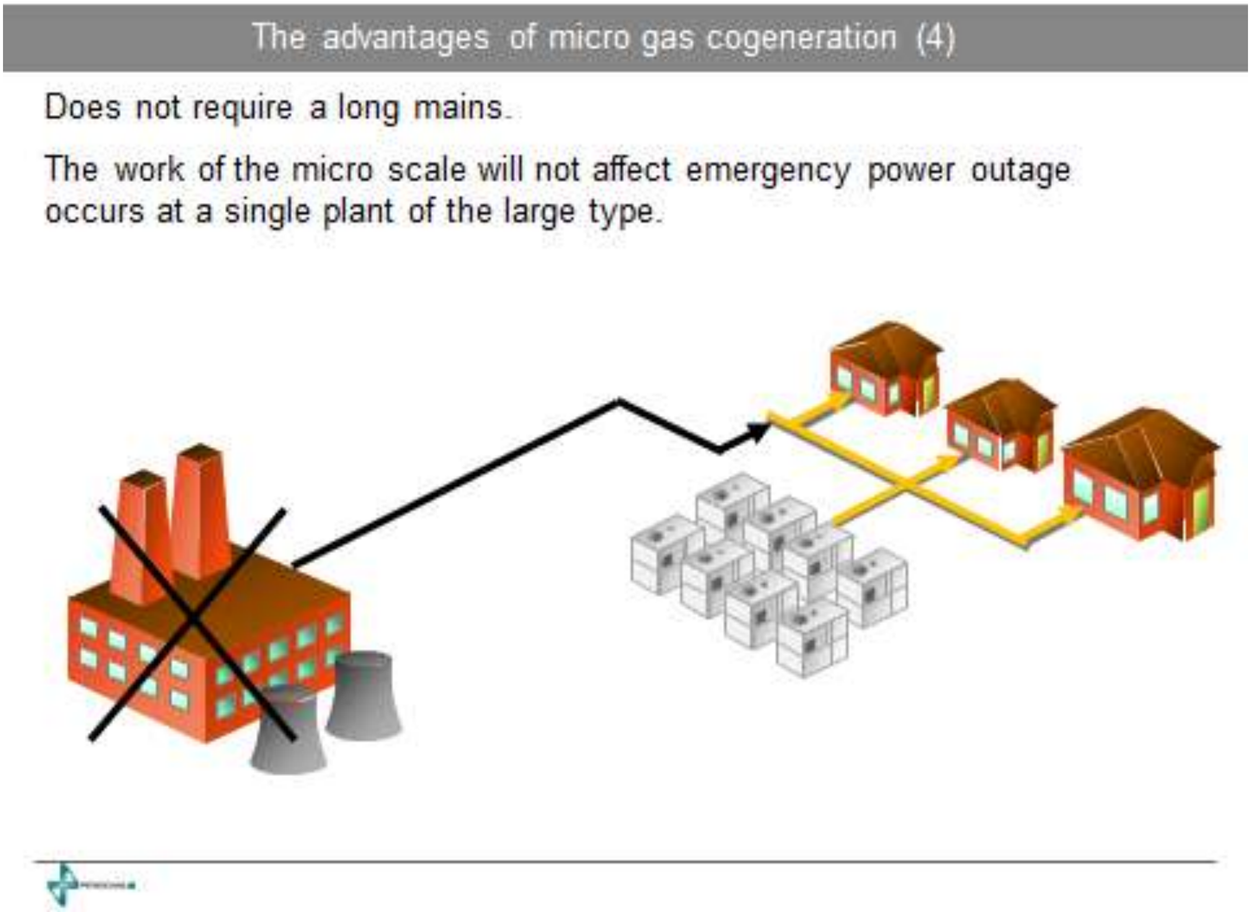
Maintenance and repair of equipment can be carried at a time and without the need for an alternative energy source.

【In the case of a single device】



【In the case of multiple devices】





Presentations were followed by the round table, where workshop participants exchanged international experience; representatives of Russian Far East local authorities admitted that the event facilitated the networking with organizations and commercial companies devoted to improving sustainable municipal development in the region;

One point of the discussion touched the point of how energy professionals could provide technical assistance for local authorities in the development of new policies, procedures, codes and standards for the industry and facilitate or take part in energy efficiency projects;

It was noted that developing formal training programs for energy managers, utility executives, utility regulators, banking and financial officials, building developers, will play an important role in supporting activities progressing towards the maturity of efficient energy generation network. The success of the workshop demonstrated that participating in industry conferences is important from the point of view of disseminating to a broad audience of policy makers, regulators and municipal authorities the accomplishments of the industry leaders.

The participants agreed that cogeneration technology is a way forward in many distributed energy generation cases.

ANNEX 2. QUESTIONNAIRE DEVELOPED FOR THE STUDY OF COMBINED HEAT AND POWER (CHP) TECHNOLOGIES FOR DISTRIBUTED ENERGY SYSTEMS

Survey on the 'Combined Heat and Power (CHP) Technologies for Distributed Energy Systems'

Instructions: If a particular question does not apply to you, or if you are either unable to or prefer not to answer it, then please proceed to the next question. If you would prefer to discuss the survey over the telephone, please indicate this so that we may contact you. Please note that accurate data will assist policymakers to better understand the scope and opportunity for cogeneration in APEC Member Economies and to develop effective policies and programs to support increased cogeneration capacity. The survey consists of 5 sections:

Section I: General Questions;

Section II: CHP Policies;

Section III: Promotion of Cogeneration;

Section IV: Technical Details on the Installed Cogeneration Technology;

Section V: Questions on Cogeneration Equipment Investments.

Where it is possible, please provide historical data for the specific indicator. Also, please try to provide the most recent data available in your country, and ***indicate the year*** and source of the ***data*** used to answer question. ***If*** the figures make the table ***too large***, include them as a ***separate file***.

Questionnaire

SECTION I: GENERAL QUESTIONS		
1.	Number of cogeneration plants in your country	
2.	Number of CHP units in your country[i]	
3.	Location of cogeneration plants in your country[ii]	
4.	Number of employees in the CHP industry	
5.	Installation date of each cogeneration plant[iii]	
6.	Service life of each cogeneration plant	
7.	CO_2 emissions savings achieved by CHP units[iv]	
8.	Power price, $/MWh	
9.	Natural gas price, $/m^3$	
10.	CO_2 certificate price, $/t CO_2	

11.	Sites with high potential for cogeneration (good prospects, with good data; potential prospect, but data are inadequate for assessment; already have cogeneration, and prospects for additional economical cogeneration is unlikely; poor prospects)	
12.	Age of existing thermal facilities	
SECTION II: CHP POLICIES		
13.	Expected market development of cogeneration technologies	
14.	Installed CHP capacity	
15.	Operational CHP capacity	
16.	CHP power generation	
17.	CHP heat production	
18.	CHP-share in power generation	
19.	Fuel input to CHP plants (natural gas, solid fossil fuels, oil and oil products, renewables, other fuels), %	
20.	Fuel input into CHP, PJ	
SECTION III: PROMOTION OF COGENERATION		
21.	Existence of national target (in relative or absolute terms) with respect to CHP in your country (Yes/No)	
22.	Specification of the target	
23.	Current status (share) of CHP energy/electricity in your country	
24.	Types of CHP support schemes existing in your country[v]	
25.	When choosing 'guarantees of origin' (GO) in the previous question, please specify status of national legislation for implementing CHP GO (passed, proposed, none)	
26.	Status of national legislation for determining the high efficiency CHP production of CHP (passed, proposed,	

	none)	
27.	Status of national legislation for implementing CHP support schemes (passed, proposed, none)	
28.	Kind of CHP support system (mandatory, voluntary, none)	
29.	When choosing 'mandatory' in the previous question, please specify existence of sanction system when somebody does not comply with the obligation concerning mandatory CHP support system (Yes/No)	
30.	When choosing 'Yes' in the previous question, please specify institutions responsible in the country for imposing the sanctions	
31.	Entities participating in the CHP major support system (the state, energy enterprises, other)[vi]	
32.	Existence of separate support scheme for heat from CHP (Yes/No)	
33.	Existence of licensing system for all CHP units in your country (Yes/No)	
34.	Existence of tracking system for CHP energy which take care of support or target uses (Yes/No)	
35.	Institutions responsible for collecting data for the CHP energy tracking system	
SECTION IV: TECHNICAL DETAILS ON THE INSTALLED COGENERATION TECHNOLOGY[vii]		
36.	Prime mover[viii]	
37.	Fuel type[ix]	
38.	Installed electrical capacity, kWe[x]	
39.	Installed thermal capacity, kWt[xi]	
40.	Annual operating hours[xii]	
41.	Fuel input, e.g. tonnes, litres[xiii]	
42.	Fuel input, MWh[xiv]	

43.	Total electricity generated, MWh[xv]	
44.	Total heat generated, MWh[xvi]	
45.	Heat usefully employed, MWhr[xvii]	
46.	Grid connection to export[xviii]	
47.	Electricity exported to the grid, MWh[xix]	
48.	Power to heat ratio[xx]	
49.	Displaced thermal efficiency, %	
50.	CHP fuel cost, $/MMBtu	
51.	Purpose of electricity and heat generation (sale or own use)	
SECTION V: QUESTIONS ON COGENERATION EQUIPMENT INVESTMENTS		
52.	Investment cost, $/kW$_{el}$	
53.	Depreciation period	
54.	Fixed operation & maintenance cost, $/kW$_{el}$	
55.	Variable operation & maintenance cost, $/MWh	
56.	Have you been able to estimate your approximate actual or expected net dollar savings per year from cogeneration (Yes/No) or your rate of return on cogeneration investments (Yes/No)? If so, approximately what do these annual savings amount to (USD) and what is your annual rate of return on the cogeneration investment (USD)? Is this savings estimate on pre-tax basis (Yes/No) or on an after-tax basis (Yes, No)?	
57.	Please circle the letters corresponding to any of the factors listed below which, in your opinion, would be significant in making cogeneration a more attractive investment in APEC Member Economies: A). Ability to automatically sell cogenerated electricity to utilities at prices equal to the utilities' 'avoided costs' for electricity;	

	B). Increased fuel and electricity prices in past years; C). Improved efficiency, reliability and quality of cogeneration equipment; D). Favorable price trends for cogeneration equipment; E). Concerns about future cost and availability of fuel and electricity; F). Other (please specify).	
58.	Please circle the letters corresponding to any of the factors listed below which, in your opinion, significantly hinder the utilization of cogeneration equipment: A). Costs of power grid interconnections needed to transmit cogenerated electricity to utilities; B). Lack of favorable national tax policies for cogeneration equipment; C). Excessive costs of cogeneration equipment and/or difficulty in obtaining financing for equipment purchases; D). Lack of familiarity with cogeneration technologies; E). Other (please specify).	
59.	Economically realizable CHP potential in your country	

Return Completed Application to:

Email your completed ***questionnaire*** to **Ms. Nelly Segizova,**

Head of Strategic Cooperation Department of the Russian Energy Agency

E-Mail: Segizova@rosenergo.gov.ru

Cc: **Mr. Dmitry Lifatov,**

Specialist of the Strategic Cooperation Department of the Russian Energy Agency

E-Mail: Lifatov@rosenergo.gov.ru

Dr. Svetlana Beznasyuk,

Chief specialist of International Cooperation Department

of the Ministry of Energy of the Russian

Federation

E-Mail: BeznasyukSA@minenergo.gov.ru

Information Prepared and Submitted by[xxi]:

Date:

Here given sample answers from experts on the questionnaire:

1. Canada

Survey on the 'Combined Heat and Power (CHP) Technologies for Distributed Energy Systems'

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Section I: General Questions;

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Section IV: Technical Details on the Installed Cogeneration Technology;

Section V: Questions on Cogeneration Equipment Investments.

Where it is possible, please provide historical data for the specific indicator. Also, please try to provide the most recent data available in your country, and ***indicate the year*** and source of the ***data*** used to answer question. ***If*** the figures make the table ***too large***, include them as a ***separate file***.

Questionnaire

SECTION I: GENERAL QUESTIONS		
1.	Number of cogeneration plants in your country	There are 32 plants that use wood refuse as fuel (870 MW) and 16 plants that use spent pulping liquor (685 MW). These plants function as cogeneration, producing power and heat.
2.	Number of CHP units in your country[xxii]	
3.	Location of cogeneration plants in your country[xxiii]	19 in British Columbia, 5 in Alberta, 7 in Ontario, 9 in Quebec, 3 in New Brunswick, 4 in Nova Scotia and 1 in Prince Edward Island.
4.	Number of employees in the CHP industry	
5.	Installation date of each cogeneration plant[xxiv]	
6.	Service life of each cogeneration plant	
7.	CO_2 emissions savings achieved by CHP units[xxv]	

8.	Power price, \$/MWh	http://www.hydroquebec.com/publications/fr/comparaison_prix/pdf/comp_2011_fr.pdf
9.	Natural gas price, \$/m3	
10.	CO_2 certificate price, \$/t CO_2	
11.	Sites with high potential for cogeneration (good prospects, with good data; potential prospect, but data are inadequate for assessment; already have cogeneration, and prospects for additional economical cogeneration is unlikely; poor prospects)	
12.	Age of existing thermal facilities	
SECTION II: CHP POLICIES		
13.	Expected market development of cogeneration technologies	
14.	Installed CHP capacity	
15.	Operational CHP capacity	
16.	CHP power generation	
17.	CHP heat production	
18.	CHP-share in power generation	
19.	Fuel input to CHP plants (natural gas, solid fossil fuels, oil and oil products, renewables, other fuels), %	
20.	Fuel input into CHP, PJ	
SECTION III: PROMOTION OF COGENERATION		
21.	Existence of national target (in relative or absolute terms) with respect to CHP in your country (Yes/No)	No
22.	Specification of the target	N/A
23.	Current status (share) of CHP energy/electricity in your country	
24.	Types of CHP support schemes existing in your country[xxvi]	
25.	When choosing 'guarantees of origin' (GO) in the previous question, please specify status of national legislation for implementing CHP GO (passed, proposed, none)	
26.	Status of national legislation for determining the high efficiency CHP production of CHP (passed, proposed,	

	none)	
27.	Status of national legislation for implementing CHP support schemes (passed, proposed, none)	
28.	Kind of CHP support system (mandatory, voluntary, none)	
29.	When choosing ‘mandatory’ in the previous question, please specify existence of sanction system when somebody does not comply with the obligation concerning mandatory CHP support system (Yes/No)	
30.	When choosing ‘Yes’ in the previous question, please specify institutions responsible in the country for imposing the sanctions	
31.	Entities participating in the CHP major support system (the state, energy enterprises, other)[xxvii]	
32.	Existence of separate support scheme for heat from CHP (Yes/No)	
33.	Existence of licensing system for all CHP units in your country (Yes/No)	
34.	Existence of tracking system for CHP energy which take care of support or target uses (Yes/No)	
35.	Institutions responsible for collecting data for the CHP energy tracking system	
SECTION IV: TECHNICAL DETAILS ON THE INSTALLED COGENERATION TECHNOLOGY[xxviii]		
36.	Prime mover[xxix]	
37.	Fuel type[xxx]	
38.	Installed electrical capacity, kWe[xxxi]	
39.	Installed thermal capacity, kWt[xxxii]	
40.	Annual operating hours[xxxiii]	
41.	Fuel input, e.g. tonnes, litres[xxxiv]	
42.	Fuel input, MWh[xxxv]	
43.	Total electricity generated, MWh[xxxvi]	
44.	Total heat generated, MWh[xxxvii]	
45.	Heat usefully employed, MWhr[xxxviii]	
46.	Grid connection to export[xxxix]	

47.	Electricity exported to the grid, MWh[xl]	
48.	Power to heat ratio[xli]	
49.	Displaced thermal efficiency, %	
50.	CHP fuel cost, $/MMBtu	
51.	Purpose of electricity and heat generation (sale or own use)	
SECTION V: QUESTIONS ON COGENERATION EQUIPMENT INVESTMENTS		
52.	Investment cost, $/kW$_{el}$	
53.	Depreciation period	
54.	Fixed operation & maintenance cost, $/kW$_{el}$	
55.	Variable operation & maintenance cost, $/MWh	
56.	Have you been able to estimate your approximate actual or expected net dollar savings per year from cogeneration (Yes/No) or your rate of return on cogeneration investments (Yes/No)? If so, approximately what do these annual savings amount to (USD) and what is your annual rate of return on the cogeneration investment (USD)? Is this savings estimate on pre-tax basis (Yes/No) or on an after-tax basis (Yes, No)?	
57.	Please circle the letters corresponding to any of the factors listed below which, in your opinion, would be significant in making cogeneration a more attractive investment in APEC Member Economies: A). Ability to automatically sell cogenerated electricity to utilities at prices equal to the utilities' 'avoided costs' for electricity; B). Increased fuel and electricity prices in past years; C). Improved efficiency, reliability and quality of cogeneration equipment; D). Favorable price trends for cogeneration equipment; E). Concerns about future cost and availability of fuel and electricity; F). Other (please specify).	
58.	Please circle the letters corresponding to any of the factors listed below which, in your opinion, significantly hinder the utilization of cogeneration equipment:	

	A). Costs of power grid interconnections needed to transmit cogenerated electricity to utilities; B). Lack of favorable national tax policies for cogeneration equipment; C). Excessive costs of cogeneration equipment and/or difficulty in obtaining financing for equipment purchases; D). Lack of familiarity with cogeneration technologies; E). Other (please specify).	
59.	Economically realizable CHP potential in your country	

Information Prepared and Submitted by[xlii]: Michael Paunescu, Senior Economist, Renewable Energy, Natural Resources Canada, telephone: +1-613-996-8649, e-mail: Michael.Paunescu@NRCan-RNCan.gc.ca

Date: August 28, 2012

2. China

Notes:

This quality assessment form (QAF) is to be used prior to submission as a way of improving the proposal. Assessors are requested to provide comments against each question. These can praise, suggest changes, or highlight areas of concern. Through constructive comments from stakeholders and members, improvements to the proposals can be made prior to the formal quality assessment undertaken by the Secretariat.

Assessors should not be from the proposing economy. Co-sponsoring economies may undertake the QAF.

The QAF must be submitted along with the project proposal. Project Proponents are to incorporate all QAF comments into a single consolidated document before uploading it onto the PDB.

Please refer any questions you have to your Program Director.

Proposal name: Combined Heat and Power (CHP) technologies for distributed energy systems

Assessor one details (A1): Wei Wang, Manager, Beijing Jingneng Clean Energy Corporation Limited, China

Assessor one details (A2): Jeff Skeer, U.S. Department of Energy

Question	Comments (text, not scores)
Is all project identification data provided?	Yes
Relevance: assessing the connection to APEC's policy agenda, priority themes and goals	

Question	Comments (text, not scores)
Please tick: √ **Satisfactory**	**Unsatisfactory**
Can links to APEC priorities and key APEC themes be identified more clearly?	A: The links are clearly identified. B: Good that "alignment" section includes text from recent Energy Ministers Meetings referring to the importance of energy efficiency. Leaders' goal to reduce energy intensity by 45 percent by 2035 should also be referenced. Cogeneration (combined heat and power – perhaps combined cooling and power too) should be mentioned in the relevance section as key to achieving this objective in rapidly urbanizing APEC economies – since they can double overall efficiency of heat and power production in densely populated areas to which they are suited. Done, see paragraphs 1, 3
Can the definition of the problem (causes and constraints), and explanation of the options that are available to address it, be improved?	A: Yes. The problem is defined well. B: Could note that the key constraint is having sufficient urban density to make CHP cost-effective – but that the constraint is less and less binding as APEC economies urbanize. Another key constraint to note is the substantial upfront capital investment requirements – which require that the city government or private investor or public-private partnership have substantial financial resources to allow for the multi-year payback period for resulting savings. Noted, addition made in paragraph 2
Will this have the active participation of a large number of APEC members? How could more members be engaged?	A: Yes, a large number of APEC members will participate in this project. B: The CHP technology being studied is presumably of interest in almost every APEC economy, and several APEC economies are mentioned (they should be called economies in the text). But it would be helpful to state clearly which economies are to be included in the study scope. It appears that only cold climates are to be covered – which seems an unfortunate limitation – unless the island settings to be covered would also be in warm climates. Are we mainly talking about Sakhalin Island here? A broader scope would be preferable to interest as many economies as possible, but we should at least be clear which ones will be covered. Done, see paragraphs 2, 8, "countries" changed to "economies" throughout the proposal
Effectiveness: assessing how well the project can achieve its objectives *Please tick*: √ **Satisfactory**	**Unsatisfactory**
How can the objectives be more clear, achievable or measurable?	A: The goals of the project can be achieved. B: The project aims to focus on best practices. Can we get more specific? Best practices with respect to choice of up-to-date technology? Best practices with respect to financing? Best practices with respect to promotion to get the public and financial institutions interested? Done, see paragraph 2
Based on the problem articulated, is	A: Yes, this is the most appropriate method to address the issue.

Question	Comments (text, not scores)
this a sound way to address the problem? Could alternative approaches be considered?	B: CHP is a sound approach since it is highly efficient, and it is highly worthwhile to look at best practices for accelerating the implementation of CHP technologies in APEC economies.
Has APEC's value add been clearly articulated, particularly why it is a important project for APEC to be carrying out?	A: APEC's value has been clearly articulated. B: Could note that some APEC economies – as well as the non-APEC European economies to be studies – have significant experience and best practices to impart to those economies with less experience that could still benefit from the substantial potential efficiency gains.
Has this project integrated lessons learned from previous projects?	A: Yes B: Yes, in the sense of recognizing the importance of spreading best practices through APEC. Also the project will build upon work outside APEC such as in IEA and COGEN Europe.
Efficiency: assessing the design process and implementation management *Please tick*: √ **Satisfactory** □ **Unsatisfactory**	
Has the proposal shown how the planned outputs (goods and services) will contribute to the desired change? Could there be ways to improve their quality / utility?	A: Yes. Proposal outputs can't be improved. B: Approach of conducting a study with follow-up seminar and expert feedback seems a good way to ensure quality and broad applicability.
Should any further project risks be identified? How could they be managed?	A: No. B: Risks and mitigation strategies are well identified.
Can arrangements for assessing the project's results be improved?	A: No. B: Project should seek advice from Expert Group on Energy Efficiency and Conservation. Several EGEEC members could offer useful inputs to and assessments of the draft report. Noted, see paragraph 7
Is the budget reasonable for the project's objectives and outputs? Is there evidence of value for money?	A: The budget seems reasonable. B: Budget seems to be in a reasonable range for study plus workshop. APEC funds are leveraged well with funds from other sources.
Impact: assessing expected results for APEC and stakeholders *Please tick*: √ **Satisfactory** □ **Unsatisfactory**	
Can the intended changes from this project, particularly the difference it will make to direct beneficiaries, be more clearly expressed?	A: The beneficiaries have been clearly identified. B: Item 11 on "beneficiaries" might reiterate the potential benefits of doubling energy efficiency and halving carbon emissions from heating and cooling buildings in the economies studied. The long-run cost savings to home-owners and other buildings owners (offices, schools, hospitals) might also be noted. What is the typical payback period for CHP systems? (How many years does it take for the resulting efficiencies to pay back the extra capital investment? Presumably, the payback period is much shorter than

Question	Comments (text, not scores)
	the life of the investment since the systems may typically last for decades – in which case there are major cost savings to users.) Done, see paragraph 11. Comment regarding the typical payback period is noted.
Are there other beneficiaries and stakeholders that could benefit from this project that should be engaged in its development?	A: No. B: Involving research institutes as mentioned is a good idea. Perhaps others can be identified. Would some major European institute be interested in commenting on the draft report? Noted
How could the proposal better ensure that both women and men are appropriately involved in the planning and implementation of this project?	A: Both women and men are engaged in developing and implementing the proposal. Proposal has universal benefit. B: Should note benefits for men and women alike include not only improving the environment but also reducing energy costs and thereby making more resources available to families for health care, education, and other activities. Done, see paragraph 12
Could there be better ways to communicate and promote the project's outputs and results, particularly to external parties? Are there other quality assurance measures that should be taken over the products prior to distribution?	A: The communication scheme planned will insure that the project results are widely distributed. B:-
Sustainability: assessing if benefits and lessons learned are likely to continue after the project *Please tick*: √ **Satisfactory** □ **Unsatisfactory**	
Are the project's long term intended impacts explained well, particularly in connection to the fora's objectives and future work plan?	A: Yes. B: Should note that by spreading best practices for CHP systems and expanding understanding of their benefits in terms of reducing energy costs and greenhouse gas emissions, the project will encourage the development of such systems, which will continue to provide energy savings and greenhouse gas reductions on a sustainable basis for many decades once installed. Done, see paragraph 14
Could additional mechanisms in put in place to support the changes bought about by the project?	A: No. B: Information and financing programs could help to put more CHP systems in place faster. Presumably these will be among the strategies described and highlighted in the study. Noted
Can the project do more to get commitment for the project's success from external APEC stakeholders?	A: No. B: Be sure to involve IEA and others at all stages of project planning and review. Noted
Are there any further suggestions about how the lessons learned from	A: Yes. The project proposal is of high quality and builds on past APEC work in the important area of efficient lighting which

Question	Comments (text, not scores)
this project can be disseminated within APEC, particularly in relation to whether the project can be replicated or expanded in the future?	benefits all APEC economies. B: Strongly suggest that the report have a crisp and informative executive summary – which members of the EWG and its Expert Group on Energy Efficiency and Conservation may readily have translated into the various languages used in APEC economies. Done, see addition in paragraph 13
Overall comment on proposal quality: **Overall *quality* assessment:** *Please tick*: √ **Satisfactory** □ **Unsatisfactory**	

ANNEX 3. Workshop agenda

November 15-16, 2012

AZIMUT Hotel, Vladivostok, Russian Federation

The 2012 APEC Workshop on Combined Heat and Power (CHP) Technologies for Distributed Energy Systems will focus on the CHP systems as a highly efficient method of generating electricity and heat that has the potential to provide significant savings to local businesses. The objective of the conference is to promote constructive dialogue between relevant stakeholders from APEC Member Economies to explore the ways in which cogeneration could further contribute to the increased real cost savings and the overall competitiveness of local firms and to the reduced negative impact on the environment in the long-term. More specifically, the conference aims at bringing together leading experts, representatives of private companies, government agencies, local government officials to discuss the current progress with CHP deployment in the APEC region and to brainstorm creative and innovative ideas on a number of topics regarding the use of CHP systems. The workshop will span two days and will be organized into two plenary sessions each containing brief presentations with thought-provoking talks and case-studies. An open discussion seeking to tackle both challenges and opportunities of the CHP deployment in the APEC region will follow after the plenary sessions. After the conference the findings of the workshop will be integrated into the final report of the project which will be distributed among relevant regional and international agencies and organizations. The feedback for future thought will be presented from both the plenary sessions and roundtable discussions, and will be used to continue research on CHP in the form of the interactive forum after the conference.

THURSDAY, NOVEMBER 15, 2012	
9:00 am – 09:30 am	Registration
09:30 am – 10:00 am	Welcome Coffee
10:00 am – 10:30 am	Welcome and Introductory Remarks
	Opening Keynote Address Vasily Nagibin Head of Department Office of the Presidential Plenipotentiary Envoy to the Far Eastern Federal District of the Russia Opening Keynote Address Elena Parhormenko Deputy Director of Housing and fuel resources of Primorsky region, Russia Keynote Address Alexey Bondar Director of Russian Far East Branch Russian Energy Agency

	Brief introductory remarks, overview of the APEC Project and the Conference Nelly Segisova Academic Advisor of the Conference
10:30 am - 01:50 pm	Plenary Session 1.
	Moderator Nelly Segisova Academic Advisor of the Conference Efficiency improvement of CHP equipment on the basis of R&D undertaken by the National Research University Moscow Power Engineering Institute (~ 30 min) Vladimir Gribin Head of Department Institute for Mechanical Engineering and Mechanics, Russia CHP Markets & Policies in Japan (~ 20 min) Takahiro Nagata New and Renewable Energy Group The Institute of Energy Economics, Japan Financing CHP (~ 20 min) Zenko Shinoyama Deputy Director General, Power and Water Finance Department, Infrastructure Finance Group Japan Bank for International Cooperation, Japan Electricity Market in Chile (~ 10 min) José Carrasco Benavides Electricity Department The National Energy Commission, Chile
12:00 pm – 12:30 pm	Coffee Break
	EBRD - Financing and Investment in Russian Power Industry (~ 15 min) Alexander Filkine Head of Regional Office EBRD, Far Eastern Federal District, Russia Alternative source of funding for infrastructure projects (~ 15 min) Maxim Krilevevich Economic Research Institute FEB RAS Tavrida Electric - manufacturer and supplier of electrical equipment for

	cogeneration facilities (~ 15 min) Andrey Korobkov Deputy Director General Tavrida Electric, Russia Kawasaki Heavy Industries (~ 20 min) Masahiro Kita Deputy General Manager Kawasaki Heavy Industries, Ltd., Member Company of JASE-W, Japan Distributed power systems: microturbine-based cogeneration and trigeneration (~ 15 min) Alexander Skorokhodov Director General BPC Engineering, Russia
01:50 pm - 03:20 pm	Lunch After lunch, time may be reserved (~30 min) for a informal dialogue
03:20 pm - 03:50 pm	Photo session
03:50 am – 6:00 pm	Open Discussion
	Discussion points What are the most promising CHP technologies for near term applications? What response characteristics are desired for different CHP systems (reliability, cost, size, etc.)? How does CHP improve power reliability? What are the advantages and limitations of currently used CHP technologies? Where is CHP most useful? What is the shape and size of the market for cogeneration in APEC Member Economies? How does CHP affect the APEC Member Economies? How can a CHP system be financed? What is necessary to achieve a successful CHP project? What is the typical financial payback for cogeneration projects? What are the most significant factors that contribute to the decision of a private or a public developer to invest in cogeneration?
	Discussion points (continued) Should future CHP projects receive special consideration, incentives or other added value? What barriers need to be addressed to overcome difficulties in CHP sector development in APEC region? What additional measures can be taken that would be most useful for

	cogeneration in APEC region? How can high-level APEC policy-makers support the development of an active market for cogeneration? Are there utility considerations that affect the economics of CHP?
06:00 pm - 07:00 pm	Wrap-up of Day 1
07:00 pm - 10:30 pm	Hospitality event (formal dinner)
FRIDAY, NOVEMBER 16, 2012	
9:00 am – 09:30 am	Registration
09:30 am – 11:30 pm	Meeting of the Working Group on Energy Efficiency (list №1) / Sightseeing tour to Vladivostok (list №2)
11:30 pm – 12:00 pm	Welcome Coffee
12:00 pm – 02:00 pm	Plenary Session 2.
	Moderator Nelly Segisova Academic Advisor of the Conference Government Policy and Action for CHP in the Russia's Primorye Territory (~ 25 min) Alexey Bondar Director of Russian Far East Branch Russian Energy Agency Advantages & Benefits of Micro-CHP for Local Energy Systems (~ 20 min) Andrey Udod Ministry of Housing & Communal Services of Khabarovsk region, Russia Condition and prospects of energy Far Eastern Federal District, Russia (~ 30 min) Dr. Anatoly Shtym Head of the Department "Thermal Power and Thermal Engineering" Far Eastern Federal University Establishment of energy-saving and energy efficiency information systems in the Russian Far East Regions as an energy management tool in the public sector (~ 15 min) Victor Dyomkin Director of Khabarovsk Scientific and Technical Information Center, Russia CHP plant on the island of RUSSIAN (~ 15 min)

	Anton Poley Undergraduate department chair "Thermal Power and Thermal Engineering" Far Eastern Federal University Integrated energy solutions in the field of CHP of «Eridan» (~ 15 min) Denis Logvinenko Director of Department of Power Plants Subdivision of "Eridan", Russia
02:00 pm – 03:00 pm	Lunch
03:00 pm – 04:30 pm	Teleconference and Open Discussion
	Discussion Points Is there any competition between CHP and other forms of renewable energy generation? Could CHP partially replace some of the big coal-fired power plants that provide baseload power? How could the APEC region benefit if CHP was scaled up? How can cogeneration be improved? What barriers need to be addressed? What are the market trends in cogeneration and what are the implications of energy market changes for future of cogeneration in APEC region? What would make cogeneration easier to consider as an option? What are the collaboration opportunities among APEC Member Economies?
04:30 pm – 05:30 pm	Summary of Conference Outcomes and Adjourn
05:30 pm – 06:30 pm	Dinner

ANNEX 4. LIST OF PARTICIPANTS

#	Name	Position
1	Ms. Ab. Manan Asmayati	Head of Industry Development Unit, Energy Commission of Malaysia, Energy Management and Industry Development
2	Mr. Iwao Ohashi	Chif Representative, Nomura Research Institute
3	Mr. Jose Carrasco	Advisor, National Energy Commission, Electrical Departament
4	Mr. Masafumi Asano	Staff, Plant Project Department, Sojitz Corporation
5	Mr. Masahiro Kita	Deputy General manager, International sales Department, Kawasaki Heavy Industries, Ltd.
6	Mr. Shinoyama Дзэнко Синояма (Zenko Shinoyama)	Deputy general director, Department funding energy and water, Group finance infrastructure, JBIC
7	Mr.Takahiro Nagata	Senior Coordinator, New and Renewable Energy Group, THE INSTITUTE OF ENERGY ECONOMICS
8	Mr. Toshihisa DOI	Head of Departament, Kawasaki Heavy Industries, Ltd.
9	Mr. Akexander Filkene	Regional Chapter of the EBRD in the DFO
10	Mr. Vasiliy Barannikov	Head of the Representation Office of the Governor and the Government of Chukotka, Representation in Khabarovsk
11	Mr. Akexey Bondar	Primorsky Branch Director of REA
12	Mr Viktor Vazhenin	Chief Manager MES Vostok
13	Mr. Valeriy Glazachev	Deputy Chairman of the Government of the Khabarovsk Territory Development Committee TEK
14	Mr. Vladimir Gribin	Head of the Chair, Institute of power engineering and mechanics
15	Mr. Viktor Demkin	Director of Khabarovsk scientific and technical information center
16	Mr. Vasiliy Denisov	Head of the Department of Information and analysis of energy efficiency, Official body of the Republic of Sakha (Yakutia) "Regional Agency of energy saving and overhaul of apartment buildings"
17	Mr. Sergey Irtov	Director of Production, JSC "RAO Energy System of East"
18	Mr. Denis Kan	Deputy minister, Ministry of Energy and Utilities Sakhalin
19	Mr. Akexey Kozhevnikov	Deputy director, FGU "Russian Energy Agency"
20	Mr. Andrey Korobrov	Deputy director, Russian group of companies Tavrida Electric
21	Dr. Maxim Krivelevich	Economic Research Institute, Russian Academy of Sciences

#	Name	Position
22	Mr. Denis Kuzenko	Deputy Department head, Primorsky Krai Administration. Office of Energy, oil and gas and coal industries of Primorsky Krai. Department for energy conservation and energy efficiency
23	Mr. Alexey Lipatnikov	Director Ltd. "DALREGIONGAS"
24	Mr. Nikolay Lovyigin	Department head, Primorsky Krai Administration. Office of Energy, oil and gas and coal industries of Primorsky Krai. Department for energy conservation and energy efficiency
25	Mr. Denis Logvinenko	Director of the department of power plants, CJSC "Eridan" Department: Power Units
26	Mr. Igor Margun	Deputy Director, GC "Energotestkontrol"
27	Mr. Viktor Milush	Director, JSC "Far Eastern Energy Company"
28	Mr. Vasiliy Nagibin	Deputy Director, Office of the Plenipotentiary of the President Russian Federation in the Far Eastern Federal District
29	Mr. Viktor Odorodko	Deputy Minister, Ministry of Economic Development of the Amur region
30	Mr. Sergey Ohotnikov	Department head, Administration of city district Spassk-Dalniy
31	Mr. Vladislav Pak	Deputy Director, JSC "Sakhaenergo"
32	Mr. Alexey Pahomov	Director, Official body of the Republic of Sakha (Yakutia) "Regional Agency of energy saving and overhaul of apartment buildings"
33	Mr. Anton Poley	Magistrant, Far Eastern Federal University
34	Ms. Alena Potapenko	Manager, Office of the Plenipotentiary of the President Russian Federation in the Far Eastern Federal District
35	Mr. Nikolay Pyirlik	Technical director, JSC "Far Eastern Energy Management Company"
36	Mr. Konstantin Rahmatullin	Department head, Primorsky Krai Administration Office of Energy, oil and gas and coal industries Primorye
37	Mr. Roman Rudkovskiy	Chief of the Investment Planning, JSC "Far Eastern Energy Management Company"
38	Mr. Vitaliy Skiba	Deputy Director, Far Eastern Department of the Federal Service for Environmental, Technological and Nuclear Supervision
39	Mr. Akexander Skorohodov	Director, BPC Engineering
40	Mr. Alexander Soloshenko	Deputy Director of Housing and Energy of the Government of the Jewish Autonomous Region

#	Name	Position
41	Mrs. Galina Titova	Advisor, Ministry for the development of the Far East
42	Mr. Vladimir Tichonovich	Deputy Director, Ministry of Housing and Energy Kamchatka
43	Mr. Viktor Tryakin	Deputy Director, Primorskiy Branch of the Federal Antimonopoly Service of Russia
44	Mr. Andrey Udod	Director, KGUP RegionSnab
45	Mr. Michael Fedorov	Department head, State unitary enterprise "Housing and Communal Services of the Republic of Sakha (Yakutia)"
46	Ms. Chan Han Thi Bik	Chief representative Hanoi Foreign Affairs Service Center
47	Mr. Anatoliy Styim	Head of the Chair, Far Eastern Federal University
Organizing Committee		
1	Mrs. Julia Dacko	Head of Organizing Committee
2	Mr. Michael Shetinin	Coordinator, Organizing Committee
3	Mr. Valeriy Ozik	Manager, Organizing Committee

ANNEX 5. Pictures


APEC
Asia-Pacific
Economic Cooperation
APEC Workshop
15-16
November
Vladivostok


APEC
Asia-Pacific
Economic Cooperation
APEC Workshop
Combined heat and power
(CHP) technologies for
distributed energy systems


APEC
Asia-Pacific
Economic Cooperation
APEC Workshop
Combined heat and power
(CHP) technologies for
distributed energy systems


APEC Workshop


APEC Workshop


JBIC
Financing CHP


Asia-Pacific
Economic Cooperation
Combined heat and power
(CHP) technologies for
distributed energy systems

[i] Note that units are distinct from CHP plants and that there may be more than one CHP unit at a site.

[ii] If it is possible, please provide geographic coordinates (i.e. latitude and longitude) of each CHP plant installed in your country.

[iii] Provide the data when the CHP unit came online.

[iv] Please provide the following data: CO_2 emissions (t CO_2/y), savings by comparison to average specific CO_2 emissions rates of electricity generation, savings by comparison to specific CO_2 emissions rates of coal thermal power plants.

[v] For example, grants (investment subsidies), preferential credits, feed-in tariff, price of CHP energy fixed by government or regulatory body, feed-in premiums, obligations and targets (e.g. obligation of purchase all CHP energy produced in the country), guarantees of origin, other tradable certificates, other (please specify when choosing other).

[vi] When choosing energy enterprises please specify what types of enterprises are eligible to participate in support systems (e.g. electricity producers, electricity traders, generators defined in the legislation, CHP plants and so on). Please specify when choosing other (e.g. any economic entity).

[vii] Please provide the data for each cogeneration plant installed in the country. The survey can be completed by***cogeneration*** facility operators across your country with significant operational capacity (determined individually).

[viii] Choose one from the following: combined cycle, steam (backpressure turbine), steam (condensing turbine), gas turbine with heat recovery, internal combustion engine, other. Please specify when choosing other.

[ix] Choose one from the following: coal, peat, residual fuel oil, gasoil, natural gas, refinery gas, biogas, biomass, other. Please specify when choosing other.

[x] The rated electrical capacity of the CHP unit.

[xi] The rated thermal capacity of the CHP unit.

[xii] The total amount of hours the unit was in operation during the year.

[xiii] This is the total amount of fuel used by the CHP unit in the year, excluding fuel used for supplementary firing (i.e. firing to meet heat demand not met by CHP output).

[xiv] Same as the previous one but converted to MWh.

[xv] Total amount of electricity generated by the CHP unit in the year.

[xvi] Total amount of heat generated by the CHP unit in the year. Do not include heat generated from other sources.

[xvii] Useful heat is the total amount of CHP heat that was used during the year as distinct from the total heat produced.

[xviii] Is the unit connected to the national grid to export electricity (Yes/No)?

[xix] Total amount of electricity sold on to the national grid in the year.

[xx] Power to heat ratio is the ratio between electricity from CHP and useful heat when operating in full CHP mode.

[xxi] ***Please provide*** details of the person responsible for completing this questionnaire(the ***name, title, address***, telephone number, fax number and e-mail ***address)***.

[xxii] Note that units are distinct from CHP plants and that there may be more than one CHP unit at a site.

[xxiii] If it is possible, please provide geographic coordinates (i.e. latitude and longitude) of each CHP plant installed in your country.

[xxiv] Provide the data when the CHP unit came online.

[xxv] Please provide the following data: CO_2 emissions (t CO_2/y), savings by comparison to average specific CO_2 emissions rates of electricity generation, savings by comparison to specific CO_2 emissions rates of coal thermal power plants.

[xxvi] For example, grants (investment subsidies), preferential credits, feed-in tariff, price of CHP energy fixed by government or regulatory body, feed-in premiums, obligations and targets (e.g. obligation of purchase all CHP energy produced in the country), guarantees of origin, other tradable certificates, other (please specify when choosing other).

[xxvii] When choosing energy enterprises please specify what types of enterprises are eligible to participate in support systems (e.g. electricity producers, electricity traders, generators defined in the legislation, CHP plants and so on). Please specify when choosing other (e.g. any economic entity).

[xxviii] Please provide the data for each cogeneration plant installed in the country. The survey can be completed by***cogeneration*** facility operators across your country with significant operational capacity (determined individually).

[xxix] Choose one from the following: combined cycle, steam (backpressure turbine), steam (condensing turbine), gas turbine with heat recovery, internal combustion engine, other. Please specify when choosing other.

[xxx] Choose one from the following: coal, peat, residual fuel oil, gasoil, natural gas, refinery gas, biogas, biomass, other. Please specify when choosing other.

[xxxi] The rated electrical capacity of the CHP unit.

[xxxii] The rated thermal capacity of the CHP unit.

[xxxiii] The total amount of hours the unit was in operation during the year.

[xxxiv] This is the total amount of fuel used by the CHP unit in the year, excluding fuel used for supplementary firing (i.e. firing to meet heat demand not met by CHP output).

[xxxv] Same as the previous one but converted to MWh.

[xxxvi] Total amount of electricity generated by the CHP unit in the year.

[xxxvii] Total amount of heat generated by the CHP unit in the year. Do not include heat generated from other sources.

[xxxviii] Useful heat is the total amount of CHP heat that was used during the year as distinct from the total heat produced.

[xxxix] Is the unit connected to the national grid to export electricity (Yes/No)?

[xl] Total amount of electricity sold on to the national grid in the year.

[xli] Power to heat ratio is the ratio between electricity from CHP and useful heat when operating in full CHP mode.

[xlii] ***Please provide*** details of the person responsible for completing this questionnaire(the ***name, title, address***, telephone number, fax number and e-mail ***address)***.