Gaps Assessment on APEC Energy Efficiency and Conservation Work toward Fulfilling the Leaders' Energy Intensity Reduction Goal

APEC Energy Working Group

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1 Executive Summary

This report '*Gap Assessment on APEC Energy Efficiency and Conservation Work Towards Fulfilling the Leader's Energy Intensity Reduction Goal'* was funded by the Asia Pacific Economic Cooperation (APEC) Support Fund on Energy Efficiency through the Energy Working Group (EWG). It presents an assessment of gaps in energy efficiency and conservation work by the Energy Working Group, particularly the Expert Group on Energy Efficiency and Conservation (EGEE&C), to ensure continued progress toward the Leaders' energy intensity reduction goal. The report's outcomes are designed to help the EWG and EGEE&C develop project priorities in areas most relevant to the needs facing the APEC region, and ultimately provide guidance to APEC economies on beneficial energy efficiency efforts.

APEC Leaders identify the promotion of energy efficiency as a priority action in addressing energy security and reducing greenhouse gas emissions. At the 19th APEC Economic Leaders' Meeting in Honolulu, United States in 2011, leaders declared their aspiration to reduce energy intensity by 45 percent by 2035. This announcement complemented the work begun in 2010 with the launch of the Energy Smart Communities Initiative (ESCI), a framework for promoting energy smart communities by enhancing the understanding and practice of energy efficiency in all aspects of community development. The EWG has implemented energy efficiency and conservation projects through ESCI under its pillars of Smart Transport, Smart Buildings, Smart Grids, Smart Jobs, and Industry, together with its cross-cutting activity on Low Carbon Model Towns. Case studies, best practices and key innovations are shared on the ESCI Knowledge Sharing Platform (ESCI-KSP), which was launched in May 2011, at the 41st Meeting of the Energy Working Group in Canada.

The 2016 Leaders' Declaration reinforced the priorities for green growth. In the declaration, leaders stressed that they remain committed to implementing the United Nations 2030 Agenda for Sustainable Development along with the near-term APEC Strategy for Strengthening Quality Growth by 2020. This declaration stressed the core value that all "APEC objectives and goals must remain focused on improving the lives of our people." [1]

1.1 Gap Assessment Phases

To assessment gaps in the energy efficiency and conversation project portfolio, this research was conducted in three phases: 1) energy efficiency project data gathering and project assessment 2) sector and economy situational analysis and 3) strategic pathway and tactical gap identification. The first phase of the assessment was a critical review of the energy efficiency projects sponsored between 1993 and 2016 by the EWG and its sub-fora, as well as relevant energy efficiency work sponsored by other fora, such as the Transportation Working Group. The review of APEC sponsored projects built upon an analysis conducted by Energy Futures Australia, itself sponsored by EWG, which reviewed the projects from 1980 to 1997. Australia conducted a review of all EWG projects from 1993 to 2007 in a three-stage self-funded project. The third part of the analysis was not available for this review, but the first two reports gave a summary of the APEC EWG fora, as well as funded project outcomes. This gaps analysis, while focused only on energy efficiency and conservation (EEC) projects, builds upon the project review and analysis in the Stage 2 report. [5] The work by the Australian research team is an essential resource for its thoroughness and because it supplements the APEC Project Database, which has projects only as far back as 2006. The APEC Project Database is a web-based resource containing project summary, concept notes, and available supporting documents. [6]

This analysis reviews 188 projects dating from 1993 to those funded in Session 2 of 2016. The project database created for this project analysis expands on the Australian team project classification system for funded projects, to include other aspects of the deployment process, such as the target audience, and deployment channel because many of the earlier projects were lacking details that was captured for later projects. Missing information included the proposing economy as well as funding data. The data is publically available from the APEC Project Database and APEC Publications pages. [7] [6]

Researchers evaluated these projects using project descriptions and completion reports to categorize them based on sector, the target technology or practice, the target audience, the strategy for deployment of the targeted technology and practice, and the relevant forum supporting the work. Many of the projects fit into multiple labels in each of the aforementioned categories and thus the total number of projects analyzed often exceeds the actual number of projects.

The follow list highlights of some of the major categories used to analyze projects.

- **Sectors**. Six of the eight sector designations were used for most of the analysis - Appliances, Lighting, and Other Equipment; Buildings; Cross-Cutting/Low-Carbon Development; Grid/Energy; Industrial; and, Transportation. Two sectors with only nominal projects (2 or 3) were captured in the analysis but did not warrant separate projects assessments: 'Government/Municipal' and 'Job Development/Education'
- **Technology and Practices**. One labeled by sector, each project was sub-categorized by a specific technology or practice within each sector. In Grid/Energy, for instance, sub-categories include grid infrastructure; demand side management; and, market practices. In total, there are 17 technology and practice sub-categories and projects were occasionally labeled with more than one category
- **Project Strategy**. To understand how the project addressed knowledge transfer and capacity building, they were categorized into one of following categories:
    - Knowledge Transfer Mechanisms (Databases; Project Assessments/Case Study Development; Design Competitions; Technological and Institutional Assessments Tools; Guidebooks and Practice Promotion)
    - Collaborative Knowledge Exchange Programs (Workshops, Seminars, and Other Events; Personnel Exchange; Surveys/ Questionnaires; Website Development and Maintenance)
    - Minimizing Duplicative Efforts (Links with Other International Organizations)
    - Collaboration (Joint Development and Demonstration Projects; Joint Research Projects)
    - Assisting the Public Sector (Promotion of Economy Programs and Policies)
    - Assisting Private Sector (Direct Consulting Services
- **Audiences**: Audiences were categorized into 25 domains that could be analyzed separated or under 3 larger groupings: 'Knowledge Firms; Manufactures/Businesses; and Policy Makers/Public Entities. The dominant group was Policy Makers/Public Entities.

Project analysis sought to understand critical technologies or practices that have been omitted, untapped audiences, direct or indirect channels of deployment such as partnerships or media that have not been well utilized, missing steps or elements of knowledge transfer or capacity building strategies, and other elements that may arise out of the analysis.

To expand the evaluation phase a survey questionnaire was created targeting members of the EWG, especially EGEE&C participants, as well as other players from public and private sectors in APEC economies. The survey, based on the project categories, asked participants to rank the importance and impact of projects within their economies. This information was used in the third phase of the project to analyze the impact of project gaps on energy efficiency goals within APEC.

The second phase was an examination of sector and economy-level drivers, trends and emerging issues. The analysis focused on building a picture of macro-economic, sectoral and technological drivers in three demand sectors – building, transportation, and industry. Current energy trends, statistics and publications from multi-lateral organizations such as the International Energy Agency and United Nations, in addition to APERC research products, were reviewed.

Macro-economic drivers include population growth, national income and gross domestic product, urbanization trends, financial markets, global energy supplies, energy subsidies and multi-lateral agreements. Sector drivers can include global, regional, and economy-specific policy and regulatory environments, the composition of sub-sectors, or local conditions such as available resources and technical capacity. Other economy-specific factors include geography, climate, energy supply mix, or utility infrastructure. Technology drivers range from investment costs, availability of existing best-available technologies and emerging innovations. All of these factors often work together, making feedback loops, creating barriers and forming new opportunities. Together, they create a contextual picture of the opportunities and barriers for energy efficiency investments in the APEC region.

The regulatory and policy environments of each economy were also reviewed to identify major economy-specific drivers. APERC research products since 2009 include a number of economy-focused policy and regulatory reviews, including the Peer Reviews of Energy Efficiency (PREE) reports. Developing a comparative or cross-walk review of all 21 APEC economies was outside the scope of this report so the APERC research was used to supplement an existing set of indicators from RISE (Regulatory Indicators for Sustainable Energy), a database developed by the World Bank Group with the input of public officials from 111 economies. These indicators added an additional level of insight into the status of energy efficiency policy within each APEC economy.

Sector and economy assessments are found in Section 3, Sectoral Assessments, Section 4, Policy and Regulatory Environment, and Section 5, Project Assessments. Short economy-level summary tables of all the analysis are located in the appendix.

In phase three, project (i.e. tactical) gaps were identified, and then evaluated against APEC missions and goals, the EWG Strategic Plan, the priorities of the EGEE&C and APERC energy intensity reduction scenario modeling results. This allowed researchers to determine if, or how well, project gaps addressed established organizational goals, which strategic level gaps applied across the project portfolio and widely across APEC economies, and which gaps remained at the tactical level.

Energy efficiency projects regularly address many of the more than forty APEC-wide priorities under two APEC project themes. Under '*regional economic integration'* energy efficiency project are able to regularly, if not consistently, address: 1) human development; 2) information technology and the digital economy; 3) emergency preparedness and disaster risk reduction; and, 4) standards, conformity assessment, technical regulations and coherence.

It is the second theme - '*strengthening quality growth'* – under which energy efficiency projects are a core element of the APEC mission and consistently and regularly help APEC meet its core missions and objectives. Those include:

1. Sustainable Growth: **Energy efficiency**, security and resiliency; low-carbon technologies and alternative energy sources
2. Urbanization and smart cities, sustainable and resilient communities
3. Innovative Growth: Innovation policy and research cooperation, harnessing new technologies

The EWG breaks APEC-wide mission priorities down periodically into short-range strategic plans. The current plan provides a useful framework for analyzing trends, the overall composition of the portfolio, and how well it is aligned with current objectives, even though is has not guided all 25 years of project history. The current EWG 2014-2018 Strategic priorities are: 1) Strengthen energy security and resilience; 2) Promote fuel diversification; 3) Train a gender-inclusive workforce, and 4) Lower the carbon intensity of energy supplies. These priorities were broken down into four EGEE&C and LCMT priorities: 1) The application of energy-efficiency practices and technologies; 2) Developing and enhancing trade in products and services and energy-efficiency practices and technologies; 3) Contributing to international efforts to reduce the adverse impacts of energy production and consumption; and 4) Improving the analytical, technical, operational, and policy capacity for energy efficiency and conservation. Those priorities were further split into five objectives:

1. Collaborate on product and system standards that enhance energy efficiency and clean energy deployment, while exchanging information on the impact of such standards;
2. Facilitate the exchange of best low carbon policies, practices and tools among APEC Member Economies to promote the development of sustainable communities across the region and to achieve progress towards the goal of reducing APEC's aggregate energy intensity by 45 percent from 2005 levels by 203;.
3. Develop the human resource base and energy consumers within APEC Member Economies to improve their analytical, technical, operational, and policy capacity in the area of energy efficiency and overall energy literacy;
4. Support the development and commercialization of energy efficiency technologies in the areas of power generation and distribution, industry, transport, buildings, and appliances. (with particular attention to smart buildings); and,
5. Strengthen the reliability, adaptability, and interoperability of electric grids in the APEC region

Gaps were also analyzed in the context of the APERC scenario models, which were designed to understand the how energy policy pathways would impact the APEC-wide goal of a 45% energy intensity reduction goal by 2035. APERC identified three scenarios: the Improved Efficiency Scenario; the High Renewables Scenario; and, the Alternative Power Mix Scenario. One the key finding of the scenario modeling was that the most attractive pathways to meet intensity goals lay in the increased energy efficiency (IEE) scenario. The IEE model's underlying assumptions and data sets were also used in Phase 2 to establish economy-level trends, opportunities and barriers. Case studies of best practices or emerging practices within APEC economies were included to emphasize the impact of strategic energy efficiency policies and investments. The results of the pathway and tactical gap analysis are found in Section 2 - Strategic Pathway Gaps Analysis Summary.

2 Gap Analysis Summary

The 2016 Energy Demand and Support Outlook Report, in its analysis of various energy intensity reductions scenarios, concluded that the scenario with the largest impact on reaching intended intensity goals was a larger commitment to increased energy efficiency.

For over twenty years the APEC EWG has advanced a variety of energy agendas in the APEC region, including energy efficiency. While APEC economies have made clear progress towards the Leaders' Energy Intensity Reduction Goal in that time, it is unclear whether these programs have adequately addressed all of the APEC economies' knowledge and skill development needs. To answer this question, this research takes a systemic review of the APEC energy efficiency project portfolio to provide a gap assessment and high-level recommendations for bridging those gaps.

Guided by the EWG Strategic Plans, The EGEE&C has been promoting energy conservation, energy-efficiency practices and technologies, and analytical, technical, operational and policy capacity within APEC Economies for nearly twenty-five years. Energy efficiency projects also contribute to other APEC objectives, where applicable, such as gender inclusivity and trade liberalization. In order to leverage project funds and resources where they can make the most impact, EGEE&C has made identifying significant project gaps across APEC a priority.

Increasing energy efficiency effectively requires a strong grasp of global and regional drivers, barriers and opportunities across demand and supply sectors, as well as the unique socio-political-economic and geographic characteristics of each economy. Energy demand and supply also faces increased rates of economic and technological change, at a speed that make a 5-year project gap between 2011-2016 more disruptive than one 15 or 20 years ago. These all work together, creating signals that cause rebound effects and feedback loops that can reinforce or obstruct efficiency strategies.

This assessment analyzes the portfolio of funded energy efficiency projects between 1993 and 2016 and then compares that analysis against energy efficiency drivers, APEC's energy efficiency goals, the region's knowledge and capacity needs, and new or emerging drivers. Gaps were put in one of two categories:

1. Strategic pathway gaps: Identifies significant APEC goals, objectives, global drivers or efficiency pathways that the project portfolio does not address significantly; offers observations on why they are important and which economies could benefit from filling the gap.
2. Project gaps: Substantial functional gaps in the project portfolio, often indicating emerging strategic pathway gaps. Gaps may be address strategic objectives, sectors, domains or economies.

2.1 Strategic Pathway Gaps

Each strategic gap is a result of an iterative analysis of APEC mission and objectives, project gaps, and sector drivers. Each identified topic could benefit from strategic actions such as prioritization

within strategic planning documentation, coordinated communications and promotion with economies, active engagement with other APEC working groups and multi-lateral organizations, and an increased number of capacity building projects. A “tactical” approach, such as the 2010-2013 APEC Cooperative Energy Efficiency Design for Sustainability (CEEDS) workshops, could also be used to discuss new strategic opportunities and challenges.

The impact of a unifying strategic framework in the project portfolio is clear. The focus of the energy efficiency project portfolio shifted substantially with the launch of low-carbon pathways initiatives and the agreement by APEC leaders in 2011 to increase the 2007 energy intensity goal from a 25 to 45 percent reduction in aggregate energy intensity by 2035. The initiatives have created a unified purpose, message and set of project criteria related to cross-cutting sustainable community planning. Applying smart community principles to projects has helped APEC economies with widely varying sectors and economies move in tandem towards higher energy efficiency and highlight energy efficiency co-benefits within other APEC Working Group priorities. The energy efficiency scenarios developed by the Asia Pacific Energy Research Centre (APERC) [1], create a framework around which each economy can understand which pathways most effectively reach the intensity goal. Low-carbon high-efficiency initiatives like the Low Carbon Model Town (LCMT) and APEC Energy Smart Communities Initiative (ESCI) integrate sector strategies and pathways. Project descriptions start to made explicit links between energy efficiency, emissions and carbon. Cross-sector projects increasingly focused on comprehensive, low-carbon sustainability planning. Cooperation between economies and with other international organizations with initiatives focused on emissions or energy efficiency also increased. Only three projects before the launch of APEC Peer Review on Energy Efficiency (PREE) and LCMT projects were categorized as ‘Joint Research’ or “Joint Demonstration Project”.

However, with the focus on such an ambitious and complex goal, some areas have been infrequently covered, new socio-political drivers have emerged, and a growing list of capacity recommendations and follow-up actions have built up and could benefit from new or revived strategic attention. Economies also face an increased rate of technological change. With the pace of change in smart communities, smart vehicles and smart grids, a 5-year focus gap between 2011 and 2016 is more substantial and a 5-year gap fifteen or twenty years ago.

2.1.1 Energy and Environmental Resiliency

Like ‘Smart Communities’, resiliency is a broad conceptual framework that encompasses multiple sectors and goals related to the capacity of built environment to deal with climate changes and other stresses and shocks to a cities physical, economic and cultural systems. The Emergency Preparedness Working Group (EPWG) states that over 70 per cent of the world’s natural disasters are within APEC Member Economies. Concerns about the stability of power supplies rose after the Fukushima nuclear incident after the Tsunami of 2011. Japan’s energy imports rose due to the shutdown of nuclear facilities. Energy efficiency strategies can increase resiliency during and after natural disasters such as earthquakes, monsoons and tsunami in both urban and rural areas by reducing the demand during a crisis and increasing grid reliability. However, as demand-side technology trends including the Internet-of-Things and electric vehicles grow, they place higher demands on energy supplies. Only one energy efficiency project, proposed by the Philippines in 2015, directly addresses energy resiliency.[1]

[1] Workshop on Improving Energy Resiliency in Off-Grid Areas in APEC Member Economies, EWG 09 2015A

Potential collaborative partnerships that could support EGEE&C in identifying relevant projects are:

1. *The Energy Resiliency Task Force*. The ERTF priorities are 1) Climate-proofing energy infrastructures; 2) Providing an avenue for cutting-edge energy efficient technologies; 3) Advocating community-based clean energy use in energy poverty- stricken areas; and, 4) Improving energy-related trade and investment in APEC.
2. *Emergency Preparedness Working Group (EPWG)* objectives include developing joint research on risk, vulnerability and instruments of risk reduction, and enhancing resilience capacity of SMSEs and local communities. Although their 2013-16 strategic plan is broad, it does not mention energy. They are, however, aligning with Viet Nam 2017 priority of promoting "Sustainable, Innovative and Inclusive Growth" with activities that aim to enhance capacity building for regional challenges of climate change mitigation, emergency preparedness, and disaster risk reduction.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit most from addressing the energy and environmental resiliency pathway gap include:

1. Economies that are particularly vulnerable to climate disruptions, have rapidly growing urban areas and energy demands that strain the energy supply, and are particularly concerned with energy security (fuel imports): Chile; Indonesia; Malaysia; Papua New Guinea; Peru; the Philippines; and Viet Nam.
2. Economies with significant nuclear power resources that have been raising concerns about environmental safety, and/or the impact of the cost of nuclear power investments on the energy supply mix: China; Japan; Korea; Russia; the Unites States.

2.1.2 Transportation Fuel Standards and Diversification

Markets for light duty vehicles (LDV) across APEC continue to grow. LDVs make up 73% of the transportation sector's energy use in APEC economies and APERC forecasts that China (60%) and South East Asia (21%) will account for 80 percent of the 900 million new vehicles in APEC by 2040. The transportation sector has also been undergoing tremendous change the last few years. The impact on fuel standards and fuel types will grow as countries like China adopt policies to phase out combustion engines, and new technologies like autonomous vehicles begin to expand globally. Technology changes and strong demand increase the need for fuel economy standards, and influence energy supply diversification as non-combustion engines place greater demands on the electricity supply grid.

There are only 16 transportation projects in the portfolio and nearly 90% of them have occurred in the last ten years. Since 2010, projects sponsored by both the Transportation Working Group (TPTWG) and EWG have focused on intermodal strategies, electric vehicles (EV) infrastructure, and integration with low carbon land use planning. No projects deal specifically with fuel economy standards.

The Regulatory Indicators for Sustainable Energy (RISE) indicators also reveal that of the 15 APEC economies reviewed only three have vehicle fuel standards and labeling programs[2]. The range of program coverage is also large. In the United States, half of the energy demand covered by mandatory energy efficiency policies is in transportation. Other economies, such as Australia or Indonesia, have little or no fuel standards or labeling. While other economies have programs, many, like Thailand, are finding promotion of efficiency in the transportation sector difficult to implement or enforce. Vehicle fuel standards, like equipment or appliances standards, confront a range of challenges and barriers, including cost-effectiveness in manufacturing, reliable testing procedures, capacity for implementation and enforcement, compliance control, coverage (all vehicle types), consumer awareness, and policies tailored to local markets.

Energy efficiency in the transportation sector could benefit from increased EWG and TPTWG collaboration. Potential collaborative partnerships that could support EGEE&C in identifying relevant projects are:

> *Transportation Working Group*. TPTWG activities include Promoting the development of intelligent transport systems, promoting energy-efficient and environmentally friendly modes of transportation, and investing in new, upgraded or replacement infrastructure, in order to meet increased transportation needs, as well as safe, secure, resilient, efficient and sustainable transportation.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit the most from addressing this transportation fuel standard pathway gap include:

1. Economies with rapidly growing vehicle ownership rates and/or economies with few existing fuel economy standards or labeling requirements: Australia; China; Indonesia; Malaysia; Papua New Guinea; Peru; Thailand; Viet Nam.

2.1.3 Technology Commercialization and Innovation

The EWG objective to support the development and commercialization of energy efficient technologies in the areas of power generation and distribution, industry, transport, buildings, and appliances has focused largely on buildings and appliances, with recent projects focusing on technology-related issues such as smart grids and electric vehicles. Commercialization or technology transfer – transforming research and intellectual assets into marketable ideas and products – is a gap in the project portfolio. Although policy makers tend to be the largest target audience for projects, many outcome documents have identified critical commercial or market barriers to implementation in the private sector.

Addressing innovation in energy efficiency also addresses one of APEC's Viet Nam 2017 priorities - "Strengthening MSMEs' Competitiveness and Innovation in the Digital Age". Large economic structural shift towards service sectors is a move towards digital production, which increase demand for electricity and can strain on grids. Creating or expanding APEC markets for new or emerging

[2] RISE is a set of indicators that compare economy level policy and regulatory frameworks for sustainable energy under the three pillars of the United Nation's Sustainable Energy for All (SEforAll) initiative and run by the World Bank Group

energy efficiency technologies can help address these topics as well as directly tackle commercial and market barriers directly. Targeting audiences beyond policymakers may also support the discussion towards the commercialization of innovative products. Manufacturers, building owner associations, universities and research labs all play important roles in technology commercialization. Potential collaborative partnerships that could support EGEE&C in identifying relevant projects are:

1. *Policy Partnership on Science, Technology and Innovation Working Group* (PPSTI). PPSTI priorities include strengthening the synergy of government, academia and industry, including SMEs, and engage actors involved in joint scientific research and in the technology inception, dissemination and commercialization cycle, with both its competitive commercial sectors and non-profit elements. Discussions with PPSTI around technology innovation and markets could identify some excellent collaborations or opportunities for new projects.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit the most from addressing the technology commercialization and innovation gap include:

1. While all economies should be concerned with technology and innovation, economies with high rates of Intellectual Property (IP) and strong research universities may be particularly interested in capturing the value of commercialization of energy efficiency innovation. Four APEC economies were in the top 5 PCT (patent cooperation treaty) patent applicants in 2016 (*WIPO statistics*): United States (1); Japan (2); China (3); Korea (5)

2.1.4 Smart Jobs and Consumers - Bridging the Skills Gap

The smart city relies on data. As the Energy Smart Communities Initiative and Low-Carbon Model town have demonstrated, the cities of the future (and now) rely on data analytics to build smart girds, smart buildings, smart transport, and smart industry. APEC economies need resources to train energy efficiency installers, auditors, logistics managers, and many other professionals who can measure and certify energy performance, manage complex energy systems, and forecast and analyze energy use across communities. APEC leaders have identified a critical need for highly skilled professionals and the urgent demand among employers for a skilled workforce. By 2020, the global shortage of highly skilled workers is expected to reach 38-40 million.

In 2016, Project DARE (Data Analytics Raising Employment) brought together business, government and academic leaders to develop a set of ten *Recommended APEC Data Science and Analytics Competencies*. Research revealed that sectors such as healthcare, financial services, manufacturing, cybersecurity and retail have the highest demand for data science and analytics-enabled workers. At the 2017 Leadership forum, officials announced the launch of a collaborative data skills enhancement initiative in partnership with private sector to identify the data-related skills needs of employers in APEC economies and move implementation forward.

Working with the Human Resources Development Working Group could help policy makers identify and pursue solutions to fill critical skills gaps needed to develop and manage low-carbon and low-emission urban infrastructure.

Efforts to fill gaps in smart city data skillsets also aligns with the APEC theme on women's economic empowerment and inclusion in the workforce and the EWG objective to train a gender-inclusive

workforce. According the Policy Partnership on Women and Economy Working Group, 600 million women are in the labor force across APEC, but only 60% work in the formal sectors. At the 2016 APEC WE Forum, one of the five sub-themes of breaking barriers for economic integration of women in the global market was “Digital Literacy for economic inclusion”. Helping to provide women with the skills to participate in the development and management of smart cities addresses these goals. Potential collaborative partnerships that could support EGEE&C in identifying relevant projects are:

1. *Human Resources Development Working Group. (HRDWG*) Three objectives guide the three HRDWG networks in achieving the HRDWG’s mission: Developing 21st Century Knowledge and Skills For All; Integrating HRD into the Global Economy; and Addressing the Social Dimensions of Globalization. They manage projects through three networks: Capacity Building Network; Education Network, and Labor and Social Protection Network.
2. *Policy Partnership on Women and the Economy Working Group (PPWEWG).* The Working Group themes include “Breaking Barriers to Economic Integration of Women in the Global Market”; Mechanisms for the internationalization of MSMEs led by women; Financial and economic literacy and inclusion for access to capital; and Digital literacy for economic inclusion.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit the most from addressing the smart jobs and consumers gap include:

1. All economies will need people trained to create and manage data analytics to build smarter grids, buildings, transport, and industry as the technologies become ubiquitous.
2. In the short term, economies with Low-Carbon Model Towns either in development or planning could benefit immediately from increased ‘smart job’ capacity: China; Japan; Korea; Malaysia; Mexico; Russia; Singapore; Chinese Taipei; Thailand; United States; and, Viet Nam

2.1.5 Multi-Lateral, Peer-to-Peer Networks

Projects that describe multi-lateral organization linkages have increased steadily since the launch of low-carbon initiatives. After 2010, nine projects describe collaborations, consultations or invitations for presentations from experts at the International Energy Agency (IEA), World Bank, United Nations, OECD, ISO, Asia LEDS Forum, and the Asian Development Bank. Only three projects before 2010 mentioned this type of collaboration specifically. The most significant of those projects was the transfer of APEC-ESIS to the Collaborative Labelling and Appliance Standards Program (CLASP) to maintain on behalf of the EGEE&C. The standards and labeling database allows users to search for information on products and policies around the world.

Linkages with multi-lateral and professional organizations appear to be on a largely ad hoc project-by-project basis. The creation of agreements or regular joint professional symposia or training workshops could help formalize ties, strengthen relationships, and make expert outreach and collaborations easier to sustain. Policy, financial and technical capacity building would benefit from stronger peer-to-peer networks and knowledge sharing with multi-lateral organization experts, enhancing access to research and other energy efficiency initiatives outside of APEC. In addition to multi-lateral organizations, strengthening peer-to-peer networks with professional organizations

could also help promote and facilitate energy efficiency across APEC member economies. An example from the Energy Smart Communities Initiative Knowledge Sharing Platform (ESCI-KSP) is The Clean Energy Solutions Center, which builds partnerships to create a network of experts and policy advisors.

Economies that would benefit from addressing this gap:

1. All economies would benefit from wider expert involvement and coordination with multi-lateral organizations to support capacity building and knowledge sharing.

2.1.6 Smart Grid Case Studies

Maintaining a strong strategic focus on smart grids can help ensure that demand side efficiency strategies stay aligned as supply side innovation, investments, and renewables accelerate. As APEC economies increase their energy demand, and consumer technologies become increasingly electrified, demand sectors will become inherently more energy efficiency and cleaner when tied into smart grids. The IEA states that that the top concerns for utilities are technology obsolescence, interoperability and system security [2]. Aligning policy and regulatory environments to support technological interoperability is essential in order to integrate components from multiple vendors and enable trade of smart grid products throughout APEC.

The Smart Grid focus in EGEE&C began in earnest in 2009 with the APEC Smart Grid Initiative (ASGI), which evaluated the potential of smart grid capabilities to support the integration of intermittent renewable energies and energy-management approaches in buildings and industry. The ESCI Knowledge Sharing Platform (ESCI-KSP) [3] shares many examples of Smart Grid Road Maps and Test Bed Networks. Between 2009 and 2014, eight energy efficiency projects addressed smart grids. In 2012, New Zealand developed t a Roadmap to set out a practical course of action to maximize the social, environmental and economic benefits of a smarter grid system in Christchurch. The most recent project, conducted by Thailand in 2014, evaluated the technical feasibility and the economic and regulatory viability of implementing Smart Grid in APEC Low Carbon Model Towns and developing economies. The study looked at the technical requirements of demand-side and supply-side components, financial analysis, and regulatory planning activities prior to commercialization. After 2014, smart grids are mentioned in relation to electric vehicles and energy storage. Recommendations from projects, including Low Carbon Model Towns (LCMTs) emphasize the challenging market and technical barriers to successfully implementing smart grids, including incentives, policy, and consumer behavior.

Economies that benefit from addressing this gap:

1. Similar to the Smart Jobs and Consumers list, economies investing in Low Carbon Model Towns benefit immediately from increased attention on smart grid integration: China; Japan; Korea; Malaysia; Mexico; Rusia; Singapore; Chinese Taipei; Thailand; United States; Viet Nam
2. In addition to new Low Carbon Model towns, rapidly expanding urban areas could benefit from advance planning for smart grid infrastructure. APEC economies with highest urbanization rates are in southeast Asia, including: China; the Philippines, Indonesia; and, Malaysia.

3. Smart grids need low energy subsidy environments to incentive efficiency programs. APEC economies with energy subsidies not already mentioned above are: Brunei Darussalam; and, Indonesia

2.1.7 Increasing Economy Participation

Of the 192 projects in the database, 126 have proposing economies listed. Participation rates overall are much higher and the most popular ones are the cross-cutting multi-sector workshops, seminars and other events. Cross-cutting attendance is more than twice the rate of the appliance or grid projects and five-fold over sectors like buildings or industry.

Active participation in all energy efficiency projects is skewed towards three economies: China, The United States, and Japan. These three economies have proposed over 60% of the projects in the last decade. Economies that have participated in fewer than 10% of projects are Brunei Darussalam; Canada; Hong Kong, China; Chile; ;Indonesia; Mexico; Malaysia; New Zealand; Russia; Singapore; and Viet Nam;. There is no record of participation by Papua New Guinea. The reasons for higher rates of participation are easier to identify than lower rates. China and the United States together account for 64% of the regional projected energy savings, and Japan supports the Asia Pacific Energy Research Centre (APERC), giving them strong incentives to propose and participate in projects.

The reasons for low participation or fewer proposals are not clear from the database and vary between economies. For some economies, it is clear that other Working Groups issues have been, and continue to be, larger economy-level priorities than energy efficiency. Viet Nam is very active in the Small and Medium Enterprise Working Group and has proposed three EWG projects related to renewables since 2012. Indonesia has been active on a number of Working Groups, and last proposed an energy project in 2008 on biofuel. Chile proposed two projects this year on tsunami emergency preparedness and climate change impact on food but has not proposed an energy project since 2006 on mineral exploration. Three economies have not proposed any EWG projects, regardless of topic: Hong Kong, China, which has been recently active in the Economic Committee; Papua New Guinea has been recently active in groups related to mining and fisheries; and Peru, which hosted the *10th Senior Disaster Management officials Forum* in 2016.

As the 2016 APEC Supply and Demand Outlook [1] and the PREE reports [4] make clear, each economy has substantial savings opportunities and could benefit from workshops and other capacity building projects. Aligning energy efficiency with current priorities, such as disaster resilience, industrial efficiency or renewables, could increase participation and encourage project proposals. Identifying other reasons for low participation – whether it is funding, scheduling, travel, or the availability of other information channels or organizations – could also help identify strategies to increase participation rates.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit the most from addressing the participation gap include:

1. This applies to all economies in most sectors - with the exception of economies that have high participation/ proposal rates across the project portfolio: Australia; Canada; China; Japan; Chinese Taipei; and, the United States,

2.1.8 Expanding Non-Government Audiences and Participants

As expected, policymakers are the primary audience for both capacity building and knowledge sharing. The history of APEC started around senior official and ministerial level dialogue and the Bogor Goals, created in 1994 to promote free and open trade. The top two audiences for energy efficiency projects have been national energy offices and sub-national energy offices, distantly followed by NGOs and code officials.

Business attendance has been focused on product manufacturing (i.e. product standards and harmonization), utilities (Grid and energy supply) and ESCOs (building sector). As innovations such as in Internet-of-Things and integrated smart grids become more ubiquitous, higher manufacturer and business attendance could be valuable for technical capacity building and continuing harmonization/interoperability issues.

Knowledge firms are the smallest audience. Although international agencies have been participants in nearly as many projects as utilities, the numbers of projects targeting universities and research labs are very low. Of those projects with university and research lab attendance, 75% have been since 2009. As sources of technology transfer and commercialization experts and many of the technology innovations in the energy sectors, increasing participation by these two groups could be valuable additions to efficiency projects.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit the most from addressing the non-government audience gap include:

1. All economies could benefit from increasing technical capacity and knowledge building among audiences who would benefit from understanding policy and regulatory planning challenges in their sectors.
2. Non-government Audiences that could benefit from increased attendance include:
    - Financial Organizations, to understand low carbon development and energy efficiency investment risks;
    - Energy Utilities, to improve their own industrial efficiencies and how to improve consumer-based incentive programs;
    - Community Organizations that focus on communicating and supporting local energy efficiency initiatives;
    - City Planners who are implementing energy efficiency policy and regulations at city and regional scales.

2.2 Tactical Project Gaps

Tactical project gaps are organized into three demand sectors, the grid/supply sector and two cross-sector domains: Buildings; Transportation; Industry; Grid/Supply; Cross-cutting/Low Carbon; and Appliances and Equipment. The ‘Cross-cutting/low-carbon’ domain covers projects that fit into multiple demand or supply sectors while the ‘appliances and equipment’ domain covers commercial and residential buildings as well as industrial equipment. This section summarizes significant tactical

project gaps in the portfolio and a detailed breakdown of project gaps are outlined in subsequent sections.

2.2.1 Cross-cutting/Low-Carbon Projects

The cross-cutting category is the most complex due to the high number of sub-categories and multi-sector projects captured in the category. There is a pivot point in the category: the launch of low-carbon pathway initiatives in 2009/2010. Half of the cross-cutting projects have occurred between 2009 and 2016, only ¼ of the date coverage in the database. No project before 2009 mentions emissions or carbon. Before 2009, most projects focused on data collection and statistics, and knowledge exchange focusing largely on broad overviews of policies and practices across APEC. While those types of projects have continued, a new layer consisting of multi-sector low-carbon or sustainability master planning and public policy largely targeting policy makers and energy officers has more than doubled the average number of funded projects each year.

2.2.1.1 *Complementing "cross-sector" frameworks with technical capacity training*

As participation rates and project counts reveal, cross-cutting low-carbon projects have dwarfed single or double-sector projects over the last seven to eight years. These projects, by effectively promoting holistic energy framework, have often resulted in 50, 60+ recommendations for filling policy gaps, promoting consumer behavior, and regulating technical standards. As a result, one of the frequent outcomes has been requests for more technical capacity building to address to the challenges of the frameworks like Low Emissions Development (LED) and the LCMT.

Low Carbon Town Models (LCMT)

Launched in 2011, the LCMT Task Force established a Low-Carbon Town Indicator Systems, a self-assessment tool, to monitor projects. The LCMT-I is designed to evaluate low-carbon town planning in a comprehensive way and look at building energy in four built environment typologies: Urban (Central Business District), commercially oriented town, residential oriented town, and rural (village or island), all of which are defined by size, population density, land usage and infrastructure. Buildings are assessed on the types of systems in place that improve thermal performance (heating and cooling) and energy-saving equipment performance including the status of rating systems and standards, the existence of subsidies and incentives, and legally binding regulations and policies.

Within the entire portfolio, only 15% are categorized as multi-sector and very few projects outside of recent cross-cutting ones have more than one proposing economy. As the multi-phase LCMT project wraps up this year with a final set of feasibility studies and policy reviews, this could be a good time to encourage economies with similar policy gaps and technical concerns to continue to work together by proposing joint sector-specific capacity building projects. the PREE reports have also delved deeply into the efficiency policies of single 'host' economies, offering a unique opportunity to identify specific policy actions than can encourage the implementation of LCMT recommendations and complement targeted technical capacity building. Three follow-up PREE projects have addressed some of these issues already.

Bi-lateral proposals that match economies with high participation rates with economies with low participation rates could also help encourage increased participation over time by developing stronger relationships.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy

barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing the cross-cutting/Low carbon capacity training gap include:

1. The rate of participation for cross-sector projects was more than double next sector's rate, indicating a strong interest in the low-carbon framework for sustainable communities. Participants with the strongest interest in these projects that could benefit from follow-up technical capacity training include: Brunei Darussalam; China; Japan; Korea; Chinese Taipei; Thailand; amd the United States

2.2.1.2 *Harmonizing frameworks with multi-lateral organizations*

As energy efficiency and low-carbon planning and development become integrated into international agreements such as COP21 and U.N. Sustainable Development Goals [5], international coordination on frameworks will become increasingly important. While relatively few projects are actually joint projects other multi-lateral organizations, cross-cutting framework projects have greatly increased linkages by inviting experts from other organization programs to share knowledge at workshops and other events. In 2015, during Phase 6 of the LCMT project, APEC officials talked with experts of International Organization for Standardization (ISO) on contributions by the APEC LCMT-I System to international standardization of city indicators. In 2016, a Near-Zero Energy Building (NZED) Project explicitly tied its outcomes to COP21, and work by New Building Institute (NBI) and Natural Sciences and Engineering Research Council (NSERC). Experts from the Organisation for Economic Co-operation and Development (OECD) Green Cities Program have attended workshops to discuss their work in developed countries. Other groups mentioned in projects include the Asia LEDs Forum (Low Emission Development), International Energy Agency, World Energy Council East Asia Summit, the International Energy Forum, World Bank, International Finance Corporation (IFC), and the United Nations Development Programme (UNDP). The ESCI-KSP has published projects from organizations such as the American Council for an Energy Efficiency Economy (ACEEE), the World Bank, the Lawrence Berkeley National Laboratory (part of the U.S. national laboratory system), and the Development Research Center of China's State Council.

Continuing efforts to harmonize integrated energy and low-carbon development frameworks will help reduce trade barriers, increase cooperation, and support harmonization efforts within the energy efficiency domains such as appliance standards and testing, labeling programs and the adoption of initiatives such as NZEB.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing the framework harmonization gap include:

1. Economies with low-carbon town developments in planning and development. One major output of the LCMT initiative are the Low Carbon Model Town Indicators. Other multi-lateral organizations have or are establishing sustainable development indicators that address low carbon development strategies as well. Harmonization or "cross-walk" analysis can help APEC economies leverage the indicators in conjunction with other frameworks to meet

targets and goals, identify new resources or capacity support, and reduce confusion or conflicts.

2.2.2 Appliances/Equipment Projects

Appliance and other equipment has been a consistent focus of energy efficiency projects for the last two decades and it is the second highest number of projects after 'cross-cutting'. The number of projects after 2011 appear to be on pace with the previous decade's 25 projects. Relying largely on technology and knowledge transfer (including assessments and collaborative workshops) the dominant subject of projects has been international standards, harmonization and testing. Since 2014, the project mix reflects the EWG 2014-2018 strategic objective to focus on the building sector including building systems, net (nearly) zero energy buildings, and appliances like refrigerators and commercial lighting. Within the sector projects, only three are categorized as 'enabling public policy': Those addressed stand-by power, LED lighting, and Net Zero Buildings (NZEB). The CEEDS reviews, Energy Outlooks reports and other cross-cutting assessments do review financial and policy incentive programs for appliances standards and offer recommendations.

The steady focus on labeling and standards harmonization is reflected in the RISE indicators, which review the policy environments of APEC's 15 largest economies: second only to providing consumer energy information, appliance/equipment labeling and standards programs been adopted by most economies.

2.2.2.1 *Internet-of-Things and Smart Appliances*

Internet-connectivity is changing the way appliances and equipment use energy. Smart buildings, smart grids, and smart transport[3] will be "on" all the time through 24/7 monitoring, motion detectors, security, metering, sensors and other as-yet-to-be-determined options. The growth of the service sector will also mean more computers and devices. Energy standards for appliances such as refrigerators, boilers or A/C will need to address internet use, security, and data protocols. These devices will also be integrated in to demand-side management systems and sensor networks. Those networks and management systems will help manage energy use via optimization, demand forecasting, load balancing, and capacity utilization. In the industrial sectors, internet-of-things may be more accurately described as machine-to-machine (M2M), equipment will be linked together to manage energy efficiency. Other new technology innovations like autonomous vehicles will start to be treated as equipment or appliances as they increasingly "plug in" instead of "refuel". These issues are being addressed directly by economies (such as the U.S. National Institute of Standards and Technology) as well as multi-lateral organizations such as the International Partnership on Energy Efficiency Cooperation (IPEEC), the Connected Devices Alliance, and the International Energy Agency.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing the IoT/Smart Appliances gap include:

1. All economies benefit from addressing this emerging trend in internet connected appliances and devices in homes, officers and manufacturing facilities

[3] The PPSTI published a white paper of Internet of Vehicles (IOV)

2. Economies that are increasing their investments in smart grid technologies and energy security benefit from understanding how these devices (include smart vehicles, which EWG projects have addressed recently) connect to the energy supply and the impact on energy demand.

2.2.2.2 *Industrial Equipment Standards and Labeling*

The focus on industrial equipment has remained low over the last twenty years, as the main priority was building equipment such as refrigerators and lighting. According to the IEA, the industry sector currently uses the most energy of any sector, at 54% of global final energy demand. End use energy losses make up nearly half (42%) of the fuel supply used in the sector. Equipment inefficiencies combine with mechanical and thermal limitations make this a major area of improvement. Meeting the estimated Improved Energy Efficiency Scenario sector savings of 368MToe will require adopting best available technologies, increasing minimum efficiency standards and innovation.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing the Industrial standards and labeling gap include:

1. All economies, with a special emphasis on economies with disproportionately large potential savings in the industrial sector such as: China; Chile; Korea; Chinese Taipei, and, New Zealand.
2. Economies with large natural energy resource or refinery activities, which are typically categories as" non-energy use" such as: Australia; Brunei Darussalam; Canada; and, Singapore.

2.2.3 Transportation Projects

At 8% of all projects, transportation is the smallest sector, with little to no interest before 2007, 14 of the 16 projects have occurred between 2007 and 2016. Five of the 16 projects come out of the Transportation Working Group in APEC (TWTWG), focused largely on intermodal transport efficiencies (rail, port, maritime efficiencies within supply chains), and the United States conducted half of all the projects. Although few in number, they had the highest participation rates of all the sectors, relative to # of projects. The interest appears to be driven by the integration of urban transport into low emission and low-carbon development, particularly electric vehicles interoperability and charging infrastructure. The latest project, in 2017, is an APEC Electric Vehicles Roadmap workshop sponsored by Japan, Malaysia, Philippines, and Thailand. This is an excellent example of joint-economy proposals looking at technical capacity training focused on emerging technologies, challenges of harmonization that are mentioned under 'cross-cutting' recommendation for an increased focus on technical capacity training. Due to limited transportation efficiency policies, high economic growth rates and rapid growth of vehicle ownership in many APEC economies, the APERC IEE scenario savings for this sector are very high.

2.2.3.1 *Light Duty Vehicle Standards and Labeling*

Globally, Light Duty Vehicles (LDV), with 60% of the sector's final fuel consumption, dominate road energy. In APEC, that number rises to 73% of final energy consumption. In APEC, LDVs are expected to increase by over 900 million vehicles by 2040 and APERC forecasts that the vast majority will be in

China (60%) and South East Asia (21%). The sector also accounts for 23% of global CO2 emissions, making the sector critical in emissions reduction strategies. The IEA states that to reach GHG emission reduction goals and energy intensity targets, economies need to invest in total transport system efficiencies, including fuel standards [10].

Despite this, fuel standards have not been included in any project summary or objectives in EWG nor TPTWG projects. In the RISE policy indicators, 12 of the 15 APEC economies reviewed do not have fuel standards or labeling programs. In the 2016 Compendium of Energy Efficiency Policies, nine of the economies mention some type of fuel efficiency schemes, whether labeling, efficiency standards, or both. The Philippines and Viet Nam mentioned new initiatives and research in 2015 and 2016.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing vehicle fuel standards or labeling gaps include:

1. Economies that are currently lacking either strong fuel economy standards or labeling regulations for vehicles including: Australia; Malaysia; Indonesia; Papua New Guinea; the Philippines
2. Economies that have only recently adopted fuel standards or labeling programs and might benefit from capacity building on regulatory enforcement or consumer behavior programs, such as Thailand and Viet Nam

2.2.3.2 *Integrated Land Use Planning*

In addition to integration into low carbon city town planning, opportunities to improve transportation system efficiencies will need to be continuously promoted in existing urban areas, in rural areas, and via inter-modal planning. Recommended actions from LCMT reviews and indicator harmonization efforts can continue to motivate projects and promote these issues. If the issue was designated a continuing priority, economies already dealing with high vehicle saturation rates and land use sprawl issues - such as the Unites States, Canada, or Australia - could also decide to cultivate new projects around this issue. The Transportation Working Group's recent focus on intermodal issues such as supply chain connectivity, ports, aviation and shipping could be extended to freight land transport and land use efficiency strategies. Working with multi-lateral organizations with strong urbanization and rural issues mission focus could also be pursued.

All economies benefit from knowledge sharing and capacity building on integrating land use planning with transportation planning. Some economies may benefit more than others from projects that address specific sector drivers, regulatory or policy barriers, or constraints such as geography. Economies that may benefit immediately from capacity building in this area are ones in which vehicle sales are increasing rapidly, creating economic, traffic and environmental gridlocks, including: China; Indonesia; Papua New Guinea; the Philippines; Peru; Thailand; and, Viet Nam (see **Error! Reference source not found.** for more details)

2.2.4 Buildings Projects

According to APERC [5] the Improved Energy Efficiency (IEE) Scenario shows the largest gains in the building sector, allowing most economies to meet or exceed the APEC energy intensity target. China and the United States combined create 66% of the additional savings and nearly 80% of

building sector energy demand comes from four economies: China, the United States, Japan, and Russia. Per capita sector demand will remain highest in mature economies with high urbanization rates and mature building stock such as the U.S., Canada, and Korea.

Although building sector projects had the second lowest participation rates, it is important to note that the cross-sector projects related to low carbon model towns had significant focus on the building sector, including green building codes, certification schemes, and construction guidelines. The SCI Knowledge Sharing Platform also has four sections on smart buildings, including low energy networks, cool roof demonstration, low energy window demonstrations, and materials testing and rating centers. The <ow Carbon Model Towns in the site also cover commercial and residential sector planning and information on low or zero emission construction.

2.2.4.1 *Building Envelopes (New and Existing)*

With the focus largely on appliance standards and harmonization, building codes were not a significant focus until the late-mid 2000's. Earlier projects looked at incentives or government programs that could encourage or accelerate green building practices. In 2008, the first comparison of building energy codes in APEC launched, followed by projects on cool roofs and energy saving glazing (windows). Between 2013-16 China conducted three projects looking at Building codes and Near Zero Energy Buildings (NZEB). An assessment was followed by a review of best practices and a roadmap in response to COP21.

In the APEC region, seven economies are expected to capture nearly 90% of the building sector savings. Of that, 40% will be in China, followed by the United States at 20%. The remaining 30% will originate (in decreasing size) from Russia, Japan, Canada, Indonesia, and Mexico.

The IEA, in the tracking clean energy research, have rated building envelopes as "not on track" this year to meet low-carbon emissions targets. Progress needs to happen more quickly and economies need to create clear signals that these issues are critically important for emissions, and energy efficiency. According to the UN Habitat Data, half of the top ten cities by population are in APEC (Tokyo, Mexico City, Shanghai, Beijing, New York). When measured by Urban Agglomeration (pop/Km2) other APEC cities such as Manilla, Bangkok, Jakarta and Singapore rise to the top. With such dense urban centers, building energy codes for new and existing structures, incentives and financing mechanisms, MV&E adoption and enforcement, and consumer education are critical.

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address gaps due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing building envelopes are

1. Economies with higher savings potential in this sector, including: Canada; Hong Kong, China; Malaysia; Singapore
2. Economies with large existing building infrastructure that could benefit from addressing building envelope retrofit barriers such as Japan, Korea; and the United States

2.2.4.2 *Expanding Appliance Standards*

The focus of standards and harmonization efforts has been lighting, air conditioners, and refrigerators - with successful results. In 2011, a code mapping project reviewed seven major appliance categories - the previous three plus computers/monitors, televisions, clothes

washers/dryers, and water heating. This was the only project to mention those categories. The growth of internet and telecommunications services in the United States has already led to consumer education on computer/monitor energy use and efforts to reduce the energy use of large commercial buildings like server "Farms". With the economic growth of APEC economies, these categories can be expected to grow substantially in all economies. Economies with which are expected to see rapid urbanization over the next fifteen years will see the family incomes rise and the use of residential appliances increase. In warmer regions, where most of APEC's rapid urbanization and economic growth will continue, the use of air conditioners will also increase. In colder regions, like Russia, Canada, many parts of the U.S.,Japan, and China, water heater use will also rise. A closer look at the impact of increased labeling and use of MEPS in these categories in these APEC economies could increase building sector savings.

2.2.5 Industry Projects

Whole Sector Focus. The industrial sector, as a whole, is a gap. Since 1993, there have been only 20 industry sector projects. Unlike other sectors, the proportion of projects dropped after 2009 and those seven projects have no clear theme among them. A few projects focused on inefficiencies such as co-generation and combined heat and power. In 2011, Thailand sponsored a study on best practices in energy efficiency and technology in the industrial sector [6]. The most recent project, conducted by Japan in 2015, looks at energy and industrial competitiveness [7]. In 2012, the *APEC Smart City Industrial Technology Cooperative Forum* was sponsored by the Industrial Science and Technology Working Group (ISTWG)[4].

Table 1. Potential High-Energy Industry Sub-Sector Energy Efficiency Savings

Potential industry sector energy efficiency savings in the APERC Improved Efficiency Scenario		
Major Subsectors	Developed economies (%)	Developing economies (%)
1.Iron and Steel	10-15	25-35
2. Chemicals and Petrochemicals	10-25	15-30
3. Non-metallic mineral	20-25	20-30
4. Food and Tobacco	25-40	25-40
5. Paper, pulp, and printing	20-30	15-30
6. Non-ferrous metals	5-40	5-55

Industry is the largest sector in the APEC region and it will remain so throughout the APEC outlook period, with a 1% annual average growth rate and one third of the energy demand in 2040. IEA research indicates that decoupling industrial production from CO2 emissions is critical to achieving 2 degree (2DS) emissions targets. Annual growth in CO2 emissions between 2014 and 2025 needs to be limited to 0.1%, compared to the average 1.1%. Energy efficiency strategies are a key component of that pathway.

According the APERC research, the industrial sector has significant energy savings potential. As seen in Table 1, all six major sub-sectors show significant energy savings potential. Although the range is wider in developing economies, all economies show significant savings potential. In APEC, 94% of additional savings over BAU in the sector come from nine economies: China (198MToe), the U.S. (54MToe), Russia (21MToe), Indonesia (20Mtoe), Japan (13MToe), Mexico (12MToe) Canada (11Mtoe), Thailand (10MToe), and Korea (9MToe). In 2015, the incremental global energy efficiency investment in the industry sector was USD 39 billion. China spent 20.5% of total world efficiency spending (USD 8 billion). Subsector efficiency savings between 2010 and 2014 ranged from .8%

[4] The following year it was renamed the Policy Partnership on Science, Technology and Innovation Working Group

(calcium carbide) to 21% (plate glass). One year of industry savings equaled 48% of China's funding for energy conservation *in all sectors* during the first four years of the 12th Five Year Plan.

Analysis by the IEA (Figure 1) shows that mandatory energy efficiency policies in China are well over global averages, covering 37% of the sector demand. The only other APEC economy above the global sector average is Japan, at 13.7 percent of the industrial sector. Increasing the number of industry efficiency projects across the board could have a large impact on reaching energy intensity targets.

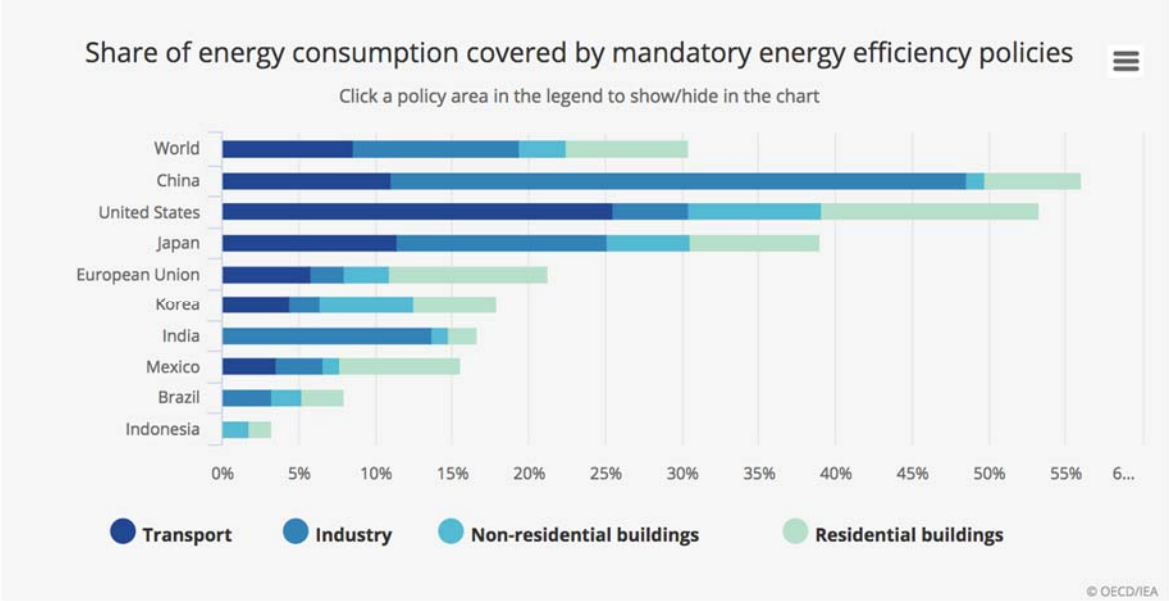


Figure 1. Share of Energy Consumption covered by Mandatory Energy Efficiency Policies, IEA

Although all economies benefit from knowledge sharing and capacity building, some economies may benefit more than others from projects that address this gap due to sector drivers, regulatory or policy barriers, or other constraints such as geography or economic development. Most economies face multiple drivers and risks. Economies that may benefit immediately from addressing industrial energy efficiency are:

1. Economies with high savings potential in the sector relative to buildings and transportation in the IEE scenario: Chile; Korea; New Zealand; Chinese Taipei
2. China. As the largest industrial sector in APEC and therefore the source of the largest energy savings, the impact of increasing mandatory standards and energy management in the sector will show large payoffs. In the IEE scenario, China's industrial sector makes up 51% of projected savings for the entire APEC region.

2.2.6 Grid/Supply Projects

"Strengthen the reliability, adaptability, and interoperability of electric grids in the APEC region" is an objective of the EWG Strategic Plan for 2014-2018. . Distributed energy systems, micro-grids, smart grid technologies, and other supply sector disruptors allow the building, transportation and industrial sectors to use energy more intelligently.

2.2.6.1 *Smart Grids*

Interest in smart grid projects kicked into high gear with the launch of low carbon pathway initiatives. Between 2011 and 2013, there were 17 grid projects. By 2016, in only six years, over 60% of all grid projects had occurred. Nearly all the projects focus on understanding and assessing "smart grids" through technical and strategic evaluation of on-going projects. China has conducted nearly half of the projects, followed by the United States. Supply sector drivers were not reviewed for this assessment; however, the ability to reach energy intensity and emissions goals by increasing the efficiency of electricity generation through renewables, nuclear power, and natural gas fired power plants, as well as energy storage, is clear. The IEA points out that only energy storage, solar, and onshore wind are on track to reach 2C scenario targets for reduced emissions. Continuing to address demand sector integration and innovation in smart grids through knowledge sharing and capacity building promotes stronger investments in clean power supplies. Concerns about smart grids include:

- **International ISO, IEC and ITU standards.** The grid technologies requires global interoperability standards for electric vehicles, motors, capacitors, batteries, fuel cells. etc.
- **Resilience**. How can smart grids and energy efficiency be best utilized to reduce natural disaster risks? Recent earthquakes and hurricanes in Mexico, the U.S. and the Caribbean point to needed discussions about strategies and roadmaps.
- **Open Energy Markets**. A follow-up to projects from 1999-2003. Are there new issues in regulatory reform (fuel and power subsidizes or lack of market-oriented markets controls), affecting energy efficiency investments? Research from other groups such as OECD or IEA that could help APEC economies
- **Industrial Sector**. New opportunities for the industrial sector to utilize smart grid technology to increase energy efficiencies in areas like combined heat and power, electric motors, or process innovation? Implications of smart grid expansion for energy efficiencies in the service and light manufacturing sub-sectors. China, Japan, U.S. might have great case studies to share.

3 Sectoral Assessment

3.1 Introduction

By understanding energy efficiency drivers and barriers across sectors and within economies, EGEE&C can identify and promote energy efficiency projects across APEC. This section reviews energy efficiency barriers and drivers primarily in the three demand side sectors - industry, buildings and transportation - across the APEC region.

Energy efficiency, often called the “first fuel” or “hidden fuel”, can deliver benefits beyond the reduced output per unit of energy. The International Energy agency (Figure 2) has identified fifteen areas that energy efficiency can enhance directly, such as energy security, or more indirectly, such as public employment. As populations grow and urbanization increases, using energy more efficiently can help reduce poverty, lower GHG emissions, and decrease local air pollution. Efficiency can reducing energy budgets, resulting more household disposable income, lower public investments in expanding energy infrastructure and a stronger business environment that can grow new market opportunities. Energy efficiency also helps increase energy security, reducing the impacts of energy-related risks like volatile energy prices. As a result, energy markets often respond to drivers unrelated to energy production or demand. Non-energy targets and goals such as GHG emissions commitments amplify the impact of energy efficiency by highlighting co-benefits or shifting public opinion. Global agreements such as COP21 and health concerns like pollution can put pressure on economies to use energy efficiency regulations as “low hanging fruit”, speeding up policy changes.

Determining which energy efficiency barriers are the most critical challenges in an economy can be difficult. Drivers work together, creating signals that cause rebound effects and feedback loops. Sector barriers include available technologies, existing infrastructure, regulatory and financial environments, geography, climate, natural resources, capital flows and financial risk, as well as general levels of economic development. Technological barriers include cost, availability, compatible infrastructure, and gaps in R&D investment. Technology innovation is disrupting business models, including the energy sectors. Economy-level policy, regulatory and market-based solutions can overcome some sector barriers, while others require coordinated

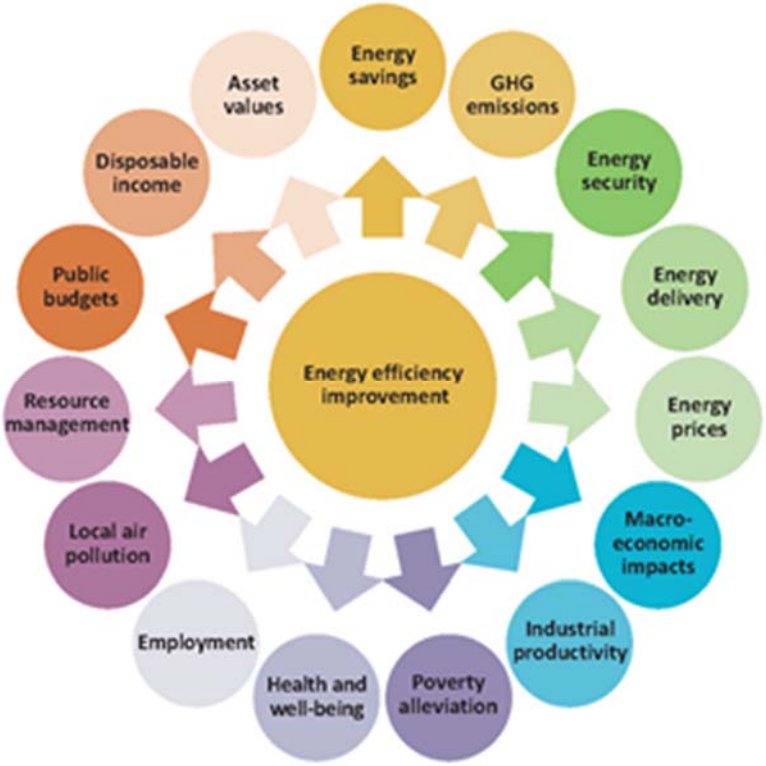


Figure 2. IEA Graphic - Multiple Benefits of Energy Efficiency

regional or global effort to reduce perceived risk or shift human behavior away from inefficient habits. In other cases, technological innovation, or cultural and behavioral shifts push policy and regulatory change.

3.1.1 APERC Energy Scenarios

The most detailed information available on how energy efficiency pathways and drivers may play out across APEC comes from the APEC 2016 Demand and Supply Outlook [1]. Other information comes from the APEC Energy Overview 2016 report [8], APEC PREE reports [9], and multi-lateral organizations that research or advocate for renewables and energy efficiency, including the International Energy Agency (IEA), and the United Nations (UN).

The four energy scenarios[5] modeled by APERC [1], explore pathways within the demand sectors and supply sectors to reach the APEC 45% energy intensity target by 2035. This report looks specifically at the pathways outlined in the improved energy efficiency (IEE) and business-as-usual (BAU) scenarios for industry, buildings, and transportation sectors. The detailed analysis gives an overview of the APEC energy environment and many of challenges and drivers that policymakers face when deciding how to promote and support energy efficiency projects.

3.1.1.1 *Business-As Usual Assumptions*

Assumptions in APERC's Business-As-Usual (BAU) scenario are conservative, excluding long-range planning and intended regulations, and policies or programs not actively implemented at the time of the analysis. As a result, BAU estimates may contradict an economy's long-range estimates[6]. In this scenario, APERC projects that APEC's 45% energy intensity target is not reached until 2037. Final energy demand increases 32% between 2013-2040 and China and southeast Asia economies supply most of the growth. Per capita demand across APEC continues to reflect differences between mature and developing economy status, regardless of annual growth projections. Mature economies such as Canada; Japan; United States; Korea; and Hong Kong, China see some of the smallest annual growth rates in the region, well under 20 percent. Japan and Chinese Taipei see zero or negative demand in the BAU scenario due to strong efficiency efforts. In contrast, emerging economies have high growth rates but much lower per capita demand. China's per capita demand in 2040 BAU is projected to be 2.1 Mtoe. In 2040 BAU, demand in the U.S. and Canada is projected at 4.1Mtoe per person, and nearly 5.5MToe, respectively. Per capita demand in Papua New Guinea (0.42Mtoe) and the Philippines (0.45Mtoe) are nine times lower than the United States, despite having the highest average annual growth rates in APEC.

3.1.1.2 *Improved Efficiency Scenario (IEE) Assumptions*

The IEE scenario explores the effect of macroeconomics and the adoption of all currently cost effective Best-Available-Technologies (BATS) and practices. The results suggests that there is a significant gap between existing policies and potential savings (Figure 3. *Potential savings in the IEE Scenario by Sector, over BAU, 2015-40*). The model does not include anticipated or potential technology breakthroughs nor technologies that exist but are widely cost prohibitive. The result is a scenario that shows policymakers the power of making feasible short-range decisions on long-range intensity targets. The model projects that the APEC region can reach the energy intensity target by 2032, five years earlier than the BAU scenario. It also looks at strategies such as increasing fleet

[5] Four scenarios: Business-As-Usual, Improved Efficiency, High Renewables, and Alternative Power Mix

[6] Detailed modeling data can be found in the 2016 Outlook Annex 1: Key assumptions and methodologies

fuel efficiencies (particularly in LDVs, which dominate land transportation), adopt best available technologies (BATs) across the industry sector, including appliances and building envelope systems, and adopting stronger building codes to reduce heating and cooling loads in the building sector. Unlike BAU, demand in this scenario peaks (in 2028), decoupling energy intensity from economic and population growth and resulting in a total energy intensity reduction of 56% by 2040. The additional savings (almost 1,000Mtoe) is approximately half of China's total energy demand in 2013.

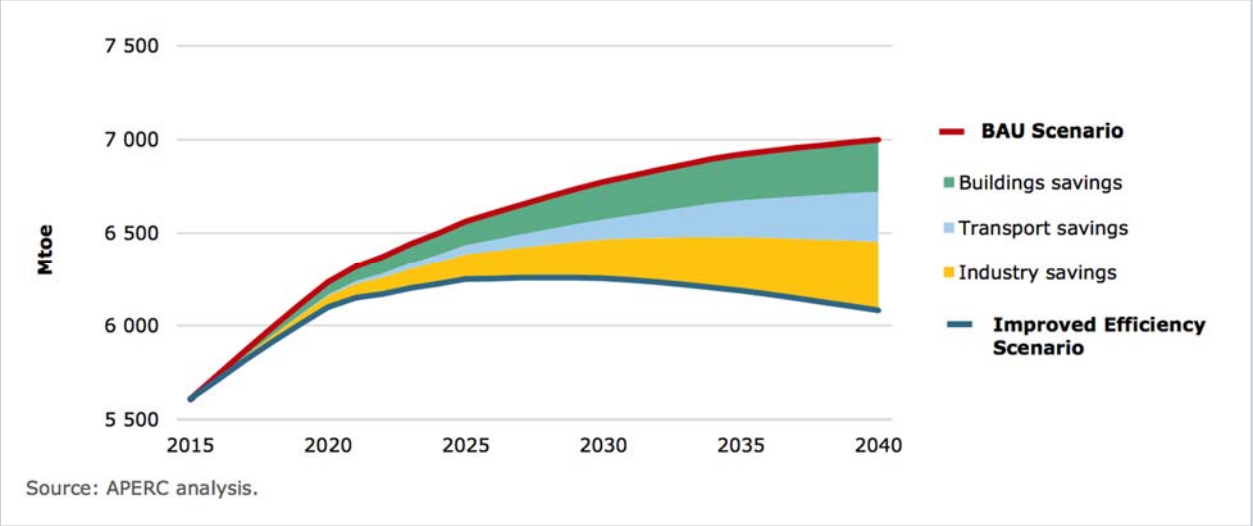


Figure 3. Potential savings in the IEE Scenario by Sector, over BAU, 2015-40

3.1.1.3 *IEE Scenario Savings Summary*

on the following page shows basic economic data along with the estimated total final energy demand of each scenario in each economy and its projected savings compared to the baseline year of 2013. The table is organized by the percent change in energy demand of the IEE scenario from the BAU. Figure 4 shows that 63% of the additional 932 MTOe potential savings in the IEE scenario comes from just the economies of China and the United States.

Four economies – Japan, the United States, Korea, and Chinese Taipei – are able to reduce their energy demand to below 2013 levels. Australia; Canada; Hong Kong, China; New Zealand; Russia; and Singapore can reduce their energy demand growth to less than 10% over 2013 levels. The per capita demands remains aligned with economy development levels. United States per capita demands drops 13%, and Canada drops 17%. China's rates drop 22%. Despite the highest annual growth rates, both the Philippines and Papua New Guinea still have the lowest final energy demand per capita in the IEE scenario. The top four per capita demand economies in the IEE scenario-Canada; Brunei Darussalam; Singapore; and the United States-are large energy producers and/or refiners.

Table 2. Comparison of BAU and IEE Scenarios, APERC 2016 data

Economy Data			Total Final Energy Demand (Mtoe) BAU and IEE Scenarios					
Economy	Average Annual Growth Rate (2013-40)	2040 Pop. (mil)	2013	2040 BAU	2040 IEE	2040 IEE per capita	% change (13-40) BAU	% change (13-40) IEE
Japan	1.1%	114	311	277	243	2.13	-10.9	-21.9
Chinese Taipei	0.9%	23	68	68	61	2.65	0.0	-10.3
United States	1.6%	383	1495	1577	1386	3.62	5.5	-7.3
Korea	2.2%	49	168	180	162	3.31	7.1	-3.6
Canada	1.7%	42	199	230	200	4.76	15.6	0.5
Hong Kong, China	2.2%	8.9	7.3	8.6	7.4	0.83	17.8	1.4
Russia	1.4%	151	434	504	449	2.97	16.1	3.5
Australia	2.8%	34	81	104	86	2.53	28.4	6.2
New Zealand	2.3%	5.5	13	16	14	2.55	23.1	7.7
Singapore	1.4%	6.2	19.7	23	22	3.55	16.8	11.7
China	4.9%	1361	1943	2875	2479	1.82	48.0	27.6
Mexico	3.0%	145	118	192	156	1.08	62.7	32.2
Chile	2.7%	20	27	45	38	1.90	66.7	40.7
Malaysia	4.2%	41	54	88	80	1.95	63.0	48.1
Thailand	3.5%	73	96	178	150	2.05	85.4	56.3
Brunei Darussalam	1.2%	0.6	1.1	2.24	2	3.33	103.6	81.8
Indonesia	4.4%	290	162	354	301	1.04	118.5	85.8
The Philippines	6.0%	142	26	64	50	0.35	146.2	92.3
Peru	3.9%	38	17	48	36	0.95	182.4	111.8
Viet Nam	5.5%	104	51	173	153	1.47	239.2	200.0
Papua New Guinea	6.4%	12	1.6	5.7	5.1	0.43	256.3	218.8
APEC TOTAL (or average)	3%	3043	5293	7012	6080			

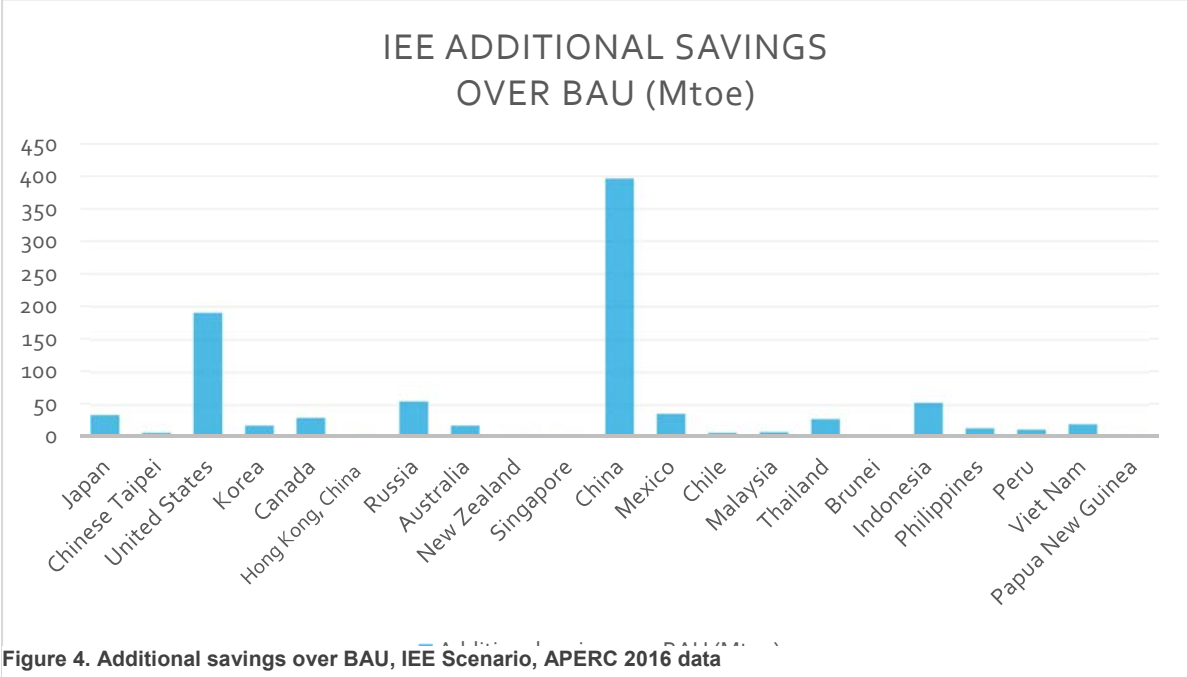


Figure 4. Additional savings over BAU, IEE Scenario, APERC 2016 data

3.1.1.4 *IEE Savings by Sector*

The potential savings across all three sectors - 396Mtoe - is the equivalent of the combined total energy demand of Thailand and Indonesia in the scenario. Despite the overall large numbers, savings potential in the IEE scenario have sharp variations when viewed by sector and economy (

Figure 5) The industry sector is the only sector in which some economies see no savings over BAU - Brunei Darussalam, Malaysia, Hong Kong China, Papua New Guinea, Singapore and Viet Nam. Malaysia, Brunei Darussalam, Papua New Guinea and Viet Nam can expect to see most of their efficiency savings in the transportation sector. Owing to their dense urbanization, savings in Hong Kong, China and Singapore favor the building sector. China, due to the sheer size of its economy and projected growth, sees the largest savings over BAU in buildings and industrial sectors. Additional potential variations are explained in the drivers section.

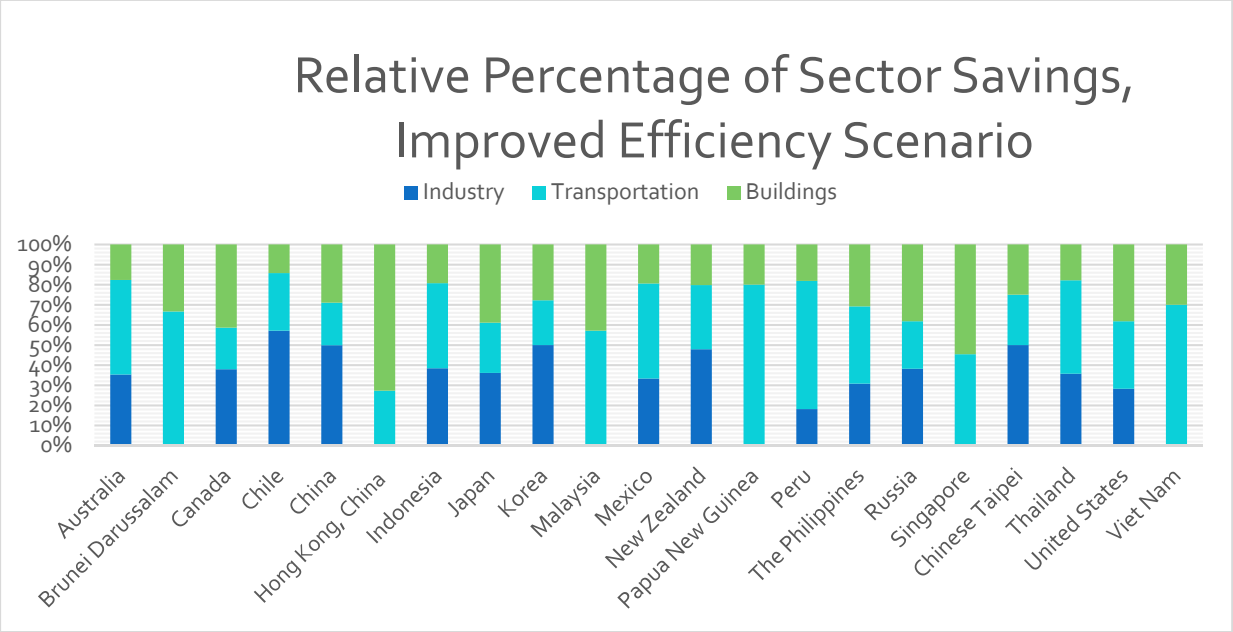


Figure 5. Percentage Sector Savings in the IEE Scenario, APERC 2016

3.2 Industry Sector

This section includes an overview of industry sector energy use and energy efficiency, drivers and barriers from recent global reports, and APERC research. According to the IEA, the industry sector currently uses the most energy of any sector, at 54% of global final energy demand. It is also the largest sector in the APEC region and it will remain so throughout the APEC outlook period, with a 1% annual average growth rate and one third of the energy demand in 2040. Although accounted separately, 'Non-energy' uses (heavy industry such as refineries that use fuel products to create energy, not manufacture products) add another 10% to the total demand.

Although estimate indicate that the global financial share of the industrial sub-sectors will not shift significantly between 2012 and 2040 [10] global averages hides large regional variations between developed and developing countries and within APEC. Energy-intensive manufacturing average annual growth rates in APEC economies range from 4.3% AAGR in China to zero AAGR in Japan. [10] . The role of strong policy and regulator environments play a large role in improving energy efficiency in such a complex sector. The International Energy Agency (IEA) estimates that between 2000-2015 the share of global energy consumption covered by mandatory energy efficiency policies rose from 11 to 30 percent. Of that 30%, about one third, (11%) covers the industrial sector (Figure 6)

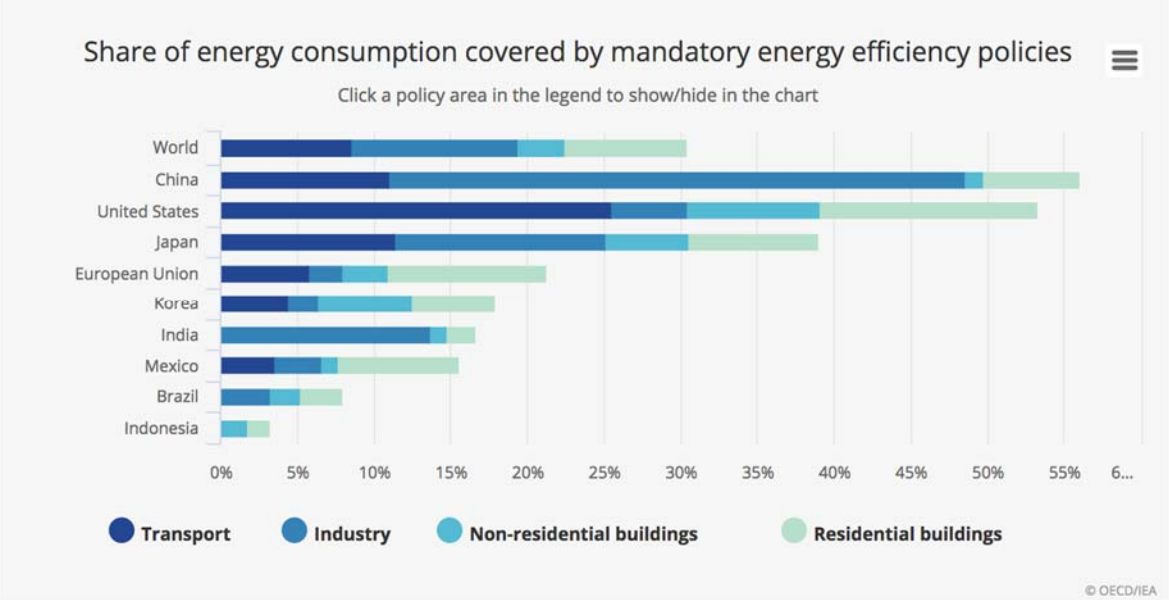


Figure 6. Energy Consumption covered by mandatory energy efficiency policies, IEA

Benefits of energy efficiency in the sector include lower production and maintenance costs for industries, lower risk from energy price volatility, reduced waste, heathier work and living environments, lower regulatory costs, reduced Co2 emissions, and even lower public expenditures.

3.2.1 Sector Overview in APEC

If all APEC economies adopt the improved energy efficiency scenario the total sector demand could be reduced by 368MToe by 2040, nearly the combined industrial energy demand of the U.S., Japan, and Korea.

Potential industry sector energy efficiency savings in the APERC Improved Efficiency Scenario		
	Assumed improvement potential (%)	
Energy Intensive Sub-sectors	Developed economies	Developing economies
Iron and Steel	10-15	25-35
Chemicals and Petrochemicals	10-25	15-30
Non-metallic mineral	20-25	20-30
Food and Tobacco	25-40	25-40
Paper, pulp, and printing	20-30	15-30
Non-ferrous metals	5-40	5-55

Table 3. Industrial high-energy use subsector savings potential in APERC IEE scenario

The sector has the widest range of potential savings in the scenario. Economies such as Brunei Darussalam; Hong Kong, China; Papua New Guinea; Singapore; and Viet Nam do not see any additional savings in the sector. One – Malaysia – was not analyzed by APERC due to lack of data. In contrast, other economies see more than half of their savings in the sector (see Table 6).

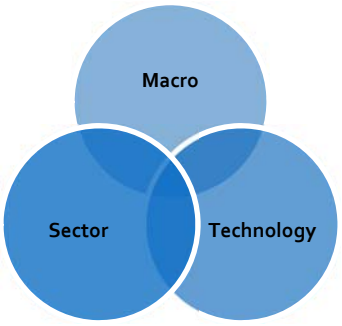
Energy-intensive manufacturing subsectors have a wider range of savings potential in developing economies, due to economic growth, current regulations and manufacturing practices. One example is the category Iron and Steel. Developed economies recycle a large percentage of steel, reducing overall energy intensity. Developing countries with high demand in sectors like buildings use more 'virgin' steel, raising the energy requirements. Within the sector, non-intensive categories like electrical equipment, wood products, and plastic account for 84% of projected growth and 70% of potential savings.

In the scenario, 94% of additional savings come from nine economies: China (198MToe), the U.S. (54MToe), Russia (21MToe), Indonesia (20Mtoe), Japan (13MToe), Mexico (12MToe) Canada (11Mtoe), Thailand (10MToe), and Korea (9MToe).

China dominates the sector savings potential over the outlook period, with 53% of the total sector energy demand in APEC. By comparison, at 15%, the United States is the second highest sector energy user. One year of industry savings in China equaled 48% of China's funding for energy conservation *in all sectors* during the first four years of the 12th Five Year Plan. In 2015, the incremental global energy efficiency investment in the industry sector was US 39 billion [2] and China spent 20.5% of total world spending (US 8 billion) Chine also dominates the use of mandatory energy efficiency policies, covering 56% of China's total energy consumption and 37% of the sector demand. The only other APEC economy above the global sector average is Japan, at 13.7 percent of the industrial sector.

3.2.2 Drivers and Barriers

The following section highlights industry sector-specific drivers and barriers collected from recent reports published by organizations such as APERC, the International Energy Agency (IEA), and the United Nations (UN). Increasing energy efficiency in the sector requires addressing macro-economic trends and global drivers, as well as overcoming sector-specific barriers and technological constraints. Drivers that fall under 'Macro' include issues that are evaluated in aggregate across economies, economic regions, or globally. Within an economy these drivers can include population growth, national income and gross domestic product, urbanization or financial markets. Other macro factors can include global energy supplies, energy subsidies and multi-lateral agreements. Sector drivers can include policy and regulatory environments, the types and size of sub-sectors, or local conditions such as available resources and technical capacity. Other economy-specific factors include geography, climate, energy supply mix, or utility infrastructure. Technology drivers range from investment costs, availability of existing best-available technologies and emerging innovations. All of these factors often work together, making feedback loops, creating barriers and forming new opportunities. Understanding these drivers and barriers can help APEC policymakers identify strategies to strengthen and promote energy-efficiency practices and technologies across APEC.



3.2.2.1 *Macro*

Energy efficiency demand and investment opportunities are driven by macro-economic trends such as energy supply prices and financial markets, energy supply sources, economic and population growth projections, socio-economic structural shifts (globalization and trade), multi-national agreements (energy access, security, emissions, etc.), and urbanization.

Energy Subsidies.(Table 4**Error! Reference source not found.**) Fossil fuel subsidies reduce incentives to adopt more stringent energy efficiency policies by economies and reduces private sector investments in all demand sectors. There are currently ten APEC economies with energy subsidies.

Table 4. Energy Subsidies in APEC Economies, 2016 Outlook

	Economy	Average subsidization rate (%)	Subsidy per capita ($/person)	Total subsidy as share of GDP (%)
1	Brunei Darussalam	30%	422.1	1.5%
2	China	2%	14.0	0.2%
3	Chinese Taipei	0%	0.1	0.0%
4	Indonesia	22%	59.5	1.8%
5	Korea	0%	2.3	0.0%
6	Malaysia	4%	35.4	0.4%
7	Mexico	8%	49.2	0.5%
8	Russia	22%	210.9	2.3%
9	Thailand	3%	13.2	0.2%
10	Viet Nam	1%	2.3	0.1%

Wholesale Energy Supply. Volatility in the markets, fossil fuel costs and cheaper efficiency/renewable technologies increase the attractiveness of energy efficiency investments. Positioned as a "first fuel", governments see efficiency as a means for increasing energy security as their economies – and fuel imports – grow.

Changes in energy supply prices can also reduce the risk and increase the ROI of efficiency projects, creating larger pools of investors willing to invest in energy efficiency programs or technologies.

Financial Markets. Investment in energy efficiency relies on financial market support. Tax and subsidy structures, debt payback frameworks with IFIs, international trade agreements, raw material and fuel subsidies, transaction costs, real interest rates, split incentives and utility business modes can all distort finance markets. These barriers negatively affect return-in-investment (ROI) calculations, creating investment risks for banks and utilities as well as reducing public and private support [16]. According to a recent U.N. survey, the financial environment is generally not very favorable for investments in energy efficiency. Banking institutions are generally unaware of energy efficiency financial instruments, or tend to see efficiency projects as weak investments. When efficiency investments become more attractive new financial instruments and markets grow and increase developing economies' access to international capital funds. In many economies, companies cannot find efficiency investments financing. International finance institutions (IFIs) such as the World Bank are designing financial instruments that integrate technology assistance with financing and risk sharing via local banks.

Energy Supply. In the BAU scenario, 90% of total primary energy supply (TPES) growth comes from the developing economies of China and South-East Asia and fossil fuels support 80% of that growth. In that scenario, energy demand projections means APEC as a region will have supply gap of more than 10%, increasing dependence on fuel imports. Although the growth of developing economies still drive demand in the APERC Improved Efficiency Scenario, the additional savings in the demand side sectors can address this gap as well as help APEC economies achieve the 45% energy intensity reduction goal.

Case Study: Overcoming Financial Barriers

HARBEC, a custom Computer Numerical Control (CNC) machining and manufacturing company outside of Rochester, New York near Lake Ontario, faced two major energy-related problems: machine shops would reach well over 100F on warm days, and the low-voltage electricity from the local utility companies wasn't compatible with their high-precision equipment. With air conditioning too expensive, the company decided to harness the waste heat instead to generate power. A Combined heat and power solution, with 25 micro-turbines powered by natural gas, along with two wind turbines was the solution. However, banks did not understand CHP and renewable energy investment risks. NYSERDA - the New York State Energy Research and Development Authority – helped HARBEC with upfront investment costs and put them in touch with a bank that specialized in energy efficiency loans. The investments save the company over $20,000 USD every month and HARBEC has begun selling energy to four neighboring companies. The owners consider the 8-year payback on the wind turbines worth the investment because the turbines have a 15 to 20 lifespan. As an employee profit sharing company, all the employees are invested in energy efficiency solutions.

The volatility of fossil fuel markets, both oil and natural gas, as well as the integration of renewables into energy grids, will all shape the investment incentives for energy efficiency policies and measures. Cost-effective demand management and storage measures increases economic energy security, a concern of economies that rely on energy imports to grow their industrial and services sectors. It can also reduce public sector budgets in economies

Population Growth and Rising Incomes. With the IEA estimating strong growth (1.2%/year), the industrial sector is, and will continue to be, the largest global consumer of energy. Population growth and rising incomes bring rising demand for buildings, household goods, appliances, and air conditioners.

Services Sector Shift. Knowledge products are now driving today's markets. In 1980, tangible assets like buildings, equipment, and inventory made up 80% of the S&P 500 Index. In 2016, nearly 80% of the index was represented by intangible assets—patents, trademarks, brands, research, and software. Employment in high intensity industry —which includes manufacturing, mining, and construction—declined as a share of total employment between 1980-2015 in developed economies such as U.S., Japan, and Korea. However, rates in developing economies such as China have gone up. Service sectors still rely on higher-intensity manufacturing and mining sectors – computers, phones and telecommunications equipment require aluminum, silica, and copper. Batteries, a critical component in renewable energy and smart grids, require rare earth metals and minerals such as cobalt and the market is expected to grow over 20% annually.

Urbanization. In response to urbanization, smart city planning and transportation investments can start to shift sub-sectors like automobile manufacturing towards other modes like buses or trains, reduce demand for new transportation infrastructure like roads, or reduce demand energy supply infrastructure such as power plants. The service sector shift is also driving the growth of commercial buildings (sometimes larger than residential growth) increasing the demand for construction materials, concrete, and building systems. As a result, building sector strategies like building codes and green supply chains will affect energy efficiency in some sub-sectors.

Global Agreements. Tying the benefits of industrial sector energy efficiency to global targets goals such as emissions, health, poverty and the environment can create stronger demand for regulation and investment interest in energy efficiency measures. Structuring information and awareness campaigns to focus on the industry sector can increase pressure on industries to adjust business models and management practices to meet targets, alter consumer demands, and grow new "green" markets. One example is the IEA's "Bridge Strategy" to address immediate GHG emission reductions and Intended Nationally Determined Contributions (INDC) to the COP21 agreement. It includes improving energy efficiency in the industry sectors as well as phasing out the least-efficient coal-fired power plants. IEA research (Figure 7) indicates that CO2 emissions from the industry sector in emerging economies doubled from 1990 to 2016, driven by large increases in the production of energy intensive

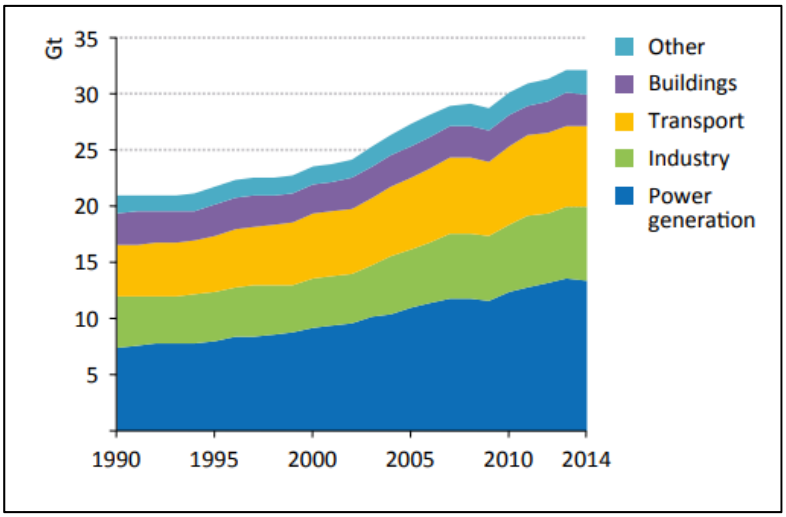


Figure 7. Global Energy-related Co2 emissions by Sector, IEA

subsectors, such as cement and steel.. Most economy INDCs reflect currently available technological solutions, but reaching larger reduction scenarios will require increasing R&D investments in technologies such as Carbon Capture and Storage (CSS) in both energy production and industry sectors.

3.2.2.2 *Sector*

The industrial energy sector is large and complex. Typically divided into energy-intensive, non-energy-intensive and non-manufacturing categories, the sources of inefficiencies, technologies, and opportunities for innovation vary widely. However, the use of steam and electricity for power and equipment such as motors are common, especially among high intensity subsectors such as aluminum, steel, and mining. A low level of mandatory efficiency regulations and lack of strong energy management practices is also common throughout the sector.

Policy and Regulatory Environment. Economies need to create clear industrial energy efficiency agendas with a policy and regulatory options customized to their sectors that support efficiency investments. In 2016, the IEA released a report [11] that outlined important actions to increase industrial energy efficiency, particularly in emerging economies. Government policies that enforce mandatory standards or create strong voluntary incentives are critical to the successful adoption of best practices and technologies such as variable speed drives; energy audit programs; low-temperature heat pumps; and heat recovery technologies. Globally, 90% of motors only follow minimum electrical performance standards (MEPS), making Improved electric motor systems performance standards an important element of industrial energy efficiency.

In the U.N.'s guide [12] to holistic green industrial policy, energy efficiency is integrated with other economic policy goals. Policies should reflect circular economic systems and the entire lifecycle of a product, including raw material extraction, production, consumption, and disposal. Water and

Case Study: Policies

The Vietnamese Energy Efficiency and Conservation Program (VNEEP) was a 10-year program between 2006 and 2016 to institute energy efficiency and conservation improvements in all sectors. The industry sector target a savings was between 875 and 1,400 ktoe by end of 2015. Goals included energy audits in 300 large enterprises and 12 power plants, certification of 2,500 energy managers and 200 auditors, and energy management system (EnMS) implementation at 1,024 designated enterprises. In 2011, Viet Nam also began requiring utility energy efficiency plans, mandatory energy labels and standards for appliances and equipment, and energy efficiency in building codes. According to the Copenhagen Centre on Energy Efficiency, total energy savings are estimated at about 4,900 ktoe, or 3.4% of total energy use at the 250 enterprises that have gone through the program.

China's Top 10,000 Energy Consuming Enterprises Program, was a 12th five-year plan extensive of the 11th five-year plan's Top 1,000 Consuming Enterprise program that established mandatory targets and auditing programs for heavy energy users in the industrial sector. The second phase, expanded to include public buildings and transportation, targeted 15,000 enterprises that were required to meet China's Industrial Energy Performance Standards. They were supported by energy training programs, financial incentives and, in 2011, the introduction of Energy Service Providers (ESCOs). Consequences for not submitting energy data and improving energy performance could include refusals of new capital or land expansion requests.

materials, in addition to energy, should be economically de-coupled from industrial growth as potable water demands increase and climate changes affect available resources. Finally, co-benefits such as lower GHG emissions and less pollution should be integrated into efficiency and intensity targets. In the IEA's 2016 renewable-based energy scenarios the investments in renewable power generation (particularly in the four largest markets in China, The United States, India, and the European Union) costs consumers little thanks to parallel investments in energy efficiency.

Case Study: Information and Education

DOE Advanced Manufacturing AMO Software Tools are open-source software designed to help manufactures increase both plant and system level energy efficiencies. The tools help manufactures calculate energy usage, as well as monitor and manage major systems including pumps, fans, process heat, steam and compressed air. Planning tools help teams track and register actions and M&V protocols.

Monitoring and Enforcement. "You can't improve what you can't measure". In addition to supporting policy pathways and regulations, economies need to implement monitoring programs and enforcement programs. These programs, however, can create administrative burdens. Programs should be designed to address financial constraints such as lack of access to capital or compliance costs. Monitoring also creates better data, helping industries understand how much energy they are using and wasting and more accurately measure return-on-investment of technologies and management practices. Better data also helps policymakers craft better programs and targets.

Information and Education. A lack of information and awareness about energy efficiency benefits and costs by policymakers, users, manufacturers, and even utility companies reduces the effectiveness of energy efficiency practices and technologies. Capacity building measures that develop skills and knowledge of in-house personnel at companies can improve technical expertise and build professional networks across the supply chain. Education for policy makers allow stakeholders to share direct experiences, best practices, learn about new research and obtain expert advice.

Geography. Climate and terrain variations (sun, hydrology, available land and ports, natural resources) shape the types of efficiency and renewable strategies that are physically and/or economically feasible within an economy. Even though the sector is heterogeneous, best practice solutions to similar geographic barriers can be shared around the world. A geographic driver that shapes efficiency in APEC is climate. Like the building sector, economies with tropical climates must contend with cooling requirements while cooler climates deal with insulation and heating requirements.

3.2.2.3 *Technology*

Innovation and Research. Unlike the building sector, increasing the adoption of best-available technologies is necessary but not sufficient to reach global efficiency and emissions goals. Industry R&D requires investments in chemical, electrical, and mechanical engineering as well as basic science research.

Energy Management Systems and Standards. Energy management systems and programs such as the ISO 50001 help organizations use energy more efficiency through a combination of data benchmarking, management techniques, consumption tracking improved technologies and process optimization. Organizations need to invest in data and systems management, training and education, and encourage new business energy missions to increase efficiency across complex manufacturing processes.

Data. Innovations in communication and data technology also creates opportunities for efficiency through better monitoring, measurement and management of manufacturing processes and systems. The development of open standards and interoperability of technology systems makes metering and monitoring simpler and more cost effective. Using similar systems also helps best practices and research spread more effectively.

Automation. Software and data technology innovation is driving systems and equipment automation. The ROI of automation is making technology innovation a more attractive investment tool than labor and regulation arbitrage (relocating for cheaper labor markets or favorable regulations and taxes) to increase profit margins. These trends can lower costs of manufacturing, but may also are transform heavy manufacturing sub-sector practices

Energy Losses. End use energy losses make up nearly half (42%) of the fuel supply used in the sector. (Figure 8) Equipment inefficiencies combine with mechanical and thermal limitations to make this a major area of improvement. Adopting best available technologies (BATs), increasing minimum energy standards (MEPs), and innovation are all needed to address areas of opportunity, including:

Case Studies: Energy Management

Kantang Hospital, a 60 bed community hospital in Trang Province in **Thailand** near the Andaman Sea, provides 24/7 care service to residents. To keep the complex running, the hospital used electricity, diesel and LPG. In 2010, the Director instituted a 3P (Place, People, and Process) strategy consisting of three energy teams with over 35 staff members. First phase projects were low-budget operation changes. Eventually, projects with less than 3.5 year payback periods were implemented. The result of energy conservation programs saved 15,008.02 kWh per year of electricity and 64,834.65 baht per year of electricity cost. The energy efficiency index for hospitals (measured in MJ per bed/days) dropped 5.61 percent from 20120 to 2013.

Indonesia Power, the larger power producer in Java Bali, started energy management planning in 2009. To be economically competitive and reduce the price of its power generation, Indonesia Power implemented ISO 50001 using a method called 5E (Enhancing and Embedding Energy Efficiency Excellence). Between 2010 and 2016, the company hired 10 certified energy auditors and 15 energy managers and created a energy management team. In 2016, the result was $37.53 million (USD) savings, a 3.21% plant heat rate savings, and a payback period of 11 days (0.032 year). [23]

- **Combined heat and power (CHP):** An approach that combines electricity generation with captured thermal energy in an integrated system.
- **High intensity system design**: steam, process heating, motor-driven equipment (e.g. data centers, server farms)
- **Materials innovation**: electronics; engine/mechanical materials; catalysts and refining; reactions/separations/catalysts
- **Process innovation**: High temperature processing; Sustainable processing; Waste Heat Minimization/recovery

In the IEA's most recent energy and emissions scenarios, renewables also play an integral role in industrial sector efficiencies by providing heat, mainly in the form of bioenergy, in emerging economies.

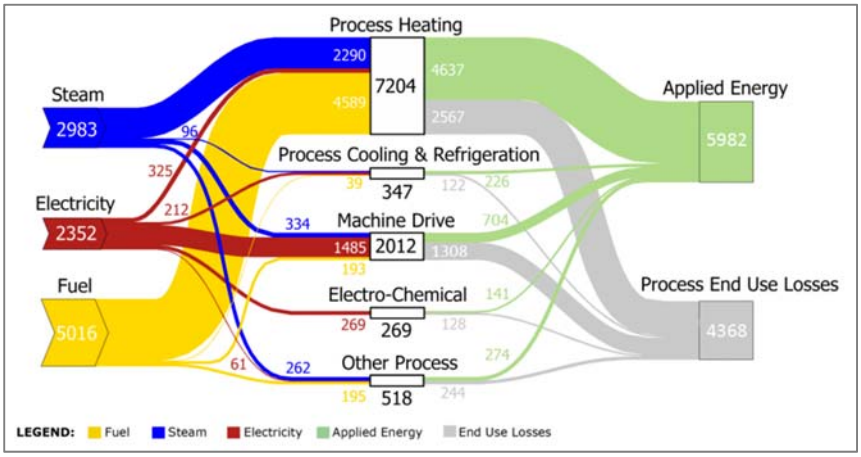


Figure 8. U.S. DOE 2010 Manufacturing Energy and Carbon Footprint

Price. Wide spread adoption of new or improved technology in the private sector usually happens once the price of the technology creates a positive return-on-investment (ROI). Education and campaigns that highlight the co-benefits of new technologies over their initial investment outlays can increase market penetration, which, in turn, helps lower the price further. This momentum effect requires early adopters and/or policy and regulatory incentives. The barrier is most often discussed in the context of renewable technologies, but applies equally to technologies that improve efficiency.

3.2.2.4 *Economy Demand*

APERC models analyze six sub-sectors all considered to be high-energy intensity categories: Iron and Steel; Chemicals and Petrochemicals; Non-metallic Minerals; Food and Tobacco; Paper, Pulp, and Printing; and Non-ferrous metals (Table 5**Error! Reference source not found.**). Due to production variations and energy intensity, potential savings vary. The range of savings is relatively lower in developed economies due to efforts, such as in the United States, where the use of ISO 50001 for industrial energy management is promoted by federal agencies. The IEE scenario shows that additional savings in the industry sector have two distinct peaks – at zero and 16-20% over BAU.(

Table 6) The sector is also the most varied in its contribution to economies potential IIEE scenario savings. At zero are Brunei Darussalam; Hong Kong, China; Singapore; and Viet Nam, which do not

show additional industry sector efficiency savings in the scenario. In addition, APERC did not model the industry sector in Malaysia due to lack of data. Economies in which the industrial sector contributes 50% or more of the savings are Chile; China; Korea; New Zealand, and Chinese Taipei.

Table 5. Potential energy savings in Industrial Subsectors in the IEE Scenario

Potential industry sector energy efficiency savings in the APERC Improved Efficiency Scenario		
	Assumed improvement potential (%)	
Sub-Category	Developed economies	Developing economies
Iron and Steel	10-15	25-35
Chemicals and Petrochemicals	10-25	15-30
Non-metallic mineral	20-25	20-30
Food and Tobacco	25-40	25-40
Paper, pulp, and printing	20-30	15-30
Non-ferrous metals	5-40	5-55

Table 6. Industrial Sector Demand Projections, APERC 2016 data

Industry Sector 2040 Demand Projections					
Economy	**GSP AAGR**	**BAU (Mtoe)**	**IEE (Mtoe)**	**% Change**	**Sector % of total scenario savings**
Australia	2.80%	32	26	-9%	35%
Brunei Darussalam	1.20%	0.2	0.2	0.0	0%
Canada	1.70%	59	48	-19%	38%
Chile	2.70%	20	16	-20%	57%
China	4.90%	1182	984	-17%	50%
Hong Kong, China	2.20%	1	1	0.0	0.0%
Indonesia	4.40%	97	77	-21%	38%
Japan	1.10%	80	67	-16%	36%
Korea	2.20%	52	43	-17%	50%
Malaysia	4.20%	27	27	0.0	N/A
Mexico	3.00%	72	60	-17%	33%
New Zealand	2.30%	5	4	-20%	48%
Papua New Guinea	6.40%	3.6	3.6	0.0	0%
Peru	3.90%	11	9	-18%	18%
The Philippines	6.00%	25	21	-16%	31%
Russia	1.40%	150	129	-14%	36%
Singapore	1.40%	7.6	7.6	0.0	0%
Chinese Taipei	0.90%	24	20	-17%	50%
Thailand	3.50%	60	50	-17%	36%
United States	1.60%	316	262	-17%	28%
Viet Nam	5.50%	65	65	0.0	0%
APEC TOTAL (Mtoe)		2289.4	1920.4	-16%	

Economy information relies on APERC research and supplemented by IEA Energy Efficiency Indicators, where available.

Australia

The industry sector (Figure 9) is the largest user of energy in Australia and basic metals mining is the largest sub-sector in the economy; AUS is APEC's second-largest uranium producer (world's 3rd largest), fourth-largest coal producer, and sixth-largest gas producer. According to the IEA, Australia's sector energy intensity outpaced the U.S, Japan, and Korea in 2013, while remaining slightly lower than Canada, another APEC economy with a large mining sub-sector. Industry demand is expected to grow less than 1% AAGR, but the share of metal and quarry mining in industry grows to 20% as the sectors focuses on production, rather than infrastructure investment.

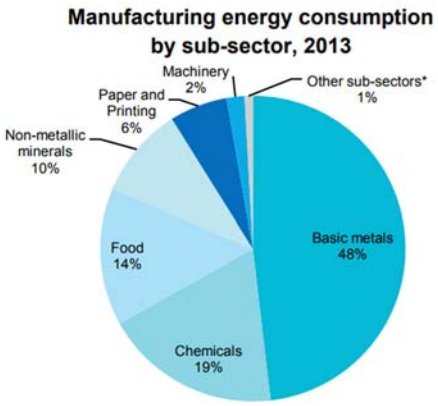


Figure 9. Australia, Manufacturing Energy Consumption, IEA

Australia's Energy Efficiencies Opportunities Program (2006) requires energy audits of large energy users (captures 56% of economy wide energy use) and the program has already led to 40% energy savings in the sector.

Brunei Darussalam

Investments in oil and gas industries, at two-thirds of GDP, dominates Brunei Darussalam's economy. With reserve estimates showing only 20-25 years of supply left, the government is committed to diversifying its economy at the same time it is increasing major industry investments. Demand will be driven by non-energy use downstream investment in refineries (such as a 2010 methanol plant). Production of non-energy fuel uses is anticipated to skyrocket to 44% of energy demand in 2040 (significantly higher than the average APEC non-energy demand average of 10%). APERC does not anticipate additional savings over BAU in the sector.

Canada

With APEC's largest oil reserves (and second-largest in the world) Canada's manufacturing and heavy industries contribute 13% of GDP. With the growth of the LNP markets, the sector's importance will grow in relation to other industry sub-sectors such as paper and printing or metals (Figure 10). Canada's energy industry can expect large structural shifts due to low-carbon climate policies and the phase out of coal-fired energy plants. The government has also implemented energy efficiency programs targeting improved technology investments and management best practices in the sector.

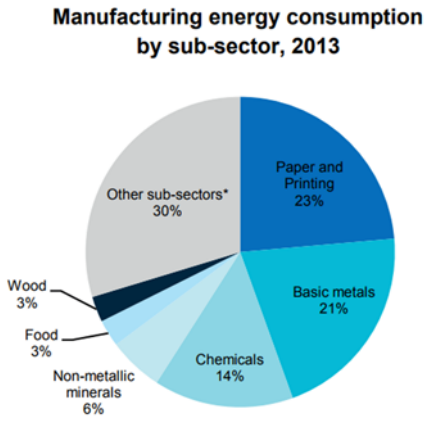


Figure 10. Canada, Manufacturing Energy Consumption, IEA

Chile

With a rapidly transitioning economy, Chilean energy demand is expected to grow 67% by 2040. Mining, specifically copper (92% of mining exports and 41% of total exports) dominates the economy and energy demand. With very limited natural energy reserves the economy imports 90% of its oil and 80% of its gas, placing pressure on growing industries to be more energy efficient and increase the adoption of renewables. Chile's Energy 2050 plan includes a 70% renewables target for electricity demand (60% by 2035).

China

Industry energy efficiency measures are focused in key high intensity sectors: iron and steel, cement, and chemicals. Energy intensity in these sub-sectors dropped by 23% from 2005 to 2013 due to policies that encourages CHP, ESCOs and mandatory energy quotas that helped retire outdated facilities. China's 13th 5-year plan continues to shift away from energy-intensive industry and manufacturing to focus on higher value-added service industries. With existing policies in place, APERC projects an economy-wide BAU energy intensity reduction of 65% (2005 – 2035), well above the APEC wide energy intensity target.

Hong Kong, China

Hong Kong, China, as a service-driven economy, has the lowest energy intensity of all APEC economies and a very small industry sector. Much of the manufacturing sector has shifted to mainland China due to space constraints and costs. Industry energy demand is expected to peak at 12% of the economy before 2040. By 2040, buildings (66%) and transportation (21%) will dominate strategies to meet the economy-wide 40% energy intensity reduction goal.

Indonesia

Indonesia is the fourth largest population in APEC dispersed over hundreds of islands. It is a large fossil fuel producer, exporting low-ash/low-Sulphur coal and the economy is expanding off shore exploration for new fossil fuel sources. Industry accounts for 21% of total employment but 40% GDP in 2015 [10]. Less-intensive sub-sectors account for 79% of the sector's total energy use. Due to the geography of the islands, efficiency initiatives are preferred over renewable options. Efficiencies lead to estimated investment savings of USD 143 billion compared with the BAU, primarily because it lowers energy generation demand.

Japan

Japan's manufacturing sector accounts for 20% of GDP while industry overall is 28% of GDP (value added). Industry as a proportion of GDP has dropped significantly since 1970 (43%). Major industries include automobiles, consumer electronics and computers, semiconductors and Japan is the third largest producer of steel in the world (Ferrous Metals, Figure 11). Due to the steep volcanic geography that limits renewables, post-Fukushima nuclear energy policy changes (and higher imports as production dropped) and imported fuel, energy efficiency is a key element to reach intensity targets The highest energy intensity sub sectors have already adopted strong EE measures and the average annual growth of energy-intensive manufacturing sectors in Japan is zero. [11] By 2040, industry is expected to be second

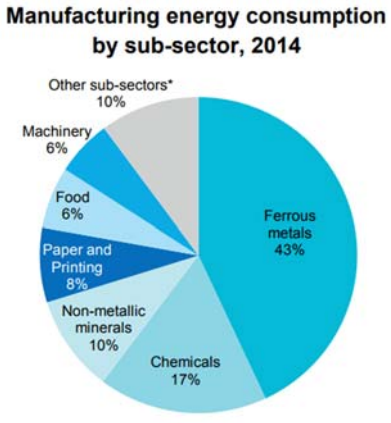


Figure 11. Japan, Manufacturing Energy Consumption, IEA

highest sector for energy, below buildings; however, industry energy demands flatten and then decline because of structural issues, including a shrinking working-age population and low birth rates.

Korea

Nearly three quarters of Korea's energy efficiency savings since 2000 have come from the industry sector. However, Korea's three largest industries (iron and steel, chemicals and petrochemicals, and non-metallic minerals) peaked in the 2010s and the building sector is estimated to pass industry in absolute demand before 2020. Existing programs facilitating efficient energy use include mandatory auditing, ESCOs and tax incentives. In 2014, the state Ministry of Trade, Industry and Energy supported the creation of six new energy-related businesses (such as ESCOs) focused on reducing sector demand. (

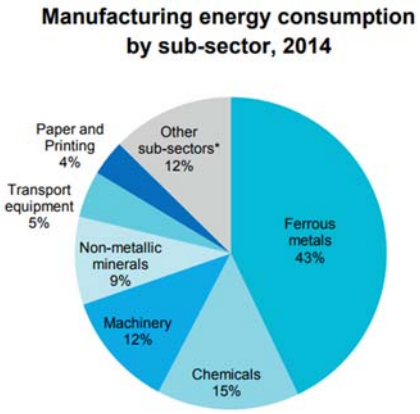


Figure 12. Korea, Manufacturing Energy Consumption, IEA

Malaysia

Malaysia is expected to achieve 'high-income economy' status in 2020. It is also estimated to be the sixth fasted growing economy in APEC, with GDP AAGR of 4.2%, and transition to a net importer of energy. As a result, it has a new focus on energy security, and increasing demand efficiencies. In 2015, the government prioritized a comprehensive demand-side management (DSM) master plan for all sectors. By 2040, the economic structure is predicted to shift from manufacturing to services. Despite these structural shifts, the economy-wide energy demands are estimated to grow 64% by 2040 from '13 levels.

Mexico

Energy reforms in 2013 that opened state control of oil and gas industries to private investment are expected to create efficiencies throughout the energy sector. Mining and fuel generation activities contributed 8.6% of GDP in 2013, but 34% of total primary energy supply. Although demand is currently dominated by services (62%), industry demand is expected to double by 2040, tying transportation for total demand (72 MTOE) in the BAU scenario. This increase is driven by cement and chemicals manufacturing sub-sectors.

New Zealand

The largest growth industry is food manufacturing, which is growing to meet Asian demands for dairy products. High intensity manufacturing is expected to remain flat but industry at large is still the major source (59%) of projected economic growth by 2040 (2.3% GSP AAGR). Anticipated industry demand will require natural gas and renewables to meet demands. New investments or imports in natural gas, however, is in stark contrast to current energy sources and intended goals. Supply is already 74% renewable and the governments stated goal is to be 90% renewable by 2025.

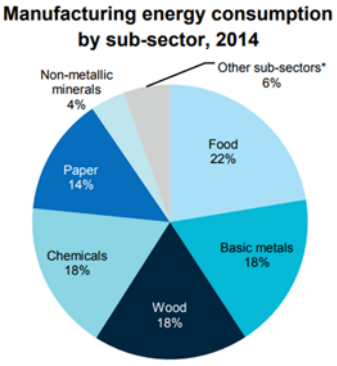


Figure 13. New Zealand, Manufacturing Energy Consumption, IEA

Papua New Guinea

Despite its small size and low access to electricity (15% pop, all urban areas), the economy is expected to be the fastest growing in APEC (6.4% GDP AAGR) with a 4-fold increase in final energy demand with industry expansion a large contributing factor (64% of total energy demand). Mining and cash crop exports drive the expansion. The government, recognizing its dependence in mining, looks to diversity with increased FDI.

Peru

Peru exports are commodity-based, particularly natural gas and mining. Industry is the largest energy demand sector in the Peru economy. Gas and Mining represent 70% of industrial GDP. Investments include a third pipeline under construction. The sector is 24% of total GDP, second to the services sector (60%). The General Directorate of Energy Efficiency (DGEE) was created in 2010 to serves as the technical regulatory body, lead energy planning, and to develop the '*National Energy Plan'.* Efficiency policies include improved technologies and labeling schemes but the economy generally lacks incentives, promotional activities, and a capacity for auditing. The industry faces geographic hazards include earthquakes, volcanos and El Nino weather systems.

The Philippines

With some of the strongest economy-wide growth projections (6.0% GDP AAGR) in APEC, the government run Manufacturing Resurgence Program aims to revive the sector under the Industry Development Program. Half of energy demand is supplied by renewables and recent studies point to large capacity for renewables based energy intensity reductions. However, programs and policies that support efficiency measures have been identified, including audits, labeling schemes, ISO standards and management best practices. The economy and the sector still relies heavily on coal.

Russia

With energy supply exports dominating the economy, industry sectors are expected to drive total energy demand. However, studies indicate that Russian cannot rely on oil and gas exports to increase GDP without energy efficiency investments in aging infrastructure (e.g. transmission lines, district heating systems) technologies. Although the share of the three most energy-intensive industries (iron and steel, chemicals and petrochemicals, and non-metallic minerals) declines slightly to 56% by 2040, it is still one of the highest shares in the APEC region.

Singapore

Singapore's energy mix is expected to shift from 95% to 100% LNG by 2040 and it already ranked as one of the least carbon-intensive economies in the world. The industrial share of energy demand is projected to increase only slightly. A small island economy with very limited renewables options and a ban on nuclear energy, efficiency is critical strategies for reducing energy intensity. The economy already invests in industrial energy efficiency programs and the APERC efficiency scenario shows no additional opportunities for increased efficiencies in the sector over BAU.

Chinese Taipei

Chinese Taipei is a developed economy that has shifted from manufacturing to services over the last 15 years. However, as a small island economy, the economy is almost completely reliant on imported fuel (97.5% of supply). In 2011, the economy announced a goal to increase energy efficiency 2%/yr, in part to decrease reliance on the domestic nuclear energy after the Fukushima accident. Total energy demand is projected to remain nearly flat through 2040 in large part through a focus on low-intensity industrial investment.

Thailand

In Thailand Industry currently accounts for 29% GDP and growing this sector is a priority for the government. With an annual 2.6% AAGR industry will continue to be the largest energy demand sector through 2040. In 2014-2015 economy level energy policies focused on security, but did include a 30% reduction target for energy intensity and promoting energy efficiency with sub-sector specific policies.

United States

Industry currently accounts for 12% of U.S. GDP. Although the U.S. has a high per capita energy use and provides the second largest contributions toward APEC intensity targets, industry efficiencies continue over the APEC outlook period but do not dominate the scenario savings. Industry energy intensity has already decreased 35% since 2000 due to efficiency improvements and the increasing shares of low energy-intensive sub-sectors. 70% of total sector demand in 2012 (EIA 2010 survey, released in 2012) is in Petrol and Coal products (6,137TBtu), Chemicals (4,995 TBtu) and Paper (2,109 TBtu). R&D efforts focus largely on technology optimization.

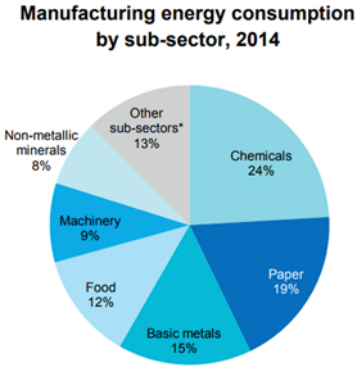


Figure 14. United States, Manufacturing Energy Consumption, IEA

Viet Nam

The Viet Nam economy is expected to rapidly industrialize over the scenario period (5.5% AAGR), but will have the third lowest urbanization rate (49%) in APEC, after Papua New Guinea and the Philippines. It is expected to achieve 100% rural electrification targets by 2020. It's energy demands growth is extreme, from 18MToe in 1990 to a projected 228MToe in 2040, a factor of nearly 13, and intensity per capita triples by 2040. It will become a net importer of fuel and energy efficiency in the energy sector will be crucial to avoiding new carbon-intensive supply investments and import-reliance to meet that demand. Government policy goals include a 1-1.5% years reduction in energy intensity (per GDP).

3.3 Buildings Sector

This section includes an overview of sector energy use and energy efficiency, drivers and barriers from recent global reports, and economy-specific analysis from APERC that affects higher energy efficiency investments in the sector. Benefits of energy efficiency in the building sector can include lower operating costs, reduced waste, heathier work and living environments, higher productivity and lower regulatory costs. More broadly, co-benefits also include reduced Co2 emissions and pollution, and utility and ratepayer benefits such as lower infrastructure demands and low peak demand prices.

3.3.1 Sector Overview in APEC

According to APERC, the Improved Energy Efficiency (IEE) Scenario shows the largest gains in the building sector, allowing most economies to meet or exceed the APEC energy intensity target. China and the United States combined create 66% of the additional savings. Over 88% of the sector's 282Mtoe efficiency gains in the IEE scenario comes from seven economies: China (115MToe), the U.S. (73MToe), Russia (21MToe), Japan (14MToe), Canada (12Mtoe), Indonesia (10Mtow), and Mexico (7Mtoe). China, due to size, dominates the sector with 40% of the scenario's savings. (Figure 15)

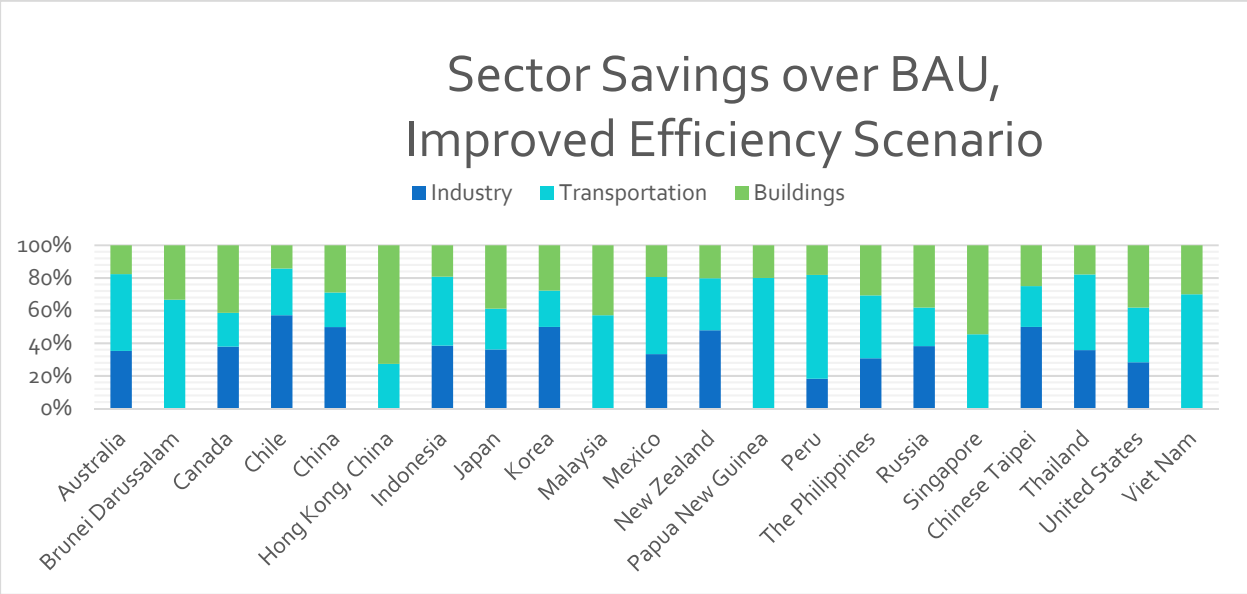


Figure 15. IEE Scenario Savings over BAU, APERC 2016 data

Per capita sector demand will remain highest in mature economies with high urbanization rates and mature building stock such as the U.S., Canada, and Korea. China's savings come from the economies projected growth rate, one of the highest in APEC (4.9% AAGR). However, the United States per capita sector energy demand is expected to remain twice as high as China, reflecting its mature economy and heating and cooling demands of a large existing building stock. Demand per capita in developing economies such the Philippines and Papua New Guinea will be up to 50 times lower than mature economies as urbanization rates remain very low and low energy access impacts rural households.

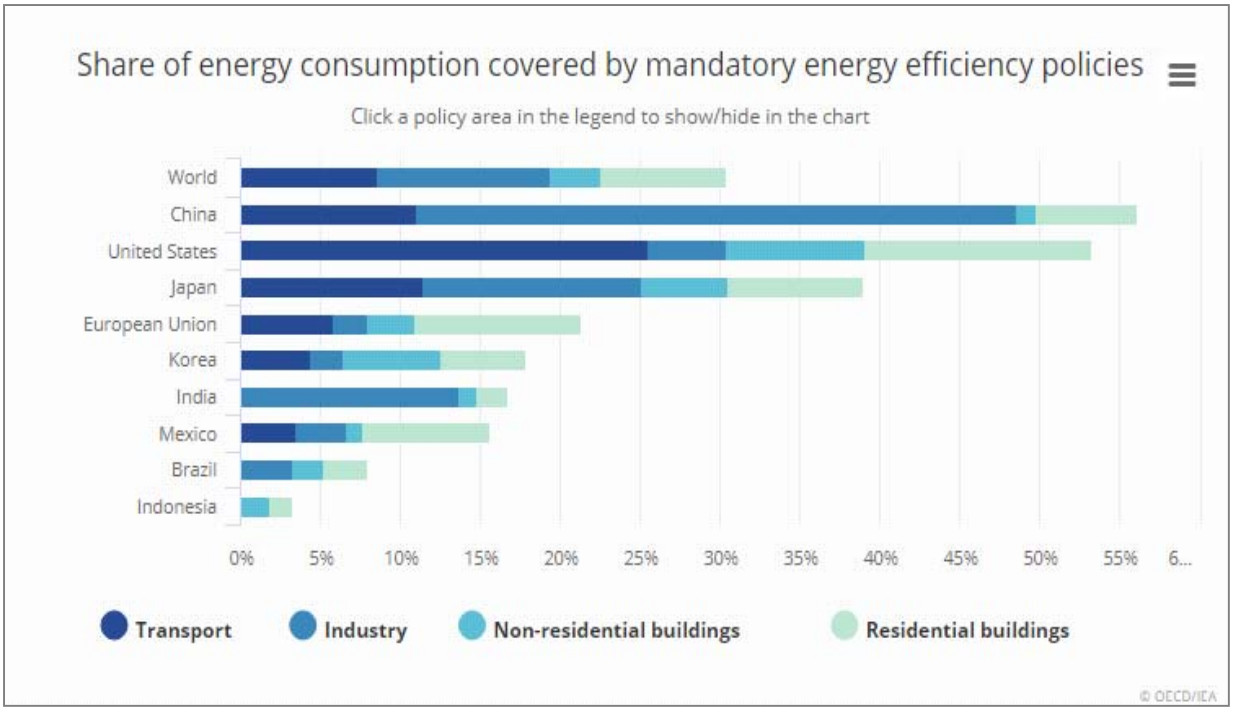


Figure 16. Share of Energy Consumption Covered by Mandatory Energy Efficiency Policies, IEA

A strong policy environment that supports and enforces regulations is important for improving building energy efficiency. The International Energy Agency estimates that between 2000 and 2015 the share of global energy consumption covered by mandatory energy efficiency policies rose from 11 to 30 percent. (Figure 16) The breakdown between sectors and among economies vary widely. Six of nine economies in the IEA analysis are APEC members. Only U.S., China, and Japan coverages are greater than the global average. The U.S., with 23%, leads in the building sector. In contrast, China's mandatory policies cover only 8% of the building sector, nearly all in the residential sub-sector. The U.S., Japan, and Korea have the largest coverage of non-residential building sub-sectors, outpacing China and the European Union. Mexico has focused half of its mandatory policies towards the building sector. In the RISE ratings in section C, the developing economies of Southeast Asia were ranked low in mandatory building energy codes This analysis does not reflect voluntary programs and incentives, which are often more easily adopted by government entities.

Minimum Energy Performance Standards (MEPS) are an important element of mandatory energy efficiency policies in the Building Sector. Analysis by the IEA (Figure 17, Figure 18) indicated that most countries have only incrementally improved MEPS over the last decade, and the spread between MEPS and Best Available Technologies (BATS) are large. Gaps in cooling system MEPS and BATS are particularly large in hot climates. This is of particular concern for APEC economies in South East Asia and China, which dominate new building growth between 2013 and 2040. Heating energy use, which uses half of the global building energy demand, is of concern for APEC economies with cold climates, including Japan, Canada, Korea, the United States and parts of China.

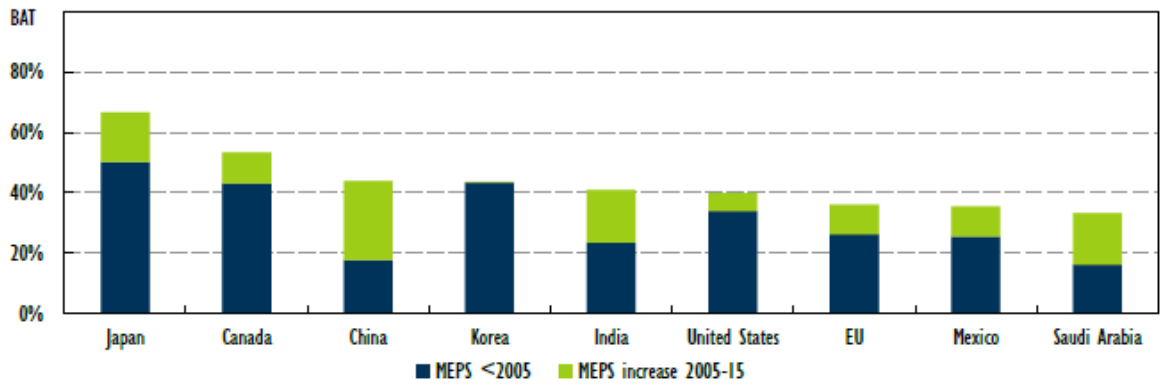


Figure 17. Space cooling equipment MEPS for selected economies, IEA 2016

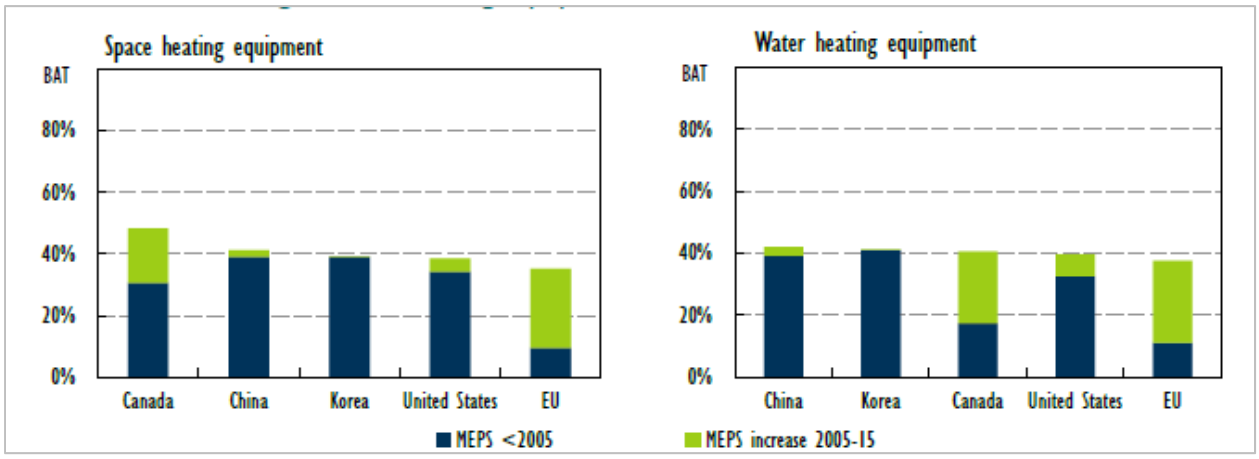


Figure 18. Space and Water Heating MEPS, IEA 2016

Despite concerns for MEPS and BATS in building systems, there have been great improvements in residential appliances and equipment standards over the last 15 years. The IEA's assessment of standard coverage highlights advances in eight APEC countries, showing substantial improvements (often from zero or near zero).

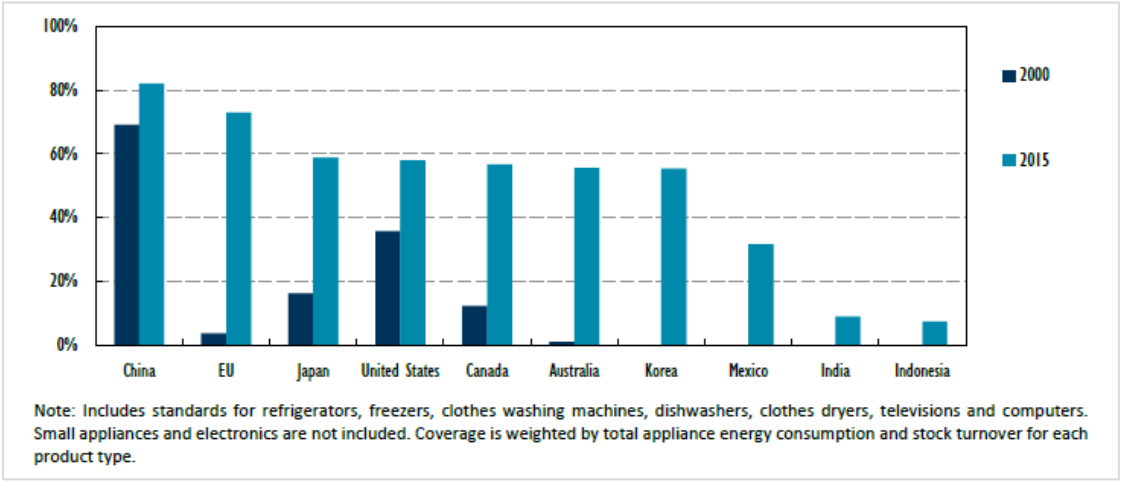
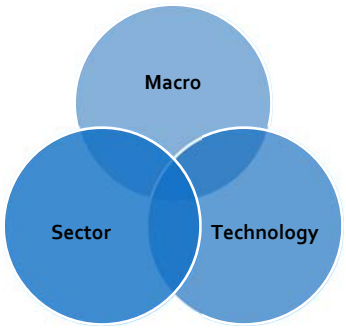


Figure 19. Appliance energy use covered by standards, 2000-2015, IEA 2016

3.3.2 Drivers and Barriers



The following section highlights building sector-specific drivers and barriers collected from recent reports published by organizations such as APERC, the International Energy Agency (IEA), and the United Nations (UN). Increasing energy efficiency in the sector requires addressing macro-economic trends and global drivers, as well as overcoming sector-specific barriers and technological constraints. Drivers that fall under 'Macro' include issues that are evaluated in aggregate across economies, economic regions, or globally. Within an economy these drivers can include population growth, income and gross domestic product, urbanization or financial markets. Other macro factors can include global energy supplies, energy subsidies and multi-lateral agreements. Sector drivers can include policy and regulatory environments, the types and size of sub-sectors, or local conditions such as available resources and technical capacity. Other economy-specific factors include geography, climate, energy supply mix, or utility infrastructure. Technology drivers range from investment costs, availability of existing best-available technologies and emerging innovations. All of these factors often work together, making feedback loops, creating barriers and forming new opportunities. Understanding these drivers and barriers can help APEC policymakers identify strategies to strengthen and promote energy-efficiency practices and technologies across APEC.

3.3.2.1.1 Macro

Global demographic and structural trends such as urbanization, population growth, and rising incomes result in smaller household sizes, more residential units, and a higher demand for appliances, air conditioning, and heating, particularly in hot climates. Rising incomes and urbanization also increase commercial demand for retail, hotels, and institutional buildings like hospitals. As economies shift away from intensive industry towards service sectors demand for new commercial buildings increase, often faster than residential building. The increase in commercial buildings also increase demands for reliable energy grids for data and communications. Investments in electricity networks and storage reached US 277 billion in 2016, with 10% of that investment in integrated data and communications technologies. Of that global total, 30% of that investment came from China, which is explicitly targeting service sectors as a prime area of growth. The International Energy Agency (IEA), in their review of the sector, state that global building energy performance has barely moved since 1990 but intensity has been falling since 2010 due to building energy codes and new standards.

Energy supply market drivers include wholesale energy prices, tax and subsidy structures, cost of new infrastructure investment, and locally available energy resources. These drivers affect **finance markets**. Financial incentives, tailored financial products and transaction costs all impact payback and return-in-investment (ROI) calculations, creating higher risks for banks, utilities and reducing public and private support. According to a recent U.N. survey, the financial environment is generally not very favorable for investments in energy efficiency. Banking institutions are generally unaware of Energy efficiency financial instruments, or tend to see efficiency projects as weak investments.

Reducing energy market barriers that increase efficiency gains in building sectors have a large feedback effect, allowing utilities to avoid constructing new plant capacity and reducing distribution and transmission network investments. According to the IEA, in 2015 world spending on building

sector energy efficient products and services was 8% of total building costs, or USD 388 billion. Eight economies account for 90% of global investment and four are in APEC: China (19%), U.S. (24%), Canada (2%) and Japan (2%). Non-APEC economies are Germany, France, UK, and India.

Geographic variations in climate and terrain play a large role in the types of building efficiency strategies that are physically and/or economically feasible across APEC (sun, hydrology, geothermal, available land and ports, natural resources). Geography also shapes the heating and cooling demands in modern buildings, increasing cooling loads in warm climates, while driving heating and insulation requirements in cooler climates. As incomes rise, demand for these building services increase. Economies with similar geographic drivers can share policy and regulatory best practices that support and incentivize similar technology solutions and consumer behaviors.

Integrating energy efficiency into **other global targets and goals** such as emissions reductions, health, security, or environmental concerns supports the adoption of efficiency strategies at the economy and global level. Coordination with multi-later and bi-lateral organizations, researchers and other **partnerships** can support or align initiatives and frameworks. Education and Awareness campaigns such as “reduce, re-use, recycle” can shift energy consumption patterns and turn energy efficiency from a goal into an effective strategy to reach other targets. An example is the IEA’s “Bridge Strategy” to address immediate GHG emission reductions includes energy efficiency in its top four global strategies. The IEA estimates that global building sector energy intensity will need to drop 80% to meet the IEA’s 2 Degree Celsius (2DC) scenario and energy efficiency in all end-uses combined with a de-carbonized power sector can reduce CO^2 emissions in the building sector to one-quarter of 2012 levels. However, of the 193 countries who have signed COP21, only 62 have adopted building energy codes and only 84 have building energy certification programs. The U.N. also noted that to reach global sustainable energy objectives by 2050, energy

Case Studies: Partnerships

The **Clean Energy Research Center-Building Energy Efficiency (CERC-BEE)** consortium conducts research jointly under the second five-year Building Energy Efficiency Joint Work Plan (2016-2020) in the following areas: integrated design, construction, and industrialized building; control commissioning and data mining; direct current buildings and smart grid; indoor environment quality; and policy and market research. The research team will also develop a net-zero building demonstration to promote the technologies in the U.S. and China. The Lawrence Berkeley National Laboratory in Berkeley, CA leads the joint research team in the U.S., with over twenty private, non-profit, and university partners. The Center of Science and Technology of Construction, Ministry of Housing and Urban-Rural Development (MOHURD) leads the China research team with over 15 private and university partners.

The World Resource Institute and its Ross Center for Sustainable Cities, based in Washington D.C., in partnership the United Nations Sustainable Energy for All (SEforALL), leads the **Building Efficiency Accelerator (BEA)** initiative to reach its goal of doubling the global rate of energy efficiency. The BEA offers access to global expertise and a venue for with city/private sector partnerships. The BEA has thirteen **city partnerships throughout APEC**: Iskandar, Malaysia; Changning District, Shanghai, China; Weuxi City, China; Suzhou Taihu New City, China; Da Nang City, Viet Nam; Jalisco State, Mexico; Mandaluyong, Philippines; Merida, Mexico; Mexico City, Mexico; Milwaukee, US; Pasig, Philippines;

efficiency investments - driven largely by residential demand - will need to increase by a factor of 3 to 6.

Another example is the United Nations Development Goal (NDC) of sustainable energy access for all. Over two billion people have either very limited or no electricity, and 3 billion people burn biomass (like wood) for household heating and cooking. However, as households gain electricity, the demand for heating and cooling and appliances like refrigerators increase. The IEA estimates that new air conditioners sold in 2016 will create up to 90 terawatt hours (7.7MToe), of new global energy demand. That demand would have dropped 40% with higher efficiency appliance standards in place.

3.3.2.1.2 Sector

Implementing strategies at the sector level in APEC face significant barriers due to its heterogeneity. No single factor or driver is a strong indicator of APEC-wide efficiency savings nor the sector's potential contribution to total efficiency savings in high efficiency model. Groups such APERC, the IEA and the UN agree that strong **policy frameworks, strong energy building codes, and regulatory enforcement** have a greater impact on efficiency improvements than end-user voluntary actions. With the expected doubling of residential square footage of residential buildings by 2050, this is especially important in emerging economies, such as China, the Philippines and Viet Nam. Economies with relatively low contributing building sectors (less than 20% of total savings in the APRC Improved Efficiency Scenario), such as Australia, Chile, Peru, or Thailand, all have different reasons lower sector savings. Reasons range from strong existing policies or high renewables investments to rural residential sectors that will continue to rely on biomass for housing fuel. In emerging economies with rising incomes and large informal urban populations, enforcing minimum standards for appliances, building energy codes and encouraging programs like audits and ESCOs can increase potential efficiency gains in the sector.

Case Studies: Energy Building Codes

As an economy, **California** in the Unites States is one of the ten largest in the world and state-wide policy can have a impact on global energy efficiency progress. **CALGreen**, developed by the California Building Standards Commission and updated every 3 years, was the first state-wide green building code in the United States. The codes cover planning and design, energy and water efficiency, materials and resource efficiency, and environmental quality for state-owned buildings, low-rise residential, public schools and healthcare facilities. The codes give regulatory control over energy efficiency codes to the **California Energy Commission** (CEC). In 2015, the California Senate directed the CEC to establish energy efficiency targets by the end of 2017 that double state-wide savings in electricity and natural gas by 2030. The recommendations are based on the California Energy Demand Updated Forecast (2015-2025) but still need to identify sources for nearly a third of the target electricity goal.

New York City's skyscrapers - only 2% of NYC property owners - account for 48% of the cities energy use. Properties over 25,000 SF are the target of the **Greener Greater Building Plan** (GGSP). The GGSP are regulations that focus on benchmarking, audits, retro-commissioning, lighting sub-meters, and the NYC Energy Conservation Code. To help property owners with financing, the city created the New York City Energy Efficiency Corporation (NYCEEC), a non-profit company that provides loans for all building types. Benchmarking alone realized 10% energy savings and 14% carbon savings from 2010 to 2015 [20]. The GGBP is also part of the cities larger Carbon Challenge.

ESCO (energy service companies) has become a major strategy for reducing building energy use by moving the responsibility from the building owner to a secondary market. The IEA Energy Efficiency Market Report, (2016) describe a burgeoning market exists for ESCOS, which represented a market of 24 billion United States dollars (USD) in 2015. In China, ESCO revenues were USD 13.3 billion. Contract structure and profits are heavily influenced by policies and subsidies. ESCOs will grow as ROI increase on efficiency investments and utility business models evolve. IEA also describes a growing interest by investors in "green" bonds, which are often a large component of energy efficiency services.

> *"Government policy has been fundamental to improving energy efficiency. The growth of mandatory policies such as standards, in terms of both their range of coverage and the performance levels they require, is having a material effect on energy demand. For example, the total oil consumption savings from all national vehicle fuel economy standards on light-duty vehicles was 2.3 million barrels per day (mb/d) in 2015. This was equivalent to almost 2.5% of global oil supply – approximately the oil production of Brazil"* IEA Efficiency Policy Progress Index (EPPI), 2016

Policy frameworks can also help shift the sector towards **denser building patterns** that reduce material and energy per capita. Although no single definition of "urban" exists, there are many ways to estimate population densities and square footage per capita. According to the UN Habitat Data, half of the top ten cities by population are in APEC (Tokyo, Mexico City, Shanghai, Beijing, and New York). When measured by Urban Agglomeration (pop/Km2) other APEC cities such as Manilla, Bangkok, Jakarta and Singapore rise to the top. Integrated land use and transportation investments and incentives that encourage higher density construction or re-use of existing structures should be encouraged.

Shifting **consumer behavior** and cultural trends through education and market pressures also change building patterns. An example is the move away from large offices to shared workspaces in the U.S. and the EU. In the U.S. average office space per person in 2017 is expected to be 151sf (source: *CoreNet Group*), down over 30% in only seven years. Real

Case Studies: Mandatory Rating Systems

China's 13th Five Year Plan set ambitious energy efficiency goals for the building sector, including that all urban buildings be green certified. In 2014, the State Council mandated that public buildings and housing, as well as any single building area over 20,000 square meters must meet the **3-Star Green Building System**, administered by Ministry of Housing and Urban-Rural Development, China Academy of Building Research (MOHURD). The Chinese Green Building System's six components - land, energy, water, and resource efficiency, environment quality and operational management - are scored individually, not a total combined score. Provincial officials administer the 1 and 2 stars; MOHURD evaluates applications for the highest 3-star label.

The Australian government requires all commonwealth agencies, or bodies that received more than 50% of their income from the commonwealth, to comply with **Energy Efficiency in Government Operations (EEGO)** statues. Compliance is through the **National Australian Built Environment Rating System (NABERS)**, using a 6 star audited performance rating program to benchmark building performance over a 12 month period. As a performance benchmarking tool with trained auditors, NABERS is similar to ENERGY STAR in the U.S. All of these efforts help Australia reach its goal to improve energy productivity by 40% between 2015 and 2030.

estate markets have also shifted due to the cultural acceptance and increased demand of green certified buildings that take a holistic view of building sustainability, from material sourcing to energy supply. Despite these trends, market segmentation (between sub-sectors and between building types) makes awareness of energy efficiency solutions a challenge. End users, property owners, and utility providers need to understand why energy efficiency is important and learn the best methods for integrating it into their business models and lifestyles.

In the building sector climate-driven **heating and cooling demands** dominate savings potential. At one end, heating and insulation investment dominate sector savings in Canada due to its cold climate. In economies with hot tropical climates and rising incomes, increasing minimum standards and codes and encouraging BATs for cooling demand show the largest untapped potential for efficiency savings

Retrofitting and new construction poses different challenges for sector efficiency. With the long lifetime spans of typical building stock, energy efficiency needs to start with construction codes, but continue with demand management systems, measurement and verification as building stocks age. The economy of Hong Kong, China, with its extremely dense housing and mature transit systems, can expect to see three quarters of total efficiency savings come from building retrofits. The United States' mature housing sector, in contrast, is disparate and dispersed, making efficiency investments more complicated. Russia faces the challenge of a building stock tied in aging distributed energy infrastructure that will require extensive upgrades. Emerging economies with large informal urban settlements grapple with a lack of land tenure, affecting the enforcement of building codes and utility investments. In China, new construction has grown at unprecedented rates the last 15 years but new 'eco-cities' in development or in planning stages are being designed holistically to maximize best available technologies for high efficiency buildings.

Case studies: Net Zero Buildings

Policy: U.S. Executive Order (EO) 13514 in 2009 required that by 2020 all planning for **U.S. federal buildings** should achieve Zero Net Energy by 2030. In 2015, the order was superseded by **EO 13693**, which requires reducing building energy intensity by 2.5 percent annually through the end of fiscal year 2025. In order to optimize energy efficiency, building managers must ensure that the building have an ENERGY STAR rating of 75 or higher (or equivalent savings against baselines or ASHRAE 90.1) and use energy efficient products as required by statute. Other actions related to energy efficiency include advanced energy metering and energy targets in all data centers by 2018; agency fleet efficiencies; re-commissioning every four years; and, benchmarking using energy Star Portfolio Manager.

Retrofit Construction: The first zero Energy Building in south-east Asia was a retro-fitted existing building in **Singapore** at the Building and Construction Authority (BCA) Academy. The building, a former three-story workshop, was retrofitted with passive design techniques, green building technology and solar power. Passive ventilation like solar chimneys and natural lighting techniques, for instance, are balanced with advanced light sensors and high-performance silicon and thin film solar panels. The building serves as a case study and testbed for Singapore's goal to achieve 80% Green mark Certification for all buildings by 2030.

3.3.2.1.3 Technology

Bridging the gap between MEPS and BATS. Both IEA and APERC analysis of the sector shows that efficiency targets can be met using best-available-

technology (BAT) pathways that improve building systems while ensuring that they are affordable, widely adopted, and manageable. One area where the use of BATS is important is the development of **Net (or Near) Zero Energy) Buildings** (NZEB). Buildings research and new technologies on the market allow smaller buildings to affordably store energy and use high efficiency appliances and equipment, as well as invest in renewable like solar and wind.

According to IEA analysis, bridging the gaps between Minimum Energy Performance Standards (MEPS) and Best Available Technologies (BAT) in heating (60% gap) and cooling (33% gap) save over 40% of total building sector savings in their efficiency scenarios. IEA analysis of OECD economies shows that in cold climates building envelope BATS save 70-80% of current average building heating costs. In hot climates, cooling BATs have ranges estimated between 10% and 40% savings. In addition to building envelopes, the top four other technology improvement priorities for the IEA are heat pumps, solar thermal, cooling systems, and biomass. Another technology challenge will be building retrofits. Although 85% of new construction floor area will be in developing and emerging economies, 75% of existing (2017) buildings will still be used in 2050 and account for 45% of the heating and cooling load due their less efficient use of energy. Mandatory energy building codes **and increased adoption of smarter building technologies** that can help manage energy loads. These technologies need cross-sector integration with smart grids technologies to reduce peak loads, lower stresses on regional energy supplies and increase energy security. Smart building technology also increases data availability. Better data quality and management improves audits, regulatory reporting requirements, and green certification. It also improves decision making by policy makers and helps researchers.

Barriers to BAT adoption include price, market availability and penetration, service and maintenance capacity, and technical assistance. BAT rates of efficiency also vary according to systemic trends such as geography access to energy, consumer education and variables such as dominant building types and available construction materials.

Research, development and innovation requirements are lower in the building sector than transportation and industrial sectors to meet intensity targets. With fewer R&D and innovation requirements, **knowledge sharing** is a critical element of expanding BAT adoption. Policy makers and regulars as well as occupants/building managers need to know about and understand options.

3.3.2.2 *Economy*

This section reviews economy factors that may affect building sector efficiency and highlights the potential impact of the Improved Energy Efficiency Scenario. APEC analysis defines building sector energy uses as residential (includes refrigerators, air conditioners, washing machines, water heaters, lighting, tv, space heating) or commercial (includes lighting, ventilation, cooling, refrigeration, space heating, lighting), and excludes industrial buildings. It is important to note that the IEA analysis includes cooking energy, reflecting an interest in global energy access. This distinction helps separate low emission renewables from biomass, such as wood, used for heating and cooking homes. The IEA also breaks down commercial building subsectors into ‘industry’ and ‘services’, allowing for analysis of global trade and economic structural shifts. Both of these categorizations can help track the shift from higher-energy intensity manufacturing to service sector growth, which relies on commercial buildings and equipment like computers.

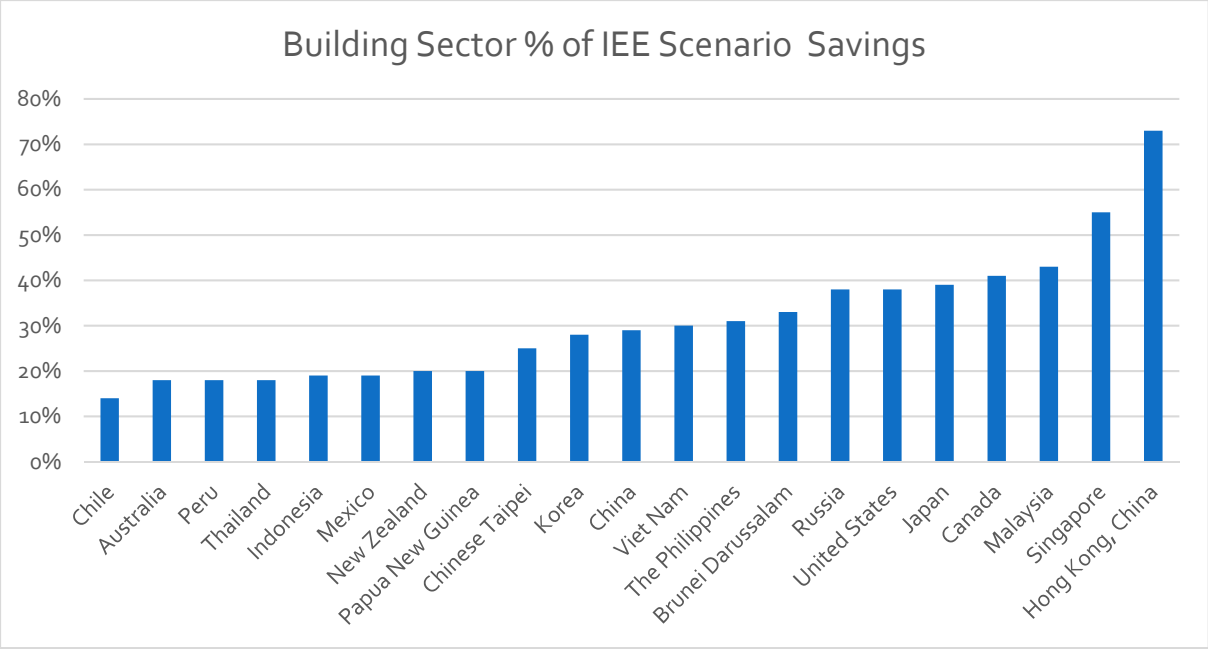


Figure 20. Building Sector Savings as % of IEE Scenario, APERC 2016 data

- Nearly 80% of building sector energy demand comes from four economies: China, the United States, Japan, and Russia.
- China's stock over the next twenty-five years will be largely new. Economies like the United States, Canada, and Hong Kong, China, however, need to address existing building stock and the more complicated challenge of retrofits and renovations.
- Demand per capita in Canada, U.S., Korea and Russia are the highest in APEC in both scenarios. This is largely due to heating and cooling demands.
- High growth emerging economies maintain their low per capita demands. The United States per capita demand in IEE is double that of China, and 40x higher than Papua New Guinea.
- Sector savings were highest in the two most dense island economies in the world: Singapore and Hong Kong, China. Low savings estimates were a result of policy assumptions that indicated lower likelihood of policy or regulatory changes beyond BAU - but not necessarily low BAU scenario savings. New Zealand, for instance, already has a very high proportion of renewables in their energy supply.
- The United States and Australia have proposed the majority of projects (65%). Canada, China, Chinese Taipei, and Japan proposed 1-3 projects a piece. Eighteen economies have participated in either one or no appliances/equipment projects over the entire twenty-five year period. Due to the general high rates of standards adoption, it is hard to say if low participation slowed APEC-wide standard and labeling policy adoption, or if the work done by larger economies with international code organizations set the groundwork for easier adoption by less-involved economies. However, as economies grow, particularly in south-east Asia, promotion of both existing and emerging IoT standards can make a huge different in both near-term and long-term savings potential.

Table 7. Building Sector Energy Demand Projections

			Buildings Sector 2040 Demand Projections			
Economies	GDP AAGR	POP (2040)	BAU (Mtoe)	IEE (MToe)	% Change from BAU	Sector % of IEE Savings
Australia	2.80%	34	26	23	-12%	18%
Brunei Darussalam	1.20%	0.6	0.6	0.5	-17%	33%
Canada	1.70%	42	74	62	-16%	41%
Chile	2.70%	20	13	12	-8%	14%
China	4.90%	1361	961	846	-12%	29%
Hong Kong, China	2.20%	8.9	5.7	4.9	-14%	73%
Indonesia	4.40%	290	90	80	-11%	19%
Japan	1.10%	114	106	92	-13%	39%
Korea	2.20%	49	59	54	-8%	28%
Malaysia	4.20%	41	22	19	-14%	43%
Mexico	3.00%	145	37	30	-19%	19%
New Zealand	2.30%	5.5	4.45	4.07	-9%	20%
Papua New Guinea	6.40%	12	0.5	0.4	-20%	20%
Peru	3.90%	38	9	7	-22%	18%
The Philippines	6.00%	142	15	11	-27%	31%
Russia	1.40%	151	177	156	-12%	38%
Singapore	1.40%	6.2	3.5	2.9	-17%	55%
Chinese Taipei	0.90%	23	13	11	-15%	25%
Thailand	3.50%	73	38	33	-13%	18%
United States	1.60%	383	532	459	-14%	38%
Viet Nam	5.50%	104	44	41	-7%	30%
APEC TOTALS			2230.75	1948.77	-13%	

As Figure 16 makes clear, the combined impact of building efficiency policies and investments in China, Southeast Asia economies, and the United States will have a huge impact on overall efficiency savings in APEC.

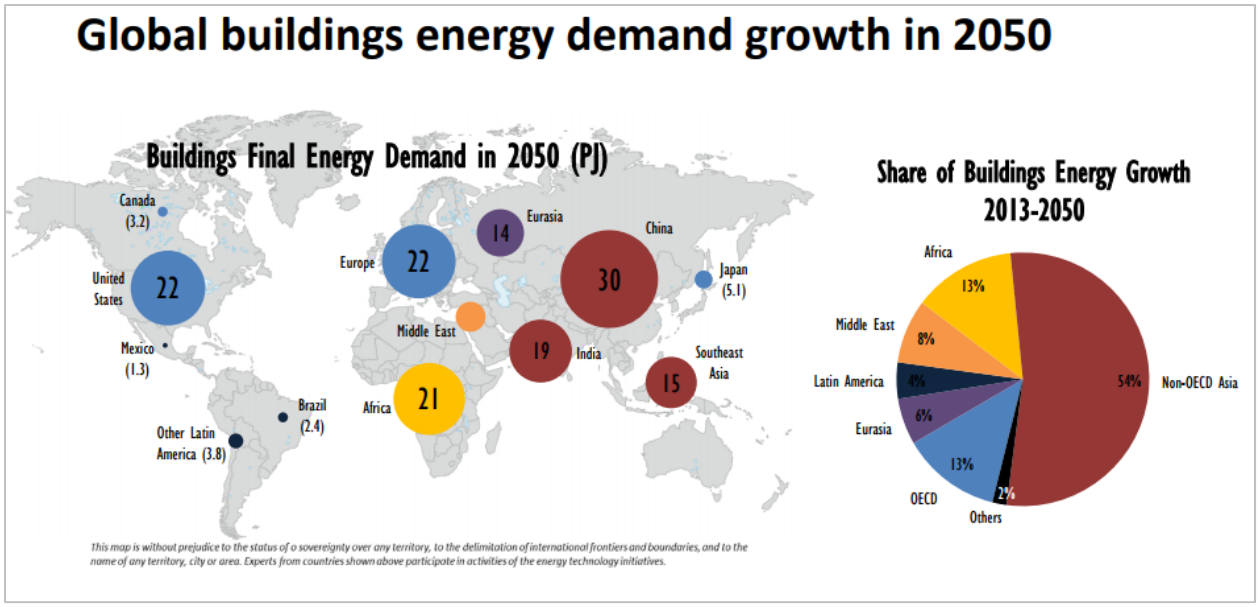


Figure 21. Global Buildings Energy Demand Growth in 2050, IEA 2017

Australia

The building sector absolute and per capita energy demand in Australia is low because of low population density as well as existing policies. The '*National Energy Productivity Plan'* (2017 update) sets a 40% productivity improvement target by 2030. According to APERC, gains in productivity and efficiency still lag behind other mature economies such as Japan. Australia has established energy efficiency programs around the economy, and the economy has high residential PV solar system coverage, ranging from 18-25% of regional markets. The economy expects that renewables will be up to 42% of the building market by 2040. As a large continent, transportation has a much higher impact on efficiency savings than buildings. However, with the largest projected sector AAGR (1%) high efficiency investments can save 20% over BAU. On 1 July 2017, it lowered the threshold of the Commercial Building Disclosure program, which requires owners to disclose energy efficiency levels when selling or leasing a property.

Brunei Darussalam

At only 5,700km^2, the economy has the fifth largest GDP per capita in the world due to energy exports. With only 20 more years of projected energy resources, the economy is focusing on reducing energy use and energy self-sufficiency by 2040. The 2014 30-year Energy Efficiency and Conservation (EEC) roadmap specifies a 63% demand reduction by 2030. Cooling demands in the hot tropical climate drive the building sector energy demand. Despite a projected 2.3% AAGR the sector is expected to see savings over BAU due to new policies such as electricity tariff reform, new standards and labeling, the EEC Building Guidelines for the Non-Residential Sector, awareness campaigns, and new financial incentives for efficient appliances.

Canada

The buildings sector accounts for the largest energy demand in Canada today (2013, 33%) and in 2040 projections (32%), just surpassing the transportation sector. Although only a 0.4% sector AAGR, efficiency savings over sector BAU are largest in the buildings sector due to the efficiency

potential in heating and insulation due to its cold climate, and that recent economy-wide improvements in energy intensity have come from industry and transportation sectors. Abundant natural resources means the economy is the third largest user of hydropower worldwide, somewhat reducing the relative value of efficiency as a driver of co-benefits such as GHG emissions. There are many energy efficiency programs, delivered at the federal level. However, energy policies are largely in the control of provincial governments, so regulatory impacts vary by province.

Chile

The buildings sector energy demand is projected to grow 1.7% AAGR, driven largely by rising incomes and housing demands due to urbanization. However, , almost half (48%) of Chile's housing is served by biomass (firewood). That number will drop to 35% with increased urbanization and access to electricity. Newer statistics from Chile indicate that number has already dropped to 33 percent. About 60% of residential energy savings are expected be from refrigerators, lighting and water heating due to stronger MEPS, BATs and building code enforcement. The most recent plan - Action Plan on Energy Efficiency 2020 - includes labeling and new buildings standards. Chile's overall energy policy is guided by 'Energy 2050: Chile's Energy Policy'. Chile, currently relying almost exclusively on imported fuel, also has a plan to generate 70% of energy from renewables by 2050.

China

In all respects, China will have the biggest influence on APEC region building energy efficiency gains, producing 40-50% of most projected sector savings. The 12th 5-year plan emphasizes green efficient buildings. Rapid urbanization, now at 57% of the population, has resulted in 1,000s of high-rises and new cities, including eco-cities under construction or planning with high efficiency building standards. Although per capita consumption is low, China's BAU annual sector demand is 43% of the APEC total demand. The IEA estimates that in 2040 residential demand will be 50% higher than the U.S. In 2012, China's residential energy consumption was 80% of the U.S.

Hong Kong, China

Hong Kong, China's highly dense building sector accounts for the 93% of today's total energy demand, and 66% of total 2040 demand across the economy. The Energy Saving Plan 2015-2025+ commits to reducing energy intensity by 40% by 2025 (from 2005). The buildings sector, as a result, is the target for nearly all efficiency policies. The Buildings Energy Efficiency Ordinance (BEEO), the Building (Energy Efficiency) Regulation (B[EE]R), and the Energy Efficiency (Labelling of Products) Ordinance (EELPO) continue to tighten standards.

Indonesia

Urbanization and economic structural shifts will drive the building sector in Indonesia. The world's largest archipelago, half of the population (254 million, 2013) still lives on small islands in rural areas and use kerosene and wood for food and heating. Most of the economies coal reserves are exported. Even with a projected 67% urbanization rate by 2035, growth is largely commercial (4.3% AAGR) rather than residential (0.6% AAGR) due to focus on service industries. Efficiencies in the building sector will come largely from appliance and equipment standards. The *National Master Plan for Energy Conservation* (RIKEN) was updated in 2014 with an energy efficiency goal of 15% for the building sector. The *National Standard Competency for Energy Managers in Building and Industry* was enacted in 2015.

Japan

Japan the third largest economy in APEC, with high GDP incomes and 93% urbanization rate. Despite a falling a population the buildings sector is projected to increase from 50% to 60% of total demand by 2040 and edges out transportation for sector efficiency savings. Japan's current 39% energy intensity goal could reach the APEC-wide 45% intensity reduction target with additional efficiency investments. Due to the Fukushima nuclear accident and a re-evaluation of long-term energy security, fossil fuel imports increased and assumptions about efficiency strategies may be adjusted.

Republic of Korea

Korea's BAU intensity reduction of 43% is just shy of the APEC 45% target. With an 82% highly dense urbanization rate and high living standards, the buildings sector will continue to drive energy demand in the economy, particularly the commercial sub-sector. (1.0% AAGR). The residential sector runs mostly on natural gas imports. Due to existing policy measures in place that focus on demand management, insulation, labeling, codes, and ESCOs to reduce electricity demands, the additional savings from the IEE scenario are some of the lowest in APEC.

Malaysia

Between 1990-2040, GDP will grow 10-fold, and the economy is projected to reach high-income status by 2020. Efficiency is an important energy security strategy. With a very high economic growth rate (4.2% GDP AAGR) the economy will become a net energy importer. The building sector will be one of the fastest growing in the APEC region (2.9% AAGR). In an equatorial region with a tropical climate, sector growth will result in higher cooling demands. As a result, the government is focusing policy on increasing, green buildings codes, standards, labeling and other measures as well as becoming the second largest producer of PV panels by 2020. Building efficiency investments will also be spurred by rising energy prices, a result of newly introduced energy subsidy reforms.

Mexico

The economy has abundant natural resources including fossil fuels. Mexico City is one of most densely populated cities in the world and urbanization continues to grow. However, with only 20% of the total projected energy demand in 2040, the buildings sector demand is well below the transportation and industry sectors. This is due to issues like the size of rural populations, and BAU policies by the Secretaria de Energia and the National Commission for Efficient Energy Use to promote efficiency in urban energy sectors such as labeling and appliances standards. Despite rising incomes APERC estimates that Mexico's per capital building energy demand will still be ¼ of the United States in 2040. Energy efficiency is projected to make a 10-fold impact on sector energy demand than renewables or alternative energy scenarios (23% v. 2.6% and 2.4%).

New Zealand

New Zealand is a well-developed economy with high income per capita and an energy infrastructure already dominated by renewables (74% of electricity). The industry has building codes and efficiency programs aimed at appliances, buildings and consumer behavior. It is a small isolated economy with a 2040 population of only 5.5Million so although housing demand is expected to grow 32%, the Improved Efficiency Scenario's additional 20% savings over BAU is only 0.38MToe: 0.1% of APEC's total sector efficiency savings.

Papua New Guinea

With the highest GDP AAGR in APEC (6.4%), energy demand is expected to grow fourfold, although absolute numbers remain very low (5.4MToe). With hundreds of rural islands with very low population density, electricity access is very low (15%) and not expected to rise significantly. Currently electricity supplies does not meet urban demands. Due to volcanic nature of the islands, the Geothermal Energy Association estimates that geothermal power could meet all electricity demand. Housing energy demand is expected to rise mostly in urban or urbanizing areas, but only account for 9% of total economy energy demand by 2040. Despite the tropical climate, in 2015, only 7% of urban households had air conditioners.

Peru

Peru is a highly urbanized (76%) economy with over a third of the 31 million residents in the Lima. Housing energy demand is expected to grow 69% as incomes rise and biomass for residential fuel is replaced by natural gas and electricity. The sector savings, however, are dwarfed by transportation sector, with 3fold higher energy demand.

The Philippines

With a projected 2040 population of 142 million, housing demand will be high but residential energy demand is expected to remain modest, due to a slow conversion from rural use of biomass to urban use of LNG. Annual BAU sector demand growth of 3.4% is much lower than the GDP AAGR (At 6%, the second highest in APEC). Efficiency is an explicit strategy for national energy security. Although ‘Energy Efficiency Initiatives 2016–2020’ include training, incentive programs and awareness campaigns, barriers include a lack of strong building codes, utility involvement, and enforcement and auditing/management capacity.

Russia

Buildings and agriculture are the largest energy users, at 35% of total demand projected for 2040. With energy policy focused on natural resources, efficiency policies for buildings are expected to remain minimal. Russia’s northern latitudes and cold weather means the economies old district heating systems consumed 46% of the sector energy demand in 2013. Both APEC and IEA identify the aging district heating systems as the major target for efficiency improvements, with estimated energy efficiency improvement of 35-45%.

Singapore

The economy is one of the lowest carbon-intensive economies in the world and LNG meets 95% of its energy demands via pipelines from neighboring economies. Although small and highly urbanized, buildings account for only 12% of the economy's energy demand due to large industrial and non-energy sectors. Singapore’s role as a business and refinery hub means the commercial sub-sectors dominate demand in building sector. However, that small demand accounts for 55% of IEE scenario savings. Strong green standards, audits, and other efficiency programs have already been adopted as part of economy emissions reduction and sustainable development initiatives.

Chinese Taipei

The economy already has an ambitious INDC emissions reduction target of 50% below 2005 levels by 2050, including a 2%/year efficiency goal with programs for appliances, lighting, and buildings

and mandatory labelling. Total Sector AAGR is expected to go down to 0.4% by 2040, with nearly all gains in commercial building subsectors. The economy's energy supplies are almost all imported, and energy efficiencies strategies are an important part of the economy energy policy goal to increase energy security.

Thailand

Energy security a high priority for the government due to a fast growing economy (estimated 3.5% GDP AAGR) and increased energy demands. Addressing limited natural energy resources and increased electricity demand requires strong energy efficiency policies. As the economy moves from manufacturing to services, the growth of commercial buildings will be a major driver of sector energy demand. APERC estimates that strengthening building energy codes, MEPS and HEPS will reduce efficiency in large commercial buildings over 50% BAU.

United States

The building sector in the U.S. is very mature and has the second highest total demand (behind China), and the second highest per capita demand (behind Canada). Although the policy environment overall is very robust with strong building codes and appliance standards, regulations at state and federal levels are mixed due to the constitutional structure of policy making. Although certain BAU assumptions may shift with current federal administration priorities, states and cities continue to support strong efficiency programs and markets for commercial and residential sectors. With a large existing building stock expected to remain in 2040, retrofit and renovation investments are an important priority in the sector.

Viet Nam

With a very high GDP AAGR of 4.5%, Viet Nam's National Energy Development 'Strategy to 2020 with a Vision to 2050' explicitly emphasized energy efficiency as one of four key issues. A largely rural residential use of biomass for cooking means low gains in IEE scenarios. However, biomass will be slowly replaced with access to electricity to meet the 'access to energy' goals. Although weak institutional support has been a barrier in the building sector, new standards and support has increased the adoption of MEPS and other programs in commercial subsectors.

Resources: Copenhagen Centre on Energy Efficiency; APERC; World Bank; IEA, U.N. Sustainable Energy for All, UNEP, U.S. Energy.gov

3.4 Transportation Sector

This chapter includes an overview of sector energy use, energy efficiency drivers and barriers from recent global reports, and economy-specific analysis from APERC that affects higher energy efficiency investments in the sector.

3.4.1 Sector Overview in APEC

In order to align with the APERC analysis this section reviews road transportation (passenger and freight modes[7]) and excludes air and water-based modes of transportation.

Despite the growth of electrical vehicle markets, nearly all land transportation (96%) currently runs on petroleum and liquid fuel. The exceptions are pipelines which use natural gas, and passenger rail, of which 40% is electrified. Globally, Light Duty Vehicles (LDV) with 60% of the sector's final fuel consumption, dominate road energy (Figure 22). In APEC, that number is 73 percent. The number of LDVs is expected to increase by over 900 million by 2040 and APERC forecasts that most of those will be in China (60%) and South East Asia (21%) due to GDP and population growth, the key drivers for vehicle purchases.

APERC estimates that if APEC economies adopt all policies and best available technologies in the Improved Efficiency Scenario model, the region could save an additional 15%, or 270MToe, over the business-as-usual (BAU) scenario in this sector. However, as Figure 23 shows, there is a wide range of potential savings across APEC economies. The reasons reflect drivers such as the strength of existing policies and regulations, rates of economic growth and increasing purchasing power, land use planning and modal shifts. Papua New Guinea and Viet Nam, which look similar in Figure 21, exemplify these differences. Viet Nam and Papua New Guinea have largely rural population and similar low vehicle ownership rates in 2013. However, urbanization rates are different and geography plays a strong role in electrification, access, and incomes in rural areas. The impact of the regulatory environment is reflected in savings differences between the U.S and Australia. Both are mature economies with large land masses, dispersed urban centers, and a similar reliance on LDVs for

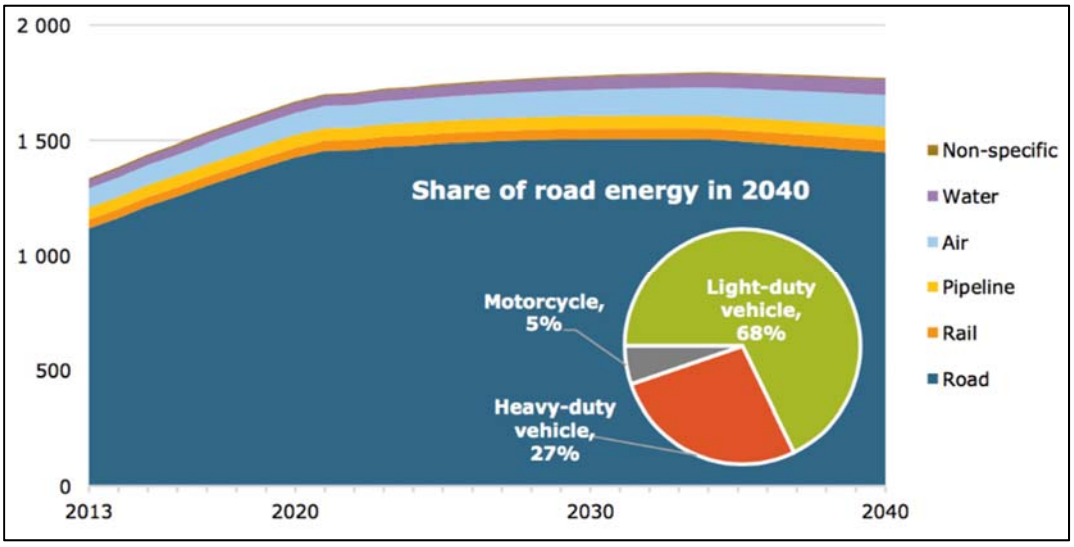


Figure 22. Transportation Energy Consumption by Sub-Sector, APERC 2016

[7] APERC analysis categories. Passenger mode= vehicles, passenger trains, airplanes and buses. Freight modes = rail, heavy-duty vehicles, maritime vessels, air, and pipelines

transportation. However, Australia does not have fuel economy standards and as a result see more savings in transportation in the IEE scenario. The impact of investments in the BAU can be seen in China's relatively lower savings potential in the IEE scenario despite rapid vehicle growth because ownership rates are increasing alongside heavy investments in regional air, rail, and sea infrastructure.

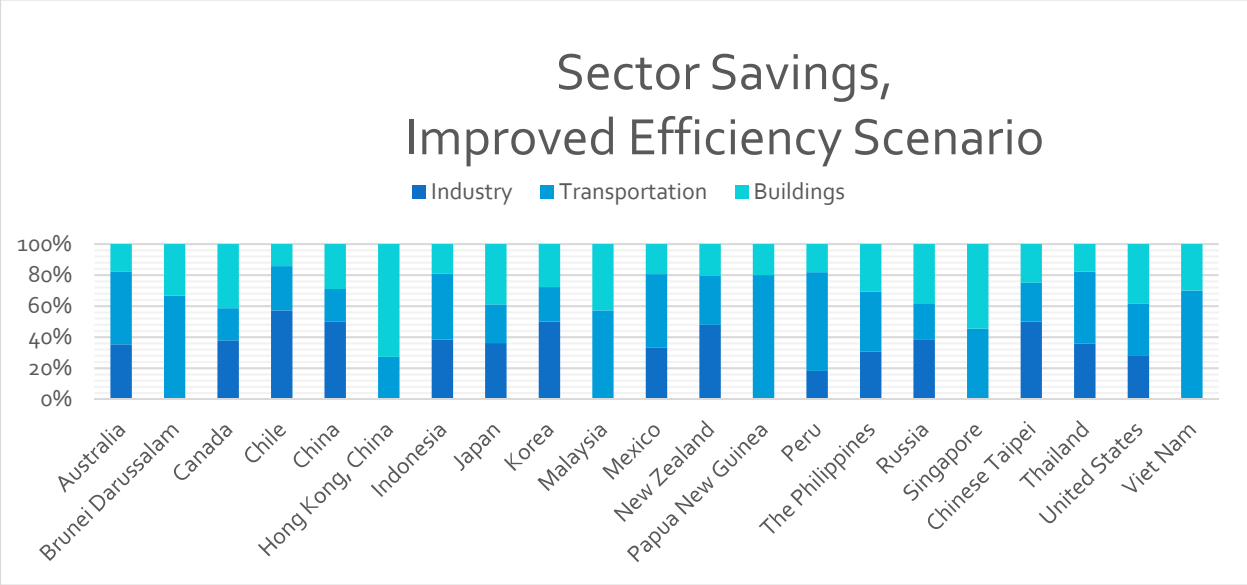


Figure 23. Sector Savings in IEE Scenario, APERC 2016

IEA research into transportation investments shows that the largest incremental investments in the sector are coming from APEC economies, including China, the United States, Japan, Korea, and Mexico. (Figure 24) The numbers in Figure 22 reflect a range of reasons for those efficiency investments – economies such as the United States and Japan have established efficiency programs like CAFÉ, have saturated vehicle markets, and slightly higher percentages of light trucks due to terrains (and popularity). Other economies, such as Indonesia, are just starting to invest in vehicles that are more energy efficient and have lower vehicle ownership rates.

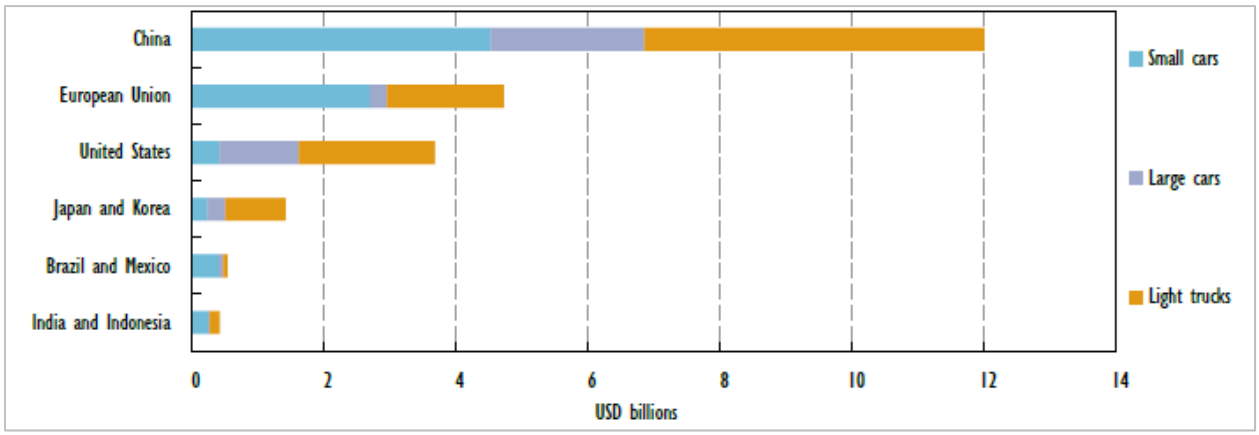
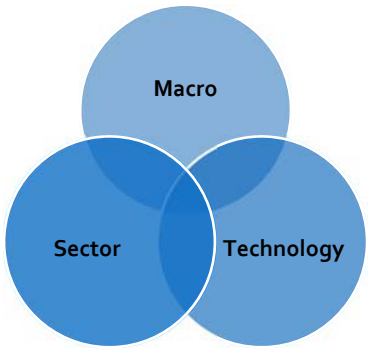


Figure 24. Incremental Efficiency Investments by Vehicle Type by Region, 2015, IEA 2016

3.4.2 Drivers and Barriers



The following section highlights transportation sector-specific drivers and barriers collected from recent reports published by organizations such as APERC, the International Energy Agency (IEA), and the United Nations (UN). Increasing energy efficiency in the sector requires addressing macro-economic trends and global drivers, as well as overcoming sector-specific barriers and technological constraints. Drivers that fall under 'Macro' include issues that are evaluated in aggregate across economies, economic regions, or globally. Within an economy these drivers can include population growth, income, gross domestic product, urbanization or financial markets. Other macro factors can include global energy supplies, energy subsidies and multi-lateral agreements. Sector drivers can include policy and regulatory environments, the types and size of sub-sectors, or local conditions such as available resources and technical capacity. Other economy-specific factors include geography, climate, energy supply mix, or utility infrastructure. Technology drivers range from investment costs, availability of existing best-available technologies and emerging innovations. All of these factors often work together, making feedback loops, creating barriers and forming new opportunities. Understanding these drivers and barriers can help APEC policymakers identify strategies to strengthen and promote energy-efficiency practices and technologies across APEC.

In the transportation sector, these categories roughly align with the "Avoid, Shift and Improve" strategy. "Avoid" refers to integrated land-use planning and transport demand management that avoids trip generation. "Shift" refers to mode shifts, or improving trip efficiency. Finally, "Improve" optimizes technology such as engines.

3.4.2.1 *Macro*

The IEA estimates that achievable global transportation efficiency savings are in the range of the current annual oil consumption of the EU. **Global macroeconomic factors** such as oil prices, domestic fuel production and the growth of service sub-sectors shape the energy efficiency environment while urbanization, population growth, and rising incomes increase demand across the entire system. Non-fossil fuel energy supplies will have the largest expected impact on sub-sectors such as buses and passenger rail, which already use them. As prices for batteries and electric

Case Study: Integrated Land Use and Transportation

The Delaware Valley Regional Planning Commission (DVPRC) in southeast Pennsylvania, United States has been the federally designated Metropolitan Planning Organization for over fifty years for a nine-county region in two states. One of its main objectives is regional transportation planning, including corridor modeling and analysis that integrates transportation and land use to improve congestion, transportation systems and operations, and safety. Planning includes all transportation modes, including freight, aviation, road vehicles, passenger rail, transit, bicycles, and pedestrians. DVRPC, as part of long-range planning efforts, develops the Transportation Improvement Program (TIP), a set of regionally agreed upon priority transportation projects that use state or federal funds.

vehicles decrease, market share will increase. The share of natural gas as a transportation fuel is expected to grow from 3% in 2012 to 11% in 2040, including 50% of bus energy demand, 17% of freight rail, 7% of light-duty vehicles, and 6% of domestic marine vessels. In most business-as-usual scenarios, electrical LDVs count or less than 2% of the market but account for 40% of passenger rail energy demand. The U.S. Energy Information Agency anticipates that by 2040 as share of transportation gasoline demand declines from 39% in 2012 to 33% in 2040, though it does remain the dominant energy supply for the sector. These numbers may be increasing as the world's largest vehicle market – China – continues to increase its requirements for electric vehicles (see NYTimes, September, 2017 article)

Integrating land use planning with transportation planning is an important strategy to address the impacts of urbanization and population growth across APEC. For instance, the IEA explicitly models transportation demand and vehicle ownership across three urban land use patterns - 'High Sprawl', 'Constant Density', and 'Fixed Urban Land' to understand how transportation mode shifts will evolve in economies. By integrating planning of land uses, zoning, density and design with transport at economy, regional, municipal and metropolitan scales, both passenger and freight transportation can become more sustainable and energy efficient. One of the critical land use issues in APEC economies is urbanization. **Urbanization** creates rising incomes and increases demand for personal vehicles, rapidly expanding problems such as congestion and poor air quality. Growth in the industrial sectors increases demand for the movement of goods, increasing the number of heavy vehicles, freight rail, and port facilities. However, the economic shift in many economies from high intensity manufacturing to IT service sectors will add to urbanization pressures with increased demands for commercial real estate.

Land use planning strategies such as transit-oriented development and higher density development around rail lines can decrease sprawl and help avoid or shorten trips, improving the

Case Studies: Mode-shifts

The California High Speed Rail (CAHSR), approved by voters in Proposition 1A in 2008, began construction in 2015. The system will eventually connect San Diego, near the Mexican border, with Los Angeles, San Francisco and Sacramento, a distance of over 800 miles. The rail is part of a larger effort by the state of California to create a higher-efficiency no-emission transport sector, to help reach the states emissions targets of a 40% reduction from 1990 levels by 2030. It will be powered by 100% renewable energy, and all rail stations are being designed to connect to regional public transit and support Zero Emissions Vehicles, such as plug-in electric cars.

In 2015, China had 19,000 kilometers of high-speed tracks and plans to spend over $500 billion USD on rail systems by 2020, including 3,000 kilometers of urban transit systems. The **Beijing-Shanghai high-speed rail**, which opened in 2011 and covers over 800 miles, shuttles over 130 million passengers a year. The system has helped China build up a mega-corridor of dense satellite towns along the coast. According to the Economist, there are about 75 million people living within an hour of Shanghai along the high-speed rail. The high-speed rail between Beijing and Tianjin, a large port city, takes less than 30 minutes for a 120km trip. The Yujiapu Financial District (于家堡金融区) a Low Carbon Model Town, is only another 26 minutes on high-speed rail from downtown Tianjin.

overall efficiency of the transportation system. According to APERC, APEC economies that invest in efficient **transit** and land use planning to have the greatest potential to offset the impact of high personal vehicle ownership rates and reduce emissions. For the freight sub-sector, land use planning supports the integration of land, air and water based transportation in multi-modal hubs, optimize the utilization of assets, and can reduce urban freight congestion.[8] These strategies are required to defray the impact of both mature vehicle markets and rapidly increasing vehicle ownership rates in developing economies.

Integrating energy efficiency into **global targets** and goals such as emissions reductions, health, security, or other environmental concerns supports the adoption of efficiency strategies throughout APEC. The sector accounts for 23% of global CO2 emissions, making the sector critical in emissions reduction strategies. The IEA's notes that to reach GHG emission reduction goals and energy intensity targets, economies need to invest in total system efficiencies, not just target domestic road transportation. Additionally, electrical vehicles, while a small proportion of the LDV market, are critical technologies to help reach reduction goals. [10] According to the World Bank, 100 of the 147 signing parties of COP21 prioritized transportation emissions in their Intended Nationally Determined Contributions (INDCs). Multi-lateral banks have also joined in the effort, averaging US 25 billion a year in loans and grants for sustainable transportation projects. In addition to climate issues, economies have taken the opportunity to combine COP21 goals with social and economic resiliency strategies. Both Viet Nam and the Philippines are part of the V20 (Climate-Focused Vulnerable Twenty Group of Ministers of Finance), formed in 2015 to promote high-level policy dialogue around resiliency and low-carbon development.

The United Nation's **Sustainable Development Goals** (SDGs) also rely on energy efficient

Case Studies: Vehicle Fuel Economy

China began a **four-phase fuel economy** implementation strategy in 2005, starting with model thresholds, corporate average fuel consumption standards, and finally fleet regulations, with mandatory labeling and incentives for high efficiency cars. Phase four, starting in 2016, sets a fleet average of 5.0 L/100KM for new vehicles sold in 2020, much lower than China's 2012 Energy Saving and New Energy Vehicle Industrialization Plan's target of 6.9L/100km. As the largest light duty vehicle market in the world, fuel efficiency standards have helped the economy deal with serious air quality problems in urban areas. According to the IEA, the average specific CO2 emissions of new vehicle sales in China have been decreasing since 2010 despite average increases in engine power (typically an indicator of lower fuel economy)

The first **fuel economy standards for vehicles in Japan** were enacted in 1985. By 2000, the Top Runner program included consumer labeling and mandatory fuel economy standards. Targets for 2020 reduce fuel consumption a further 19.7% from 2009 levels for LDVs, trucks and commercial vehicles. Tax incentives encourage lighter vehicles, by increasing taxes on heavier, powerful cars. Exceeding fuel economy standards qualifies for tax breaks. Targets for 2020 range from 24.6 km/L for the lightest vehicles, to 10.6 km/L for the heaviest commercial vehicles. According to the IEA, Japan is only economy where electric vehicles account for more than 10% of sales last year.

[8] According to the U.S. Energy Information Agency, truck freight accounts for 60% of global freight fuel consumption, followed by marine (30%) and rail and pipeline (10%). Subsector is expected to see 1.5% AAGR.

transportation. According to the Partnership on Sustainable Low Carbon Transport, five SDGs directly related to the sector, including access to all-season roads, access to public transportation, passenger and freight volumes, and death rates due to road injuries. The sector indirectly contributes to seven others including goals related air pollution and public heath, equity and access to education and employment

3.4.2.2 *Sector*

Sector level drivers and barriers in the transportation sector include the lack of strong policies and regulatory environments, missing or weak market mechanisms, consumer behavior, infrastructure development, and growing vehicle ownership rates.

Government policies and incentives drive market wide adoption of higher efficiency vehicles. Eight economies make up 87% of global energy efficiency LDV investments, and six are in APEC: China (41%), United States (17%), Japan/Korea (8%), Indonesia/India[9] (2%) and Mexico/Brazil* (2%). The key regulatory strategy in the sector is the adoption of mandatory **fuel economy standards**. The OECD's 2017 global fuel economy benchmark study analyzed both OECD and non-OECD countries. OECD fuel economy rates have dropped over the last ten years and increased in non-OECD economies. The slowdown in the OECD are largely attributable to fuel standards in two APEC economies: Japan and the United States. Accelerating fuel efficiency rates in non-OECD economies are attributable in large part to efficiency gains in China. Other economies in APEC that contributed to increased global fuel economy standards include Indonesia, Malaysia, Peru, Philippines, Russia, and Thailand. The study recommends targeting more powerful and heavier classes of LDVs for improved fuel standards, because they have the most potential for gains. Local, regional and economy-wide policies can also **increase market penetration** of higher efficiency vehicles by adopting labeling schemes, passing tax incentives, and supporting infrastructure investments.

[9] IEA categories and 2016 data

Case Studies: Consumer Behavior

Seoul, Korea won an Energy Smart Communities Initiative (ESCI) Annual Best Practice Award for transport in 2015 for its **Car-Free Days** program. Unlike a ban, the Weekly No Driving Day Program incorporates incentive measures to encourage participation including reductions on auto-tax, discounts on congestion charges and parking fees (public sector) and discount gas prices, maintenance fees and car washes (private sector). By relying on voluntary participation, the city got a 30 percent participant rate, decreased traffic flow by 7 percent, and a reduction of emissions by 12 percent.

The Victoria, Australia FleetWise program, which ran from 2011-2013, provided a framework and suite of tools to assist organizations with fleet energy efficiency, GHG emission reduction and fuel savings. Participants learned how to benchmark their fleet operation through face-to-face training and strategic services over a twelve-month period. The FleetWise program included a promotion, workshops, implementation and assessment phases. Results from the one-year pilot program included a 149-tonne reduction in Greenhouse Gas emissions (2% improvement) during the pilot phase.

The American Council for an Energy Efficiency (ACEE) ,in the United States, allows consumers to compare every new model of LDV in the US on **greenercars.org**, on fuel economy (EPA testing), lifecycle analysis of emissions, vehicle mass and battery mass (for EVs and hybrids). The site also includes tips and information, research, and ratings back to 2007, giving car buyers a comprehensive 'Green Book' for both new and used green vehicles.

Governments can promote consumer marketing and education campaigns that shift **consumer behavior for transit**. Encouraging **mode share shifts** move trips from passenger vehicles to higher capacity transit options such as buses, regional and high-speed rail, or to non-motorized modes like bicycles and walking. Governments can also ensure that subsidies and policies do not hide the real costs of transportation decisions by making certain that users are aware of and pay for the environmental and energy-security costs.

Vehicle Saturation. (Error! Reference source not found.**)** The number of vehicles on the road in an economy increases in tandem with economic growth and urbanization– and higher CO2 emission. Developed economies already have high levels of vehicle ownerships, while developing economies, particularly in southeast Asia, are expected to increase their market saturation rates quickly as populations grow, incomes increase, and people move into urbanized areas.

Economy	Urbanization Rate (%)		LDV Vehicle Saturation Rate (%)		
	2013	2040	2013	2040	% increase
Australia	89	92	90	98	9%
Brunei Darussalam	77	82	100	100	0%
Canada	81	86	83	94	13%
Chile	89	92	45	84	87%
China	53	70	28	98	250%
Hong Kong, China	100	100	93	94	1%
Indonesia	52	66	18	82	356%
Japan	92	97	96	100	4%
Korea	82	87	84	99	18%
Malaysia	79	84	69	99	43%
Mexico	73	83	59	99	68%
New Zealand	86	89	93	99	6%
Papua New Guinea	78	84	4	12	200%
Peru	45	53	18	84	367%
The Philippines	13	20	9	24	167%
Russia	74	79	54	85	57%
Singapore	100	100	96	99	3%
Chinese Taipei	75	-	96	99	3%
Thailand	48	66	37	91	168%
United States	81	86	93	97	4%
Viet Nam	32	49	5	39	680%

Table 8. Urbanization and LDV saturation rates, APERC 2016

3.4.2.3 *Technology*

Improving the overall efficiency of transportation systems, the fuel efficiency of vehicles on road, and the ability to improve metrics, relies on technology **innovation**. Like the industrial sector, a large proportion of R&D focuses on engineering advances and basic science research to improve **engine performance**. Research includes combustion engines, hybrid technologies, batteries, and electrical vehicle components. Other non-engine components that effect fuel consumption include air conditioning, tires, and lighting. Another focus of transportation R&D is **alternative fuels**. Although

APERC anticipates that fossil fuels will continue to dominate the sector, technological advances and break-through in biofuels, electricity, hydrogen and batteries will continue to shift sector fuel use.

Innovations in communication and **data technology** creates opportunities to design software that more efficiently manages congestion and system flows (fleet logistics, tolls, parking, etc.). It is also enabling the rapid expansion of car-share and rise-sharing companies such as Zip car, Uber and Lyft. In addition, software and engineering innovation is spurring **driverless car** technology R&D, already being tested on public roads in APEC economies such as the U.S. Canada, Japan, Singapore, and China.

Currently, detailed **disaggregated data** of LDV sales are available. Other vehicle type data (freight, rail, aviation and marine shipping) are limited. For researchers and policy makers, better software can also mean more information about metrics ranging from real-time activity to human behavior, allowing for more accurate modeling, projections, and integration with land use planning.

A recent study from the IMF and Georgetown University in 2017 posits a bullish scenario that projects the **electric cars battery** cost threshold will be much earlier than APERC estimates and cover 93% of the U.S. car market by 2040. Other predictions in recent reports include 100% electric cars in India by 2030 and high rates of adoption in China. Some automobile manufacturers have recently announced dates for an all-electric stock to meet global demands and the world's largest market, China. This could change the IEE scenario assumptions significantly over the next ten years.

3.4.2.4 *Economy*

Understanding the differences between APEC economies can help EWG EGEE&C identify and promote types of projects that can make the significant impact across APEC. This section is summary of economy-specific factors from the APERC research that effect potential energy efficiency gains in the transportation sectors. (Table 9) Transportation sector graphics come from the IEA Energy Efficiency Indicators Report [18] for OECD members and show sub-sector breakdowns of transport energy use.

- Combined, the U.S. and China make up 60% of the transportation demand in APEC. However, unlike other sectors, energy demand of the transportation sector in the U.S. is larger than China in both BAU and IEE scenarios.
- Due to limited transportation efficiency policies, high economic growth rates and rapid growth of vehicle ownership in many APEC economies, IEE scenario savings for this sector are extremely high. Five economies see over 50% of additional savings from the sector: Papua New Guinea (80%), Viet Nam (70%), Peru (64%), and Malaysia (57%). Another six see nearly half of additional savings from transport: Australia (47%), Brunei Darussalam (46%), Mexico (47%), Thailand (46%), Singapore (45%), and Indonesia (43%).
- Per Capita energy demands in the sector are highly varied. Although savings potential is the highest in Papua Guinea, it also has the lowest demand per capita (0.09 MToe per mil). The highest per capita demand remains Canada. In the scenario, Canada's demand per capita is nearly 5 times higher than China's, even though the economy will be 32 times smaller by population.
- Geography is an important variable in this sector. Large land masses like Australia and the United States have sprawling housing pattern and long distance truck freight routes. Other economies are small islands with higher rates of motorcycle usage. Extreme geography such

as mountain ranges and water bodies, and hazards like earthquakes and monsoons impact the viability of transit investments.

- With over 900 million new LDVs expected in APEC by 2040, and vehicle saturation growing quickly, critical elements for accomplishing sector savings will include fuel standards and labeling, as well as the growth of hybrid and electric vehicles. (Table 8**Error! Reference source not found.**)

			Transportation Sector 2040 Demand Projections (Mtoe, mil)				
Economy	GDP	Pop, Mil 2040	BAU 2040	IEE 2040	% change from BAU	% of IEE Scenario savings	IEE Mtoe/ per capita
Australia	2.80%	34	40	32	20%	47%	0.94
Brunei Darussalam	1.20%	0.6	0.5	0.3	40%	46%	0.50
Canada	1.70%	42	70	64	9%	21%	1.52
Chile	2.70%	20	11	9	18%	29%	0.45
China	4.90%	1361	517	433	16%	21%	0.32
Hong Kong, China	2.20%	8.9	1.8	1.5	17%	27%	0.17
Indonesia	4.40%	290	143	121	15%	43%	0.42
Japan	1.10%	114	51	42	18%	25%	0.37
Korea	2.20%	49	24	20	17%	22%	0.41
Malaysia	4.20%	41	27	23	15%	57%	0.56
Mexico	3.00%	145	72	55	24%	47%	0.38
New Zealand	2.30%	5.5	4.4	3.8	14%	32%	0.69
Papua New Guinea	6.40%	12	1.5	1.1	27%	80%	0.09
Peru	3.90%	38	27	20	26%	64%	0.53
The Philippines	6.00%	142	23	18	22%	38%	0.13
Russia	1.40%	151	95	82	14%	24%	0.54
Singapore	1.40%	6.2	2.6	2.1	19%	45%	0.34
Chinese Taipei	0.90%	23	10	8	20%	25%	0.35
Thailand	3.50%	73	45	32	29%	46%	0.44
United States	1.60%	383	571	507	11%	34%	1.32
Viet Nam	5.50%	104	34	27	21%	70%	0.26
APEC Totals		3,043	1,771	1,502	20%		

Table 9. APEC Transportation Sector Demand Projections, APERC 2016 data

Australia

The continents size, vast distances between population centers means the economy relies on light and heavy vehicle freight as well as air transportation (20% of transportation demand). Land use patterns encouraging sprawl in urban areas also drive LDV use. Although low carbon climate policies have resulted in from fuel economy improvements the economy does not have fuel economy standards. Increased EV share of market would benefit from the economies strong renewables potential, though growth may be slow. Transport retains the highest energy demand out of all three sectors through 2040. In both BAU and IEE scenarios 2040, Australia is the third highest sector per capital demand (after United States and Canada). However, at 41%, Australia's BAU nearly meets APEC's energy intensity target.

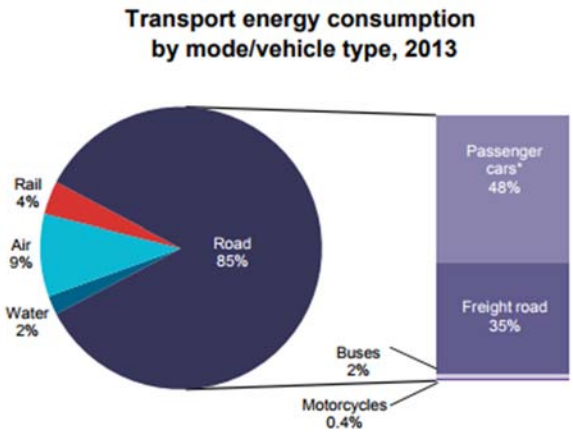


Figure 25. Australia, Global Transportation Energy Consumption, IEA 2016

Brunei Darussalam

As a very small state (410,000 pop) with a very high GDP per capita, high incomes, subsidized fuel prices and minimal transit options has resulted in a rapid rise in vehicle ownership. The road infrastructure is excellent and the fleet is relatively modern. Although the economy is expected to be energy self-sustaining, BP estimates of only a 23-year oil reserve has resulted in new focus on energy efficiency. The government's Energy Efficiency roadmap includes rapid adoption of fuel economy standards and electric/hybrid vehicles.

Canada

Canada's large land mass, isolated natural resources and large distances between urban centers puts a strong reliance on long distance transportation, both light and heavy duty vehicles. However, the government has adopted stringent fuel economy standards, tied largely to reducing GHG emissions. The economy is one of four in APEC with efficiency standards for freight. The growth of hybrid and electric vehicles will benefit from the economies 78% renewables portion of the energy supply mix of (2013), one of the highest in the world. In business-as-usual scenarios for 2040, Canada is top three (With United States and Australia) for domestic transportation

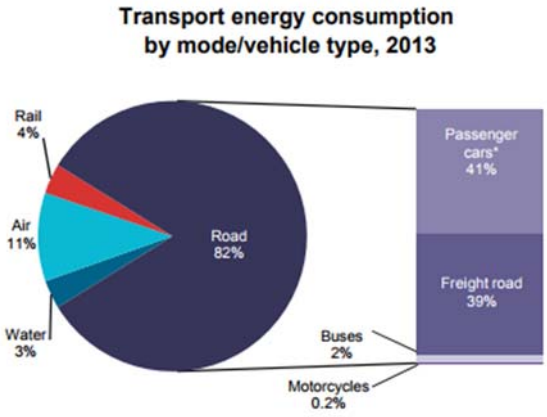


Figure 26. Canada, Transportation Energy Consumption, IEA 2016

energy demand per capita.

Chile

A developing economy, energy demand is anticipated to grow 67% by 2040. Private vehicle ownership is already near saturation levels (85%) and road transport uses 91% of transportation energy. The counties long narrow geography running in the middle of the Andres mountain range makes public transportation difficult. However, just over one third of the population lives in the capital, Santiago, where investments to increase urban transit and bus transportation options would have a large impact and decrease energy intensity. Chile's Action Plan on Energy Efficiency 2020 include improving fuel standards, and promoting transit and electric vehicles.

China

With a population of almost 1.4 billion and one of the largest land masses of any economy, vehicle ownership has skyrocketed on tandem with urbanization rates and incomes over the last fifteen years. In 2012, China's fuel consumption for truck freight was higher than passenger vehicles, reflecting strong industrial growth. The economy is one of four in APEC with efficiency standards for freight. Controlling vehicle emissions is a top mitigation priority for reducing air pollution caused by rapid urbanization. Cities like Beijing have vehicle lotteries to control market growth, and billions are invested in new high-speed rail lines and transit options. Other green transport policies include tax incentives for EV purchases and biofuels. Scenarios suggest at least 300 million new LDV stock, mostly small high efficiency cars, will be added to the economy by 2040.

Hong Kong, China

Hong Kong, China is an advanced economy with extremely high population density. The economy already has extensive public transport systems and ninety percent of commuters use transit. It is also at near saturation levels for LDV and promotes electric vehicle use. Due to its role as a global trade center heavy duty vehicles, shipping, and aviation are the main transportation sector energy users. The government promotes EV use and is actively increasing EV charging infrastructure

Indonesia

A long archipelago, the economy's large population is spread across a few thousand of islands. Motorcycles use almost a third of transportation energy, a distinct departure from other economies (typically less than 2% of the share). LDV saturation is currently low but is expected to skyrocket over 3 times its current energy demand and achieve a saturation higher than China in 2040.

Japan

Japan is the third largest economy in the world, as well as in APEC. A mountainous archipelago, population is already 93% urbanized and is expected to decline 10% by 2040. heavy duty vehicles are a higher proportion of land transportation than average due to the economies mountains Transportation demand has been falling steadily since 2004, reflecting strong efficiency policies. Even with strong rail and bus transit, however, LDV vehicle saturation is projected to increase from 95% to 99% by 2040, the highest in APEC. After the Fukushima accident oil demand increased, putting pressure on the government to address energy security concerns.

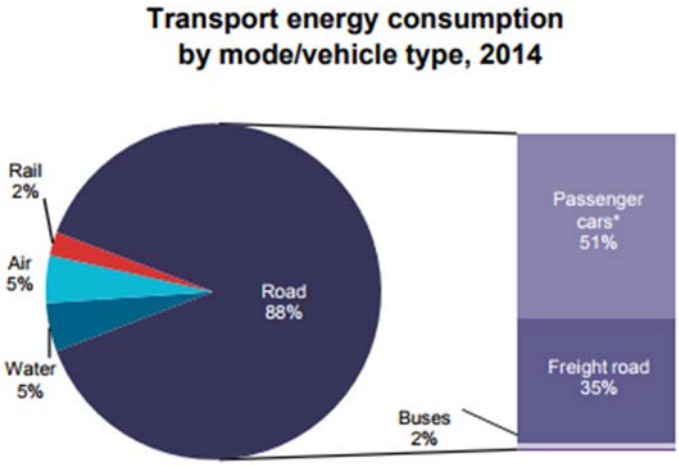


Figure 27. Japan, Transportation Energy Consumption, IEA 2016

Republic of Korea

Over eighty percent of the economy's population is urbanized. LDVs accounted for 96% of land transportation demand in 2013. However, it has a robust and mature transit system with high-speed rail and six international airports connected by rail. APERC estimates that transportation investments will add relatively minimal savings in higher efficiency scenarios. Unique among APEC, 25% of domestic transportation demand in Korea is marine vessel, reflecting geography and maritime investments in the economy. The economy is also one of only four in APEC with efficiency standards for freight.

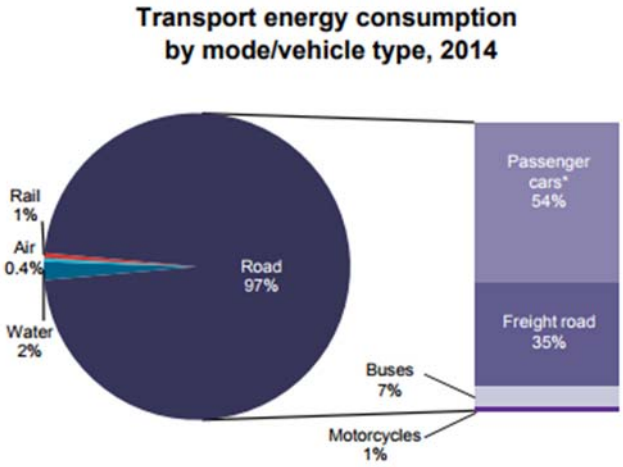


Figure 28. Korea, Transport Energy Consumption, IEA 2016

Malaysia

With rapid economy growth, Malaysia is projected to achieve "developed" status by 2020, with higher incomes allowing for higher vehicle ownership rates, expected to reach 98% saturation by 2040. Transportation currently uses more energy (36%) than either industry (28%) or buildings and agriculture (19%). Lack of transit options are notable in its largest city, Kuala Lumpur but a the first two phases of the Klang Valley Mass Rapid Transit System have been completed, and nearly 1,000KM of new rail lines are under construction. The city supports only 5% of the total population, with the remaining 30 million dispersed over six main islands, and hundreds of minor islands. After

China, it has the second highest growth rate for renewable energy in APEC.

Mexico

Transportation has been the largest consumer of energy (43%), and nearly half of the IEE scenario savings comes from the sector. The growth of vehicle ownership has made urban air pollution a serious problem, particularly in Mexico City. LDV fuel efficiencies are only indirectly impacted by Co2 regulations and fuel economy standards are based on older U.S and the EU standards. There are no heavy vehicle efficiency policies. Vehicle saturation, while currently low (59%, 2013) is expected to reach 99% by 2040. Transit systems consist largely of BRT and old minibuses – systems which are over 60% ad hoc in major cities. APERC models show the most sector impact with efficiencies (23%) over renewable investments (2.6%).

New Zealand

New Zealand's 4.4 million people already get 73% of their electric power supply from renewables. Although it is an isolated island nation with 86% living in urban centers, agriculture is the largest sector, largest source of GHG emissions, and a major driver of land vehicle transportation, which carries 70% of freight. (Ministry of Transport, NZ) Vehicle saturation in 2013 was the same as the U.S (93%), and overall transit use is low outside of cities.

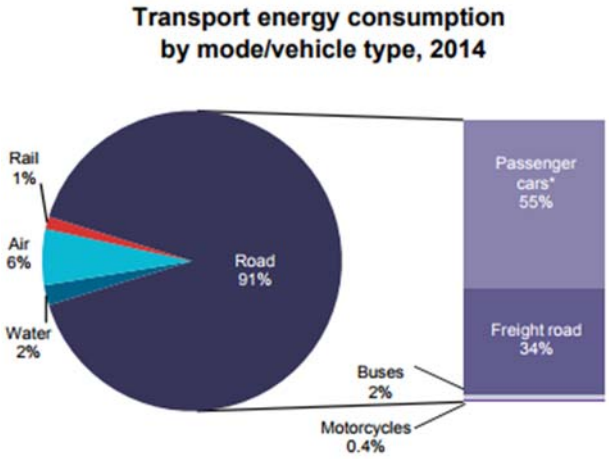


Figure 29. New Zealand, Transport Energy Consumption, IEA 2016

Papua New Guinea

PNG is a largely rural and forested island(s) economy, with access to electricity (15%) concentrated mostly in urban centers. Energy access is projected to grow demand 4-fold through 2040. Although road transport is dominant the sector it is sparsely developed – vehicle saturation levels were at 4% in 2013, and are expected to rise only to 12% by 2040.

Peru

Energy demands are expected to rise 185% by 2040, with transport accounting for the largest share (40%) due to an expected rapid increase in vehicle saturation from 18% (2013) to 84% (2040) from urbanization and rising incomes. The economy does not have fuel efficiency standards and little to no hybrid/EV market.

The Philippines

APERC projects a rapid growth rate (6% annually) for the Philippine economy. Although vehicle saturation will grow over 2.5fold its current rate, it will remain low at 24% by 2040. Industry (40%) is projected to outpace transportation (37%) as the largest user of final energy in BAU. The Philippines plan to implement (but does not currently have) labeling and efficiency standards. The impact of

renewable investments on transport is seen in the increased use of biofuels.

Russia

Russia's energy export-focused economy is under pressure to adopt energy efficiency measures to maintain economic growth. Rising incomes are projected to increase vehicle ownership, from saturation of 54% (2013) to an expected 85% in 2040. As the world's largest export of energy, pipeline infrastructure consumes 30% of the land transport energy. Assumed transport saving are due in large part to fuel standards, which the economy does not currently have.

Singapore

With Singapore's small island geography, efficiencies will dominate savings over renewables (lack of space). Already a low carbon urban economy, Singapore's transport sector is the lowest end user of energy. It the only one expected to decline by 2040 in absolute MToe demand. Policy focuses on expanding rapid transit to reduce vehicle ownership. HDV continues to have an outsized share of road transport due to heavy industry (e.g. oil refining) in the economy.

Chinese Taipei

Chinese Taipei is a largely services dominant developed economy constrained by geography (four islands) and lack of natural resources. Domestic transport (at 15%) is the lowest power demand sector in the economy. The islands have extensive mass transit and high speed rail in the 3 largest cities and motorcycles are an exceptionally large portion of the road sector (37%). The government offers incentives to increase electric motorcycles and scooter purchases.

Thailand

Thailand's economic growth is expected to transform low vehicle saturation (37%) to a high of 91% in 2040. Transportation infrastructure has been prioritized to connect economic zones in smaller urban centers, including rail (freight and passenger). With few natural energy sources, energy security is a priority. With high vehicle saturation increases expected (37%, 2013; 91% (2040) transport efficiencies are expected to make the largest sector impact on energy demand.

United States

In APERC's energy scenarios, the U.S. accounts for 21% of APEC's potential savings. The U.S. has fuel economy and other transport sector policies in place at federal (e.g. CAFÉ standards), state, and local levels. The transport sector has the highest energy demand, and that trend continues through 2040, with slight declines. The U.S. has one of the largest EV/Hybrid markets and an expanding EV infrastructure. BAU and projected savings measures driven by meeting GHG emission targets may be impacted due to divergence

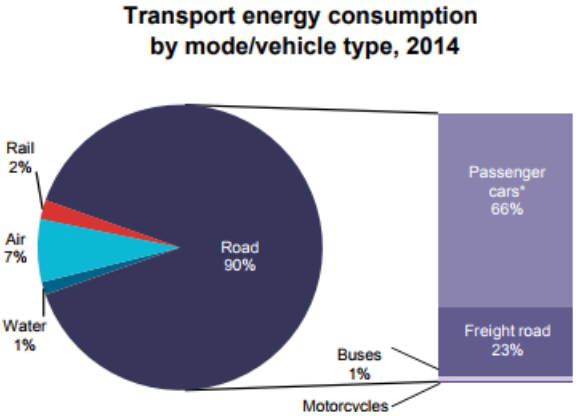


Figure 30. United States, Transport Energy Consumption, IEA 2016

between federal and many state commitments to the Paris Climate Accord.

Viet Nam

Viet Nam's vehicle saturation is extremely low (5%, 2013) and will be one of the few economies to remain under 80% in 2040 (39% projection) despite being an emerging economy. Motorcycles, at 26% of the transport sector and 86% of privately owned vehicles, is projected to remain the dominant LDV in the sector. Emissions and fuel economy standards are expected to be implemented.

4 Policy and Regulatory Environment

4.1 Comparative Policy Indicators

APERC research, such as *The Compendium of Energy Efficiency Policies of APEC Economies*, *APEC Peer Review on Energy Efficiency Reports* (PREE) and the *Demand and Supply Outlook* reports provides comprehensive descriptive analyses of APEC economies and their respective policies. Organizations such as IRENA and IEA also provide databases of policies and targets. As an alternative to extensive descriptive summaries, we have used the Regulatory Indicators for Sustainable Energy (RISE) framework to understand the state of energy efficiency regulatory and policy environments across APEC. RISE, run by the World Bank Group, is a set of indicators that compares government policy and regulatory frameworks for sustainable energy under the three pillars of the United Nation's SEforAll initiative. The three pillars of energy are 1) access to modern energy, 2) energy efficiency, and 3) renewable energy. The data, ranking criteria, and methodologies for the indicators are publicly available for review and download.

RISE AVERAGE SCORES (1-100)			
Economy	**Energy Access**	**Energy Efficiency**	**Renewable Energy**
East Asia & Pacific			
China	100	68.46	74.29
Indonesia	61.49	33.88	55
Malaysia	100	51.66	68.29
The Philippines	82.24	42.23	66.57
Thailand	100	62.54	59.57
Viet Nam	100	70.58	64.14
Europe & Central Asia			
Russia	100	69.51	60.57
Latin America & Caribbean			
Mexico	100	79.37	71.71
Peru	66.89	31.34	60.86
OECD high income			
Australia	100	71.75	73.29
Canada	100	85.36	87
Chile	100	50.1	77.86
Japan	100	67.58	78
Korea	100	82.99	71.71
United States	100	88.12	84.71
Score : 0-33	Score : 34-66	Score : 67-100	

RISE reviews 111 countries representing 96 percent of the world population. Of the 21 APEC economies, 15 are included in the RISE economy analysis (Table 10). Of those 15, nine APEC economies are in the top global 20 for energy efficiency performance: United States (#1); Canada (#4); Korea (#5); Mexico (#6); Australia (#13); Viet Nam (#15); Russia (#17); China, and Japan (#20). The six economies excluded from RISE are Brunei Darussalam; Hong Kong, China; New Zealand; Papua New Guinea; Singapore; and Chinese Taipei. The average scores for energy efficiency range from 31 -88 and the category includes the only poorly performing score. The EE scores are an average of twelve indicators. The second and third tables break down each sub-indicator and reveals some of the challenges facing APEC economies and policy gaps.

Table 10. RISE Indicator Scores, APEC economies

RISE Energy Efficiency Indicators within APEC

RISE uses twelve indicators to rank an economies score (Table 11) including economy-level policies, regulatory environment, incentives, standards and labeling within the supply and demand sectors. The following list describes what each indicator measures.

1. **EE Indicator 1: National energy efficiency planning** – This indicator requires the existence of a legislative action planning, national targets and sector targets. Internationally, 74% of economies have strong national energy efficiency planning. The average score for APEC is good, but relatively low due to five economies scoring just over the average cut-off.
2. **EE Indicator 2: Energy efficiency entities** – The indicator looks at the coverage of government entities that are responsible for energy efficiency policy, regulations, and compliance. With an average of 75, it is the highest score of the twelve for APEC at large. Only 61% internationally score as strong performers on this indicator.
3. **EE Indicator 3: Information provided to consumers about electricity usage –** This indicator evaluates mandatory reporting and the quality of the usage data reported. The APEC average of 62 aligns with international averages – Only 15% of economies score high on this indicator. The highest scorer is the economy of Korea, at 79. The lowest is China, at 42.
4. **EE Indicator 4: EE incentives from electricity rate structures –** This indicator reviews electricity rate structures such as demand charges and time of use tariffs. Only 49% of economies internationally score strongly on this indicator. This is second highest average score (73) in APEC.
5. **EE Indicator 5: Incentives and mandates: large consumers –** This indicator reviews large mandatory regulations, incentives and performance recognition. The international average is only 59% for strong performances. In the APEC economies, there are only three exceptions to overall high scores: Chile, Peru, and the Philippines.
6. **EE Indicator 6: Incentives and mandates: public sector** – Only 23% of international economies score strongly on this indicator, which reviews obligations on public facilities, procurement and ability of governments to retain energy savings. APEC economies have the widest range of scores, from zero to 100. Economies with poor scores are Indonesia; Chile ;and Japan.
7. **EE Indicator 7: Incentives and mandates: utilities –** A mere 8% of international economies score strongly on this indicators, which looks at mandated regulations and cost recovery mechanisms for utilities. Not surprisingly, it is the lowest average score of all 12 indicators. Only four economies rank as strong performers: Russia; Mexico; Canada; and the United States. With industry the largest energy-consuming sector over the outlook period and one-third of final energy demand, this score represents an area with a lot of room for improvement.
8. **EE Indicator 8: Financing mechanisms for energy efficiency –** This indicator reviews financing mechanisms available in each sector. his indicator score is only average across APEC.
9. **EE Indicator 9: Minimum energy efficiency performance standards –** This indicator reviews products, verification and penalties for non-compliance and only 40% of international economies score mid or high. This is another wide-ranging indicator for APEC economies. Although some economies are very high performers, five received very low scores: Chile; Indonesia; the Philippines, Russia; and Thailand.
10. **EE Indicator 10: Energy labeling systems –** With only 17% of international economies scoring strongly on this indicator, APEC's high performers keep APEC average in the middle

of the pack. May economies are strong performers, with the U.S. and Viet Nam performing the strongest. Weaker scores included Indonesia, Malaysia, and Peru.

11. **EE Indicator 11: Building energy codes –** This indicator evaluates new building codes, compliance systems, renovated building codes, labeling, and incentives**.** In APEC, there is a wide mix of strong and weak performers, with the lowest scores in Southeast Asia and Latin America.
12. **EE Indicator 12: Carbon Pricing.** Globally, 77% of economies score poorly on this indicator. This trend continues across APEC, with an average of 45. Eight economies scores zero.

Table 11. RISE Energy Efficiency Indicators, by APEC Economy

	ENERGY EFFICIENCY INDICATORS											
Economies	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
East Asia & Pacific												
China	91.67	85.71	41.67	77.78	88.89	50	50	100	58.33	83.33	40	54.2
Indonesia	66.67	85.71	62.5	44.44	94.44	0	0	16.67	11.11	25	0	0
Malaysia	66.67	85.71	50	77.78	72.22	75	29.17	50	50	33.33	30	0
The Philippines	58.33	42.86	66.67	100	38.89	75	58.33	0	16.67	50	0	0
Thailand	91.67	100	62.5	62.96	100	37.5	62.5	91.67	33.33	58.33	50	0
Viet Nam	83.33	100	62.5	77.78	66.67	100	16.67	83.33	100	100	56.67	0
Europe & Central Asia												
Russia	91.67	100	54.17	88.89	66.67	100	75	100	11.11	66.67	80	0
Latin America & Caribbean												
Mexico	66.67	100	57.64	81.48	100	87.5	87.5	83.33	94.44	83.33	36.67	73.9
Peru	75	57.14	66.67	48.15	33.33	50	4.17	0	41.67	0	0	0
OECD high income												
Australia	66.67	71.43	58.33	96.3	66.67	100	16.67	91.67	83.33	66.67	93.33	50
Canada	91.67	85.71	68.75	74.07	88.89	100	87.5	100	97.22	83.33	86.67	60.1
Chile	100	71.43	62.5	100	22.22	25	0	50	33.33	83.33	53.33	0
Japan	75	71.43	68.75	81.48	88.89	0	16.67	91.67	83.33	83.33	66.67	83.79
Korea	66.67	100	79.17	81.48	88.89	100	50	83.33	100	83.33	80	83
United States	100	100	75	88.89	88.89	75	83.33	100	100	100	93.33	53
Economies Average	**71.76**	**75.39**	**61.65**	**73.25**	**57.25**	**57.29**	**31.94**	**63.65**	**57.40**	**55.78**	**58.24**	**44.6**

Score : 0-33 Score : 34-66 Score : 67-100

One important difference between APERC analysis and the RISE indicators in the inclusion of Indicator 12 – Carbon Pricing. Carbon pricing is not included in APERC scenario analysis. Of the fifteen APEC economies included in RISE, only Japan, Korea, and Mexico have strong carbon pricing ratings. Eight economies have zero scores. Excluding carbon pricing, however, there are still 27 instances of poor performances across economies. '*Incentives and mandates for utilities'* has an average 'poor performance' rating, signaling a large area of improvement across the region, particularly because Industry will account for one third of final energy demand over the outlook period. Only three areas – government planning, energy efficiency government entities, and electricity rate structures (indicators 1,2 and 4) have a strong average across APEC.

RISE Policy Framework. RISE considers seven of the twelve energy efficiency indicators policy framework elements. (Table 12) The following table breaks down those indicators to reveal the range of policies and regulations across APEC economies and major gaps at an economy-wide level. No single economy is 100% across energy efficiency. Indicators focus on mandatory, not voluntary programs.

Table 12. RISE Policy Framework Indicators, by APEC Economy

Policy Framework Indicators	China	Indonesia	Malaysia	The Philippines	Thailand	Viet Nam	Russia	Mexico	Peru	Australia	Canada	Chile	Japan	Korea	United States	# of Economies
EE Indicator 1: National energy efficiency planning																
1.Legislation	■	■	■		■	■	■	■	■	■	■	■	■	■	■	14
2.Target: Overall	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	15
3.Target: Residential	■			■	■		■		■			■			■	7
4.Target: Industry	■			■	■	■	■				■	■			■	8
5.Target: Commercial				■	■	■					■	■			■	6
6.Target: Supply	■						■				■	■	■		■	6
EE Indicator 3: Information provided to consumers about electricity usage																
Industry																
7.Consumption	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	15
8.Price	■	■	■	■	■	■	■	■		■	■	■	■	■	■	15
9.Time of Use	■		■	■		■	■	■		■	■	■	■	■	■	12
Residential																
10.Consumption	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	15
11.Price	■	■	■	■	■	■	■	■		■	■	■	■	■	■	14
12.Time of Use	■			■		■	■	■		■	■	■	■	■	■	11
Commercial																
13.Consumption	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	15
14.Price	■	■	■	■	■	■	■	■		■	■	■	■	■	■	14
15.Time of Use	■		■	■		■	■	■		■	■	■	■	■	■	12
EE Indicator 5: Incentives and mandates: large consumers																
16.Req'd use tracking	■	■	■	■	■	■	■	■			■	■	■	■	■	13
17.Req'd targets	■						■				■	■	■	■		6
18.Req'd Audits	■	■				■	■		■				■	■		7
19.Req'd Other		■	■	■	■	■	■	■			■	■	■	■	■	12
20.Incentives: Tax																0
21.Incentives: Financial	■		■		■	■							■	■		6
22.Incentives: Other		■	■		■	■			■	■						6
EE Indicator 6: Incentives and mandates: public																
23.Facility Obligations						■	■	■		■	■		■	■	■	8
24.Procurement Req's	■		■	■	■	■	■	■	■	■	■	■	■	■	■	14
EE Indicator 10: Energy labeling systems																
Standards																

25.Refrigerators																12
26.A/C																12
27.Lighting																13
28.Industry Motors																10
29.Industry Other																7
30.Vehicles																3
Labels																
31.Refrigerators																13
32.A/C																13
33.Lighting																13
34.Industry Motors																8
35.Industry Other																7
36.Vehicles																3
EE Indicator 11: Building energy codes																
37.Residential Codes																13
38.Commercial Codes																9
EE Indicator 7: Incentives and mandates: utilities																
39.Generation Mandates																8
40.DSM Mandates																8
41.T&D Mandates																9
Economy Total Counts	31	15	23	24	28	34	29	30	12	25	34	26	32	30	35	

Seven economies got 75% or more of the 41 policy framework indicators: Canada, China; Japan; Korea; Mexico; the United States; and Viet Nam.

1. **Indicator 1, National energy efficiency planning**: All economies except the Philippines have established economy-level energy efficiency planning documents or action plans. Economies all have an energy efficiency target but the establishment of sector targets various greatly.
2. **Indicator 3, Information provided to consumers about electricity usage**: Economies are consistently giving customers consumption and pricing information. There is a gap in Time-of-Use Pricing across all demand sectors.
3. **Indicator 5, Incentives and mandates: large consumers**: Required use/consumption tracking is the most common mandate for large consumers, followed by “other”. No economy had national-level tax incentive programs in place. Required audits and targets are policies in less than half of the reviewed APEC economies. This does not preclude voluntary or municipal programs. For instance, many cities and states in the U.S. have both mandatory and voluntary audit programs for large consumers. Incentives are 3x less likely to be used than mandates.
4. **Indicator 6, Incentives and mandates: public**: Procurement requirements are the most frequently adopted policies. All but Indonesia have them. However, only half have established policies for binding public building obligations (which may include facilities, water supply, wastewater services, municipal solid waste, street lighting, transportation, and heat supply).
5. **Indicator 10, Energy labeling systems:** The positive impact of years of workshops and projects focused on standards and labeling for lighting, air conditioning, refrigerators and similar equipment. 80-90% of economies have labeling schema and almost as many have standards. S&L for industry and vehicles, however, drops precipitously. However, only about half of the economies have standards or labeling in place for industrial equipment. The number of economies with vehicle standards and labeling drops down to 20%.

6. **Indicator 11, Energy labeling systems:** The adoption of mandatory commercial energy codes is lagging behind residential codes. Only Indonesia and Peru are missing residential energy codes.
7. **Indicator 7, Incentives and mandates: utilities** is the lowest performing in APEC, and more inconsistent that other indicators across APEC economies: Korea, with an overall high average of 88, is missing all three. Thailand, which has all three, has a middle score of 63.

An additional review of policies for the missing six economies in RISE reveal that they have government energy strategies that address energy efficiency, and municipal agencies with energy efficiency responsibilities. Hong Kong, China; New Zealand; Singapore, and Chinese Taipei all have mandatory regulations and minimum energy performance standards.

4.2 Mandatory Energy Efficiency Policies

Mandatory standards and mandates are the "gold standard" for measuring energy efficiency policies. Like the RISE indicators, the International Energy Agency (IEA) tracks mandatory energy efficiency policies worldwide.

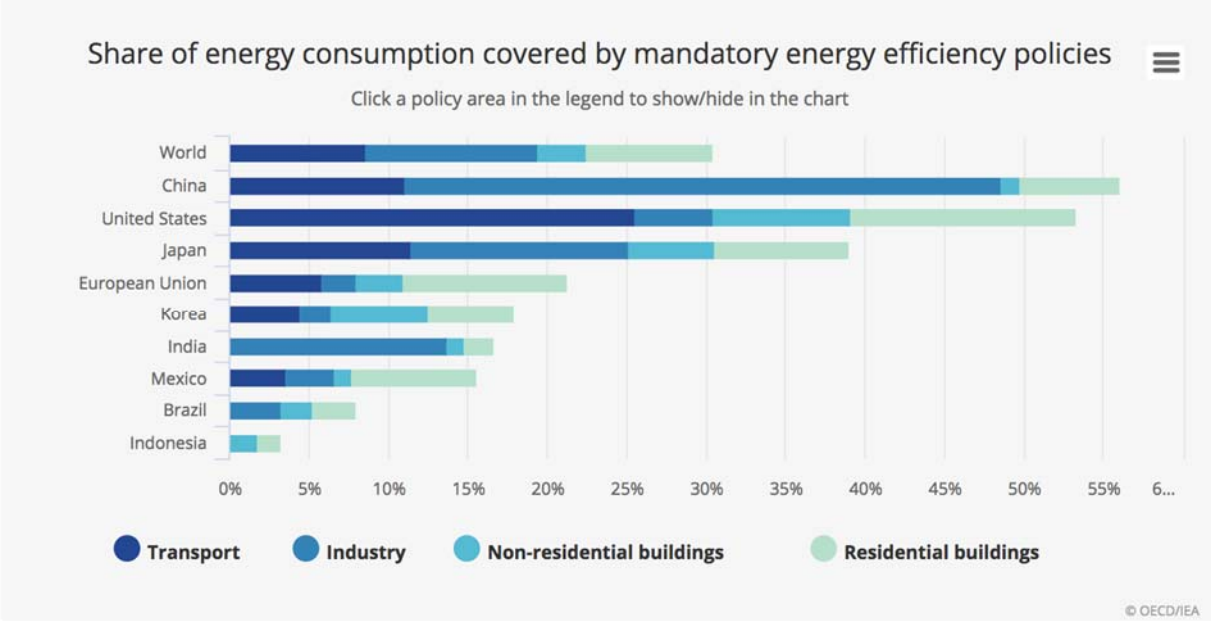


Figure 31. Mandatory Energy Policy Coverage of Energy Demand, IEA, 2016

Currently, as shown in Figure 31, mandatory regulations only cover 30% of global final energy demand. With over 50% coverage, China and the United States are significantly ahead of the world average. As seen in Figure X, China's mandatory policy focus has been on the industrial sector, which grew phenomenally fast the last fifteen years (72% of GDP in 2005). As that proportion shifts downward (40% of GDP in 2015) with the expansion of service sectors and car ownership, other sectors' share are predicted to increase. In comparison, the policies in the United States reflect an economy with a proportionally smaller industrial sector (around 19-20% GDP), a nearly saturated vehicle ownership rate, and a mature buildings sector. These IEA trends reflect the RISE indicators. In Indonesia, an emerging but fast growing economy with a large population split among thousands

of islands, only 3% of energy demand is covered - and only in the building sector. It also has one of the lowest scores in RISE. Japan's small proportion of non-residential building policies is reflected in Japan's lack of commercial building energy codes. Korea, with a small proportion of mandatory policies in Industry, does not have EE targets in industry or the supply sectors, and is missing all three utility sub-indicators. Mexico's small coverage in the transport and industry sectors, however, does not have an obvious corollary in the RISE indicators.

The IEA also produces the *Energy Efficiency Indicators Essentials for Policymakers* report (IEA, *2014*). The report highlights the context within which indicators can be developed and evaluated, as well as their limitations. A few caveats from that report worth emphasizing here are:

- The availability of "quality, timely, comparable and detailed data" must go beyond energy balances. Development of state-of-the-art indicators is not straightforward and requires financial and human resources to collect detailed data, and analyze the information; It cannot be developed within a few years.
- It is important to differentiate energy efficiency and energy intensity. Although efficiency is used as a proxy, structural factors such as industry base, exchange rates, climate and consumer behavior can mask efficiency gains.
- Indicators have limitations and gaps should be prioritized by economy

5 Project Assessment

5.1 APEC Mission

Energy efficiency is key to one of APECS most ambitious goals – A 45% aggregate energy intensity reduction by 2035. Using scenarios, APERC has identified broad policy and regulatory pathways that will enable economies to bridge the gap between current energy use and that goal. The most recent *2016 Energy Demand and Support Outlook Report* concluded that economies could meet their stated intensity goals with larger commitments to increased energy efficiency strategies. The APERC models, which assume that economies use cost effective policies and best available technologies (BATs), confirm that energy efficiency offers the "most attractive option to improve energy security and address climate change". The potential energy efficiency gaps in each sector can be substantial but are not insurmountable. Adoption of BATs in the industrial demand sector can increase efficiencies of subsectors up to 55%. Efficiency improvements in building appliances and equipment can reach 40 percent while fuel efficiency standards in transportation can double the rates of improvement between 2030-40.[10] As the "first fuel", energy efficiency is the first resource that economies can leverage in their energy intensity reduction goals. All the strategic goals and projects of the EGEE&C align with this vision – whether a project promotes efficiency, makes it easier or more cost effective to implement, or improves analytical, technical or policy capacity.

In addition to energy intensity reduction, energy efficiency projects help APEC meet its mission to "champion free and open trade and investment, promote and accelerate regional economic integration, encourage economic and technical cooperation, enhance human security, and facilitate a favorable and sustainable business environment." The mission is broken down into two broad thematic categories – '*regional economic integration'* and '*strengthening quality growth*" with more than forty sub-categories. Each Working Group also develops a Strategic Plan with four or five goals, further broken down into objectives for their respective Expert Groups and Task Forces to meet. Projects cannot directly address every mission, goal, and objective across APEC. Working from the top down, however, key themes and priorities emerge that narrow down the number of strategic gaps projects could help address.

Energy efficiency regularly address ten of the more than forty APEC-wide priorities[11]. Under the theme '*regional economic integration'*, energy efficiency projects can address:

1. Human development […] cooperation on education, skills development, science and technology and capacity building, alignment of education and training;
2. Information technology and the digital economy;
3. Emergency preparedness and disaster risk reduction;
4. Standards, conformity assessment, technical regulations and coherence

Due to the overall nonspecific nature of these categories, it is fair to say that the energy efficiency portfolio has been addressing these issues regularly. Of the first four, efficiency projects are designed to address human development through capacity building, education, and training. Projects in the last five years have tackled elements of the digital economy, particularly smart grids and

[10] APEC Energy Demand and Supply Outlook 6th Edition – Improved Efficiency Scenario, APERC

[11] The list comes from the 2017 project funding criteria, which requires projects to demonstrates support of the APEC-wide priorities of regional economic integration (18 'Rank 1' categories) or Quality Growth (22 'Rank 2' categories), Most project objectives do not deal with all these issues directly.

energy management. Standards and coherence have been a long-term focus since the 1990s. However, the portfolio does not address emergency preparedness and disaster risk reduction.

Energy efficiency projects are more closely aligned with the second theme - '*strengthening quality growth'* :

1. Inclusive Growth: Women and the economy, social dimensions of globalization, issues related to economic disparities
2. Secure Growth: disaster risk reduction
3. Balanced Growth: macro-economic policy coordination and information sharing, financial markets
4. Sustainable Growth: **Energy efficiency**, security and resiliency; low-carbon technologies and alternative energy sources
5. Urbanization and smart cities, sustainable and resilient communities
6. Innovative Growth: Innovation policy and research cooperation, harnessing new technologies

It is easier to see how energy efficiency projects have aligned with this theme's topics. The first two categories are not the subject matter of projects in the portfolio, with one or two exceptions. Project descriptions in the APEC-wide project database, however, do have a description category "gender" where participation by women in the projects is noted. Balanced Growth, in the form of policy coordination and information sharing, is fundamental to efficiency projects. The ESCI Knowledge Sharing Platform is an example of information sharing and there are over thirty standards projects that focus on harmonizing standards and testing policies across APEC economies. The Low Carbon Model Town (LCMT) initiative is a great example of a multi-year multi-phase approach to addressing sustainable growth, urbanization, and smart cities. Although LCMT projects have emphasized new technologies and research coordination, the portfolio does not broadly address 'innovation policy' – i.e. ministry-level support for innovation, research and development, and technology transfer.

5.2 Energy Working Group (EWG) Priorities

The EWG breaks APEC-wide mission priorities down periodically into short-range strategic plans. Although the current plan has not guided all 23 years of project history, it provides a useful framework for analyzing trends, the overall composition of the portfolio, and how well it is aligned with current energy efficiency objectives.

2014-2018 Strategic Plan:

Our mission is to build the capacity of APEC members to strengthen domestic and regional energy security and lower the carbon intensity of energy supply and use across the region, facilitated by information and data exchanges, joint research and development, and open trade and investment.

The mission of the EWG 2014-2018 Strategic plans is to: 1) Strengthen energy security and resilience; 2) Promote fuel diversification; 3) Train a gender-inclusive workforce, and 4) Lower the carbon intensity of energy supplies.

Increasing **energy security and resilience** means weathering short-term energy supply disruptions and securing affordable and cleaner energy supplies through increasing the efficiency of regional energy markets and improving energy data and projects. Energy efficiency projects can support a couple of objectives under the category. Specifically:

- Promote the safe, secure and peaceful use of nuclear energy: Several economies have put moratorium on the development and/or expansion of nuclear energy after the Fukushima accident in Japan. The resulting switch to fossil fuels increases emissions and places additional pressure on energy efficiency strategies to help meet energy intensity reduction goals.
- Encourage the removal of inefficiency fossil fuel subsidies that promote wasteful consumption: Fossil fuel subsidies reduce and distort the cost incentives of energy efficiency investments. Investors and financial institutions see higher risks (lower ROI) and and other stakeholders resist minimum energy performance standards (MEPS),. Reducing the uptake of BATs and slowing down efficiency gains.
- Undertake analysis of the water-energy nexus: The relationship between energy and the water used for electricity production. Economy or regional drops in energy use in building sectors (residential, commercial, industrial) can reduce operational pressures on power plants and therefore reduce water consumption.

Promoting fuel diversification translates to the objective 'Developing Cleaner Energy Sources'. The objective aims to help APEC economies adopt existing energy technologies, support innovation, and facilitate an increase in the use of new and renewable energy technologies. Energy efficiency project can support the following features of this objective:

- Promote clean energy supplies and technologies: Increasing energy efficiency in the transport sector requires expanding fuel efficiency standards, which help reduce emissions.
- Facilitating assessments that demonstrate the cost-effectiveness of clean energy: Supporting the removal of energy supply subsidies to reduce energy waste and also promote the cost effectiveness of renewable technologies.

Training a gender-inclusive workforce is addressed directly in a single item 'developing cleaner energy sources'. The goal specifies the development of human resources to support the engagement of women in green development and improve their analytical, technological, operational, and policy capacity in the area of clean energy. The other three objectives mention human resources and capacity building, but do not mention gender-based human resource capacity directly.

Lowering the carbon intensity of energy supplies is a multi-group multi-sector objective but is predominantly the focus of EGEE&C and the LCMT Taskforce through the objective "Promote Energy Efficiency and Sustainable Communities". These objectives are reviewed in detail in the following section.

- Collaborate on product and system standards that enhance energy efficiency and clean energy deployment, while exchanging information on the impact of such standards.
    - ✓ Standards have been a strong focus of energy efficiency projects since the mid-1990s.
- Facilitate the exchange of best low carbon policies, practices and tools among APEC Member Economies to promote the development of sustainable communities across the region and to achieve progress towards the goal of reducing APEC's aggregate energy intensity by 45 percent from 2005 levels by 2035.

- ✓ Tying directly to the Energy Intensity reduction goals and the Low Carbon Town Initiative, energy efficiency projects have been promoting low carbon sustainable communities since 2011.

- Develop the human resource base and energy consumers within APEC Member Economies to improve their analytical, technical, operational, and policy capacity in the area of energy efficiency and overall energy literacy
  - ✓ Capacity development has been a steady focus on EGEE&C projects.
  - ✓ The use of 'energy consumers" is not clear. The audiences have been primarily policy makers and public entities, knowledge firms, and manufacturers/businesses. They, in turn, have directed resources towards recommended consumer initiatives in reports and workshops. However, the public release of publications does help promote energy literacy to the larger "energy consumer" public.
- Support the development and commercialization of energy efficient technologies in the areas of power generation and distribution, industry, transport, buildings and appliances.
- Strengthen the reliability, adaptability and interoperability of electric grids in the APEC region.

5.3 EGEE&C and LCMT Task Force Priorities

The EGEE&C promotes energy conservation through: 1) The application of energy-efficiency practices and technologies; 2) Developing and enhancing trade in products and services and energy-efficiency practices and technologies; 3) Contributing to international efforts to reduce the adverse impacts of energy production and consumption; and 4) Improving the analytical, technical, operational, and policy capacity for energy efficiency and conservation.

The LCMT Task Force and its projects fund feasibility plans for reducing the carbon footprint, including a set of carbon dioxide emission targets and initiatives and low carbon indicators to measure the progress of these green towns. The model towns are currently implementing low carbon development plans throughout the Asia-Pacific region and details of the plans and projects are available in ESCI-KSP.

The 2014-2-18 Strategic Plan outlines five priorities for promoting energy efficiency and sustainable communities. The following section takes a detailed look at how the project portfolio has aligned with these goals over the last 23 years. Potential gaps are based on project history and a limited review of outcomes and follow-up recommendations of major projects (selected in an iterative process that considered project history, trends, and the missions and goals of APEC and the EWG)

5.3.1 Product and System Standards

Harmonizing energy standards and establishing mandatory compliance is one of the most effective ways to drive down energy intensity in all three demand sectors. Minimum energy standards, labeling schemes, and mandatory code compliance reduce energy use in ALL commercial and residential building sectors. In both the building and industry sectors, equipment MEPs and adoption of best available technologies drive down energy use and operational costs. Across APEC, where more than 900 million new LDVs will be on the roads by

EGEE&C Priority

Collaborate on product and system standards that enhance energy efficiency and clean energy deployment, while exchanging information on the impact of such standards

2040, and light duty vehicles (LDVs) make up 73% of the sector's energy use, fuel efficiency standards are critical.

Product codes and standards also address rank 1 funding criteria for APEC projects by promoting regional economic integration through improving consistency in the implementation of Standards, conformity assessment, technical regulations and regulatory cooperation. Capacity building for workforce development help accelerate the development of a qualified workforce and harmonized codes help companies more easily identify equipment and meets energy codes.

5.3.1.1 *Project History*

Forty-one projects -about 20% of the database - focuses on standards or codes across all sectors. Of those, 80% are EWG projects. The remaining projects were appliance standards and labeling projects conducted by Australia in 2006 that did not have project numbers.

Appliance Standards. Between 1993 and 2017 there have been 43 projects related to appliance, lighting and equipment, one of the largest categories in the database and the most consistently addressed since 1993. Other wide-ranging projects categorized as cross-cutting, also included recommendations or assessments of appliance standards.

Projects in the 1990s lead to the creation of the APEC Energy Standards Information Systems (APEC-ESIS) database in 2001. The database is still active today, proving up-to-date information about standards and labeling across the APEC region.

Projects over the next 5-6 years continued to addressed appliance performance standards and harmonizing testing procedures and labs through workshops and technological assessment projects. This focus was particularly strong out of Australia, which proposed seven projects related to standards and labeling.

In 2009, Phase 1 of the Cooperative Energy Efficiency Design for Sustainability (CEEDS) project hosted workshops on appliance standards and labeling. The projects identified challenges that required regional cooperation to resolve: limited data availability, more staffing and technical assistance, and strengthening test labs and certification procedures.

That year, the first four economy-specific PREE reports (Chile, Viet Nam, Thailand, New Zealand), were published. Each report included recommendations on appliance standards and labeling.

In 2010, Japan produced a report mapping APEC-wide standards, concluding that harmonization was critical to broader adoption of standards and collaborations with key international organizations would strengthen S&L in the region. Subsequently, APEC-ESIS, which tracks standards and labeling, began being updated by CLASP (Collaborative Labelling and Appliance Standards Program). New projects were launched addressed Air Conditioning and Lighting, both priority areas.

In 2010, Phase 2 of CEEDS kicked off a new focus on Building Codes, standards and labeling. In the database only a 2008 project comparing building energy codes, pre-dated CEEDS Phase 2. CEEDS Project outcomes included a need for more monitoring and tracking data, advanced code implementation, moving beyond construction codes to "outcome-based" operations, and integrating building codes into broader "Green building" sustainability criteria. Ensuring projects addressed these issues. An MV&E network (monitoring, verification, and enforcement) network was launched, and projects benchmarked or assessed energy management systems and smart community integration. The latest project

Buildings. With the focus largely on appliance efficiency, building codes were not a focus until the late-mid 2000's. Earlier projects looked at incentives or government programs that could encourage or accelerate green building practices. In 2008, the first comparison of building energy codes in APEC launched, followed by projects on cool roofs and energy saving glazing (windows). Between 2013-16 China proposed three projects looking at Building codes and Near Zero Energy Buildings (NZEB). An assessment was followed by a review of best practices and a roadmap in response to COP21.

Industry and Transportation Standards. Twenty projects in the database In the 1990s, workshops on industrial technologies and standards included the Industrial sector. The APEC-ESIS database does not include industry equipment except where electric motors overlap sectors. Sector-wide policy surveys in 2007-08 were the first projects to address industrial and transportation sector standards. ISO 50001, reviewed in 2009, is an energy management standard used by industrial facilities and manufacturers. In 2011, China produced an overview of current energy performance evaluation programs for industrial enterprises and Thailand produced a best practice roadmap for industrial efficiency. Two projects since 2011 reviewed Combined Heat and Power (Co-generation) a distributed energy system that can be used in grid supply or implemented in the industrial sector.

Less than 10% of the projects relate to the transportation sector, and 60% of those were established between 2010 and 2013. Although energy efficiency in the transportation sector relies on fuel efficiency, the first survey of transport efficiency in APEC was in 2007. Launched in 2011, Phase 3 of CEEDs examined energy efficiency in the urban passenger transportation sector, and a framework to analyze fuel efficiency effects of Transit-Oriented Development was completed in 2012. Recommended follow-up actions included an Energy Efficiency Urban Transport network (through ESCI), integrating efforts with ESCI's low-carbon model town initiative, and a list of collaboration ideas with the groups such as the APEC Transportation Working Group, The Asia Development Bank, and ASEAN. The first workshops on fuel efficiency labeling schemes and VFEL programs were in 2014.

Electric vehicles (EV) are inherently more energy efficient than conventional gasoline cars, converting more energy from the grid to wheels. Starting in 2011, EV projects included a report on the EV/smart grids and a workshop on the integration of EVs into green transportation objectives with APEC experts and delegates from German, Switzerland, Portugal, and Macau.

5.3.1.2 *Potential Gaps*

All gaps offer opportunities for capacity building or collaboration with other APEC working groups in multi-lateral organizations. Gaps are divided into 5 sections in Table 13 based on the project database: Appliance and equipment (mostly building appliances), Buildings, Industry, and Transportation. A fifth section covers cross cutting standards gaps that could be addressed in multiple sectors.

Table 13. Potential Project Gaps, Standards and Systems Standards Goals

Topic	Related Projects	Potential Gaps (and Opportunities)
Appliance/Equipment		
Smart Appliance Standards (AKA Internet-of-Things)	There was a 2011 call for action on exchanging info on smart appliance standards development.	**Smart Appliance Review.** There are no other projects after 2011 that mention smart appliances in project summaries or outcomes. Could use Standards assessment, roadmap related to NZEB or Internet-of-Things issues (like cyber security); Collaboration with CTI
Consumer Appliance Standards**.**	APEC ESIS links to the CLASP database, which focuses on consumer appliance standards and labeling. However, among projects, only 3/7 major consumer appliance categories appear in the db: Lighting, Air Conditioners, and Refrigerators	**Missing Appliance categories:** 2011 code mapping project reviewed 7 "major" categories - the previous three plus computers/monitors, televisions, clothes washers/dryers, and water heating; it the only project that explicitly mentions all these categories. **Industrial (not transport) Motors:** the last mention of electrical motors was a 2008 project mentioning APEC-ESIS **CTI partnerships:** projects on computers/monitors/Internet-of-Things? Tie between shift to services sector, regulatory cooperation, standards conformance and EE
Transport and Industry Equipment Standards, Standards and Labeling (S&L) Databases	APEC ESIS links to the CLASP database, which focuses on consumer appliance standards and labeling. 2/3 of projects that dealt with industrial equipment were twenty years ago. The 3rd project, in 2010, looked at EMS standards (ISO)	**Databases**. Is there a database for transport or industry standards similar to CLASP? The ESCI 'EE Urban Transport network', 'EE Freight Transport network', and Industry and Enterprise pages do not include standards databases.
Certification and Testing Labs – Code development	Technical assistance, including coordinated labs, mutual recognition of tests, operational guidelines, emphasized in 2009-2010. ASEAN partnership on AC in 2013, and one on IEC62552 for frigs do not appear to address testing labs and certification capacity building	**Supporting Free Trade through adoption of new standards**: Follow-ups on capacity building for new standards such as IEC62552 **Technical Assistance**: Question - Establishing need for continuing certifications and testing lab technical assistance – are these still barriers?
Smart Grid Interoperability Standards (this can impact appliances, vehicles and building standards)	In 2010, a project outcomes for "Using Smart Grids to Enhance Use of Energy Efficiency and Renewable Energy Technologies" states that under the APEC Regulatory Cooperation Advancement Mechanism for Trade-Related Standards and Technical Regulations (ARCAM), APEC will develop recommendations for cooperation on smart grid interoperability standards.	Has this happened? Only found reference to it as Phase 4 of the Smart Grid Initiative and it is not listed as a sub-task on the KSP for Smart Grids.
Buildings		

Building Energy Codes and Labeling	last APEC-wide comparison of building codes appears to be 2008. Projects that discuss building codes in the last few years focus on Net Zero Energy Buildings (NZEB)	**Assessment and Analysis**: 10 yr Comparison Update not focused on just **International Building Codes** – 2018 Codes, trends **NZEB:** continuing trend for building code discussions. Role of standards and codes in roadmaps, definitions. Examples from recent docs: 2017 publication of "APEC 100 Best Practice analysis of Nearly/Net Zero Energy Building" describes passive and active component of NZEBs, minimal codes and standards discussion. **SCSC Partnerships:** current activities include SCSC 'energy efficiency of commercial building sector"
Benchmarking, Audits, MV&E	The best way measure the energy standards and codes compliance and keep them updated is through consistent and accurate benchmarking, audits, and MV&E. Only a handful of the 190 projects mention audits, benchmarking or MV&E in project summaries.	**More SCSC Partnerships.** 2016/17 SCSC sponsored project " Best Practices Sharing and Technical Capacity Building for Measurement and Verification Standards of Energy Savings" **Regulatory assistance –** challenges of implementation, compliance and enforcement of building energy codes
ESCOs	Related to benchmarking, audits and MV&E is the establishment and support of ESCOs as a market partner. Technical support for ESCO development is mentioned as a recommendation in many reports	**Capacity Development - technical** - In 2012, CEEDs project highlighted ESCO challenges including lack technical capacity and knowledge. No projects after 2012 mention ESCOs.
Transportation		
Transport Fuel Economy Standards	A survey in 2007 and related workshop in 2008 followed by VFEL labeling review in 2015 and 2 projects that integrate Transport planning in LEDS	**Policy review:** **Mandatory Fuel Standards**. Only 50% of LDV in the world are covered by mandatory policies **Operational Collaboration** **TWG.** Increasing partnerships with TWG on fuel economy standards and labeling efforts. Recent TWG projects related to EWG objectives include a 2014 report on the EE of supply chains through improving intermodal transport, and two 2013 reports on energy benefits of TOD strategies and Intermodal freight strategies **ASEAN partnership**: on fuel economy standards, labeling programs and promotion
Autonomous Vehicles		Though early, standards and liability issues may need to be addressed, as well as impact on existing codes and standards used in LCMT roadmaps
More attention on transport sector, generally	Less than 10% of the database is transport related. Although there is a separate Transportation Working Group (TWG). activities including Intelligent transport systems, but not fuel economy standards.	**TWG partnerships**. TWG priority to promote use of intelligent transport systems is an "LCMT-friendly" topic. Multiple projects ID'd area-wide management planning standards as a concern. **Other Projects** that address EE in Transport that are not being addressed by TWG.

	They do not list EGEE&C as collaborators	
Industry		
Municipal Utility Energy Efficiency	According to the US EPA potable water and wastewater plants are typically the largest energy consumers for muni gov't, often accounting for 30 to 40 percent of total energy consumed.	1 project in 2009 addressed energy and water efficiency. The workshops were attended by only 4 economies, despite significant interest from other economies (fiscal constraints).
Service Sector Structural Shift	Service sector shifts means less manufacturing and more computer and telecommunications based services. The appliance discussion gap re: computers is relevant	Computers/Monitors/Tech Growth of server Farms, Data Centers (particularly as LMCT like Tianjin grow that use intelligent systems – centralized data centers)
ISO standards	One project in 2009 addressed ISO standards in Industry	
Cross-cutting Opportunities		
Energy Resiliency – efficiency codes and Standards	Codes and standards in all three sectors, plus more broadly in urban planning	Role of efficiency standards and codes in energy resiliency planning. In 2016 'Guidelines to Develop Energy Resilience in APEC off-grid areas', recommendations including expanding gov't grants and incentives to include resiliency and technical standards in sustainably planning (Rank 2 Funding Criteria)
Disaster Preparedness - Efficiency Codes and Standards	No projects in the DB mentions disasters.	Role of energy efficiency codes and standards in reducing the impacts of post-disaster recovery .E.G. post-Fukushima nuclear shut-down. (Rank 2 Funding Criteria)
Smart City interoperability standards	Cross-cutting issue established with LCMT initiative. Interoperability issues growing as more objects and systems become interconnected, both with the grid, and the internet.	Most recently in APEC project re: cybersecurity and grids. Topics include Internet-of-vehicles Internet-of-Things (appliances, buildings) How integrating appliance and devices into the smart grid
Mandatory Policy Implementation	From the IE: only 30% of world energy is covered by mandatory standards. Lighting has seen the largest gains (60+%)	Best practices and policy discussions for how to increase mandatory policies.
Economy Participation	Nearly all proposing economies for appliances/equipment standards are: U.S.; Japan; Chinese Taipei; China; Australia	

5.3.2 Promoting Low Carbon Policies, Practices and Tools

5.3.2.1 *Project History*

> ***EGEE&C Priority***
>
> Facilitate the exchange of **best low carbon policies, practices and tools** among APEC Member Economies to promote the development of sustainable communities across the region and to achieve progress towards the goal of reducing APEC's aggregate energy intensity by 45 percent from 2005 levels by 2035.

The term "low carbon" in EWG projects started with the launch of the Energy Smart Communities Initiative (ESCI) in 2010. The cross-cutting framework of 'Smart Communities' and the Low Carbon Model Town (LCMT) specifically aims to promote energy-efficient buildings, transport, and power systems to build communities that reduce energy use and carbon emissions.

Launching the APEC-wide initiative ESCI promoted a major policy agenda shift and changed the focus of many projects. Before ESCI, projects addressing carbon and emissions was almost exclusively the domain of renewable energy. The idea that energy efficiency projects inherently support low-carbon policy objectives by reducing energy usage is a relatively recent theme. Between 1993- 2006 there are no projects mention of emissions, carbon, or related terms. Between 2006-2010 the APEC-wide database lists only six EWG sponsored projects that used the terms 'carbon' or 'emissions' in the project summary – three related to coal-fired power plants, two related to carbon capture technology, and one about biofuels. Only the coal projects also mention efficiency. The terms 'hidden fuel' or 'first fuel' are not used in any project field in either database. The term 'Clean Energy' is used only in reference to two collaborations with the Clean Energy Ministerial, a separate organization with 24 members, including nine APEC economies. The joint projects addressed trade barriers for Light Emitting Diode (LED) lighting, and improving certification requirements for ISO 50001 Auditors.

After 2010, 24 projects funded by EWG mention "low carbon" in the project summary. Due to the holistic multi-sector approach, understanding gaps in these projects was challenging. Reviewing the recommendations and follow-up actions pinpointed major challenges and priorities identified by participants. As a result, gaps are limited to reviews of projects that specifically use the term 'low-carbon' in important project fields like project title, objectives or outcomes.

Between 2010-15, eighteen projects - including the seven-phase LCMT initiative - directly addressed low-carbon policies and capacity building. Surprisingly, despite the clear call for boosting energy efficiency, only five LCMT projects mention energy efficiency in the project descriptions. In reviewing project reports, however, it was obvious that they all include energy efficiency recommendations for follow-up actions. looks at the most common recommendations that could benefit from benefit from EGEE&C follow-up and support**.**

5.3.2.2 *Potential Gaps*

Table 14. Potential Project Gaps, Promoting Low Carbon Policies Goals

All project recommendations typically included requests for technical and policy capacity building		
TOPIC	**Recent projects**	**GAP Observations**
Smart Grids and Area Energy Management Systems (AEMS)	Starting in 2009, nine projected addressed smart grids, out of more than 20 related to grid energy. Projects were wide-ranging, including technical workshops, roadmaps, the feasibility analysis LCMTs, and heating system best practices, cyber security, and EV interfaces. A 2015 project focused on building regional capacity for ISO 50001 Energy Management Standards	Area Energy Management Systems: -a need for more technical capacity (education and professional networks) to create and support such complex systems.
Building Energy Management Systems (EMS) (including creation of energy manager networks)	The LCMT – EMSCA project in 2014 took a detailed look at EMS across APEC, including best practices, and future trends like user interaction and Energy Internet. Other related projects looks at NZEB, codes and compliance.	Technical Capacity -NZEB as possible new initiative focus
Demand Side Management Programs (DSM) : wide –ranging program elements including incentives, codes, MEPs	DMS is found throughout EWS reports and assessments, always as a suite of recommended actions – in whole or in part depending the economy. Workshops focus on policy training.	Technical training and best practice examples. Implementation training
Total Building Lifecycle Assessments – Moving past new construction standards to total lifecycle management, including commissioning and O&M.	A 2015 capacity building workshop for M&V (measurement and verification) is the most recent project. All three The Net (Nearly) Zero Energy Building (NZEB) projects include research on NZE oriented management & commissioning in buildings.	Continued focus on NZEB, again? -other lifecycle management practices and challenges
Capacity Building for managing the complexity of the LCMT process	2016 The Low Carbon Town Indicator (LCT-I) System guidelines – a self- assessment tool to assess and monitor LCMT projects. Additionally, China has created an Index System for LCMT technologies and analyzed technologies in Yujiapu to help replicate LCMT in China and other APEC economies. The Eco-Point Program (EPP) and Forum also looked at bottom-up stakeholder involvement and incentives	Doesn't appear to be a significant gap -more training on use of self-assessment tools, next steps, iteration of tools? -new v. retrofit challenges?
How to create ESCOs and integrate them in DSM programs and increase local energy data gathering	3 projects in 2003 and 2005, 2009 looked at audit training and small scale financing. In 2012, CEEDs Phase 4 Project focused on ESCOs.	Recommended follow-up to 2012 CEEDS was to integrate ESCO findings with PREE Phase 5 (2015). Did this happen? Potential gap: technical capacity building.
Intelligent Transport Management Systems	The CEEDS Phase 3 project in 2011 looked at urban passenger transportation through "Avoid-Shift-Improve" framework. U.S. proposed 2 projects in 2013 and 2016 that focusing on transportation planning in Low Emissions Developments Strategies (LEDS). Recent projects have looked at electric vehicles and their integration in smart grids	Potential gaps: *follow-up projects with Asia LEDS Forums *autonomous vehicles

Economy involvement	Few proposing economies. The 7 LCMT Phases were proposed by multiple economies. 11 proposed by China, 6 by other economies	Potential gap in participation. Without more detailed participation documentation, this is hard to establish.

5.3.3 Capacity Building: Analytical, Technical, Operations, Policy

5.3.3.1 *Project History*

Capacity building is a fundamental goal of the EWG and the EGEE&C. Efficiency project inherently enable people, businesses, and government agencies to improve their skills and knowledge. Analytical, technical, operational and policy capacity building all support increased efficiency and reduced energy intensity across APEC. However, as a very ambitious objective, there are bound to gaps in how well projects can cover four types of capacity building across five sectors and multiple audiences.

EGEE&C Priority

Strategic objective: Develop the human resource base and energy consumers within APEC Member Economies to improve their **analytical, technical, operational, and policy capacity** in the area of energy efficiency and overall energy literacy.

5.3.3.2 *Gap Analysis*

As the broadest and largest category of projects in the portfolio, an historical narrative is not easy to condense. Instead, three indicator categories were chose to allow a portfolio-wide analysis of capacity building trends: strategic objectives, target audiences, and strategy/deployment channels.

5.3.3.2.1 Strategic Objectives

The 2014-18 Strategic Plan outlines the most recent EGEE&C capacity building objectives: 1) Work with the APEC Human Resources Development Working Group (HRDWG) to inventory and collect work related to EE workforce needs and put them on the ESCI-KSP; and 2) work with the APEC Policy Partnership on Women and the Economy (PPWE) to integrate gender in this work.

Table 15. Potential Project Gaps, Capacity Building Goals

Strategic Objective Category	Related Projects	Gap Observations
Workforce Training Inventory	Projects on ESCI-KSP come from only half of the APEC economies	Missing training programs in nearly half of the APEC economies – If this is a lack of capacity, (rather than research gaps): -opportunity to development project that expands training programs into new economies -Japan/Thailand lesson study project is not on the KSP
Addressing Gender Issues	Projects descriptions include gender in project participation; there are no projects that address gender directly	After a general review of gender in project participation, the lack of women's participation in training was identified a few times. This could be addressed in workforce training projects

Working with HRDWG. The ESCI-KSP has a section called 'Smart Jobs and Consumers' which includes Energy Efficiency Training and School Curricula categories, as well as Sister Schools Programs. Efficiency Training Programs and Resources are listed from nearly half of the APEC economies: Australia; Canada; Chile; Chinese Taipei; Indonesia, The United States, Mexico, New Zealand, Singapore, Viet Nam. Two international programs, CURB: Climate Action for Urban

Sustainability, and the Clean Energy Solutions Center, are also included. Within the School Curricula pages, programs and resources some from Chile; China; Indonesia; Singapore; Chinese Taipei; Hong Kong, China; and the United States. In addition to this effort, Japan and Thailand proposed a three-year project in 2015 called "*Textbook Development for Energy Efficiency, Energy Security and Energy Resiliency: A Cross-border Education Cooperation through Lesson Study*". This project, under the HRDWG, aims to produce innovative textbooks in mathematics and science on the topic of Energy Efficiency (2016), Energy Security (2017) and Energy Resiliency (2018) for secondary schools.

Working with PPWE. There are no projects in the database under PPWE for energy efficiency and there are no EWG projects that includes gender as a project objective. However, gender issues related to project participation are included in project profiles since 2006. Some project outcomes recognize the absence of women in their related fields and attempts to include them in on-site training programs. All projects take into account gender issues in project participation, including invitations to women speakers and participants in workshops as well as the preparatory stages and execution of the projects.

Other capacity building gaps are addressed in throughout sector and project assessment sections of this report.

5.3.3.2.2 Target Audiences

Developing the human resource base for energy efficiency requires reaching a broad array of audiences across APEC. The audiences for capacity building fall under three broad categories: Policy makers and Public Entities, Manufacturers/Businesses, and Knowledge Firms. Nearly all projects target multiple audiences, either within a single category or across multiple sub-categories. A further breakdown of potential gaps is in Table 16.

Policy Makers and Public Entities*.* The principal audience for 85% of the portfolio has been Policy Makers and Public Entities. Within that category, 98% of the projects targeted National Energy Offices. Planners have been audience targets starting with the launch of Low Carbon Pathways initiatives in 2010; however, only seven projects targeting NGOs have occurred since 2010. (Table 16)

Manufacturers/Businesses*.* Within the category of Manufacturers and Businesses (55%), there is no dominant sub-category. The relatively low representation by energy service providers (ESCOs) may reflect the LCMT project requests for additional ESCO technical support. Outreach to product manufacturers is nearly all related to appliances and equipment. Two-thirds of the projects targeting utilities and energy consultants have occurred since 2011, reflecting the growing interest in smart grids and combined heat and power (CHP) spurred by energy smart community projects.

Knowledge Firms. Knowledge Firms (35%) are the smallest category of audiences in the portfolio. Of the 68 projects, nearly two-thirds have occurred since 2010. Before 2010, the dominant topic was standards harmonization. The Post-2010 increase appears related to cooperation on low-carbon/low emissions strategies. Increasing university audiences could help address issues such as technology transfer and commercialization and the training curricula in college-level coursework such as engineering and environmental studies.

Table 16. Potential Target Audience Gaps

Audience Category	Selected Subcategories	Project Counts	Gap Observations
Policy Makers and Public Entities	**TOTAL**	**164**	
	National Energy Offices	160	Do national and sub-national energy offices see a need for higher attendance by other policy stakeholders? Unknown gap.
	NGOs	29	
	Sub-National Energy Offices	60	
	Planners	26	
	Regulatory Commissions	14	
Manufacturers/Businesses	**TOTAL**	**107**	
	Product Manufacturers	38	Nearly all projects are appliances/equipment related
	Energy Service Providers	21	A good mix of sectors, but some LCMT projects request more ESCO-related support
	Utilities	38	Most projects are grid/supply, a couple are cross-cutting. With Smart grids, could use more cross-cutting project participation?
	Engineering Consultants	25	Largely cross-cutting and buildings. Low representation on Industry reflect low # of sector projects
Knowledge Firms	**TOTAL**	**68**	
	International Agencies	37	A new trend – except for cooperation on standards harmonization. High university participation could help address tech transfer and training curricula issues.
	Research Labs and Laboratories	33	
	Universities	12	
Total category counts (projects can fall under more than one category)		*339*	
Total projects (1993-1016)		*192*	

5.3.3.2.3 Strategic Deployment Channel Strategies

Capacity building across analytical, technical, operational, and policy domains is a large objective. The deployment channels that EGEE&C used within these domains shed light on potential gaps. A breakdown of potential gaps are found in

Technology/Practice Transfer Mechanisms

The Technology/Practice transfer mechanisms category has four sub-categories: 1) Databases; 2) Case Studies/Project Assessments; 3)Technological/Institutional Overviews; and 4) Tools, Guides

The only sub-category with a large number of projects before 2009 is ‘technological/institutional assessments’, which is also the second largest category of projects in the entire portfolio. The databases sub-category however, has been dormant for ten years. CLASP now maintains the ESIS database.

Projects after 2009 and the launch of ESCI dominate the entire category (between 75%-100% of each sub-category). Before 2009, Technological/Institutional assessments were almost the only

method for technology transfer. After the launch of ESCI Case Study/Project Assessments and Tools/Guidebooks became a significant strategies for capacity building, and combined are nearly equal to the 'technological/institutional assessments' category. Within both categories, cross cutting projects dwarf the other five sectors.

Overall, ESCI and low-carbon pathway initiatives have led to a significant increase in technology and practice transfer projects in the grid/energy and transportation sectors (80% of the projects in both sectors are 2009 or later). However, the story for buildings, appliances and industry are a more complicated. The focus has remained on technology and intuitional assessments as a method of technology capacity building in these sectors. Although they saw their % increase in the two new categories, those overall numbers easily 3-4x lower. In the case of the Industry sector, the portfolio has 11 assessment projects and zero case study/project assessments

he traditional channel of assessments has been a concurrent drop in number of specific projects that focus on housing, there have been only 8 technology transfer projects and no case study/project assessments in the industrial sector. There have been only 8 buildings sector projects, and only 13 of the 23 appliances sector projects.

Joint Projects

Three initiatives dominate Joint Projects in the portfolio (70%): Low Carbon Model Towns (LCMT), The Cooperative Energy Efficiency Design for Sustainability (CEEDS), and Peer Review on Energy Efficiency (PREE) projects. With two other projects related to building envelopes and intermodal freight efficiencies, nearly 80% of the joint projects have happened since 2009. Projects that established links with other international multi-lateral organizations also largely been spurred by ESCI. The exception is in the appliance/equipment sector. Appliances and equipment projects have focused on standards harmonization since the 1990's, necessitating outreach to international standards organizations such as the ISO.

Policy and Best Practice Promotion

Policy and Program promotion has been the leading strategy for capacity building since 1993. It includes three major sub-categories: 1) Economy Policy and Program Exchange; 2) Workshops, Seminars and other Events; and 3) Surveys and Questionnaires. The 'Workshops' sub-category is the largest in the entire project portfolio, while 'Policy and Program Promotion' is third. This strengthens the audience analysis, which shows a dominant focus on policymakers. This group of projects tackles a wider mix of sectors, but is still dominated by cross cutting projects. The small survey/questionnaire sub-category is an exception. The category has only 11 projects and the majority are in the appliances/equipment sector.

All three sub-categories are disproportionately represented in the time period between 2010 and 2016 in comparison to the period 1993-2009, but not to the same degree as Technology/Practice Transfer Mechanisms or Joint/Cooperative Efforts.

Table 17. Potential Strategic Deployment Channel Gaps

Category	Project Counts	Sector Highlights			Gap Observations
Technology/Practice Transfer Mechanisms		**Sectors**	**All years**	**% ≥2010**	
Databases	27	Only 11 projects not ESIS or APERC analysis	27	0	Last DBs projects were 2007; DB like ESIS for other sector technologies or policies.
Case study/Project Assessments	24	Appliances Buildings Cross-Cutting Grid/Supply Industrial Transportation	*2* *3* *16* *3* *0* *2*	*100%* *66%* *75%* *100%* *0* *100%*	Industry case studies Smart buildings (per the special emphasis in the EWG Strategic plan)
Technological or Institutional Assessments/ Overviews	65	Appliances Buildings Cross-Cutting Grid/Supply Industrial Transportation	16 9 19 20 11 8	44% 22% 48% 70% 36% 75%	Industry overviews - potentially related to growth of service sectors or technological issues like CHP or motors?
Tools, Guides, and Other Practice Collections	33	Appliances Buildings Cross-Cutting Grid/Supply Industrial Transportation	*5* *2* *16* *7* *4* *5*	*80%* *100%* *100%* *100%* *100%* *100%*	A deeper analysis of cross-cutting project outcomes and recommendations for sector-specific capacity building
Joint/Cooperative Efforts		**Sectors**	**All years**	**% ≥2010**	
Joint Research	16	LCMT PREE Transportation Other Cross-Cutting	6 6 1 3	100% 100% 100% 0	Large initiatives appear to be the most effective strategy to spur joint projects
Joint Development and Demo Projects	6	CEEDS Appliances Buildings	3 2 1	100% 0 100%	CEEDS Phase 1 ('09) was appliance standards /labeling, not cat. as joint
Create links to multi-lateral organizations	12	Appliances Buildings Cross-Cutting Grid/Supply Industrial Transportation	6 2 3 1 2 1	50% 100% 100% 100% 100% 100%	Low-carbon initiatives have spurred increased links to multi-lateral organizations.
Policy, Program Promotion		**Sectors**	**All years**	**% ≥2010**	
Economy Program and Policy Exchange	49	Appliances Buildings Cross-Cutting Grid/Supply Industrial Transportation	10 10 19 10 4 6	70% 30% 45% 60% 50% 83%	Last Transport and Industry projects were in 2011. 4/6 of Grid/Energy were in 2011. Only 3 Building projects.
Workshops, Seminars, Other Events	76	Appliances Buildings Cross-Cutting Grid/Supply Industrial Transportation	20 15 27 14 11 6	60% 40% 66% 50% 55% 66%	As mentioned before, low #s in Industry, Transportation, Building sectors
Surveys/ Questionnaires	11	Appliances Cross cutting Grid	6 1 3	50% 0 66%	A limited strategy in the portfolio. Gap? Do not know the effectiveness of surveys in general.
Other Categories					
-Product/Service Directories **-Design Competition** **-Direct Project Financing**	1 1 2 6	**Demand Side Mgmt** **LCMT-related** **LCMT & Buildings**	1 1 2	0 100% 100%	Product/Service Directory was 1994 –

Total category counts (projects ≥ one category)	*314*
Total Actual projects (1993-1016)	***192***

5.3.4 Development and Commercialization of EE Technologies

The largest gap in this category is the general lack of attention towards supporting this objective.

5.3.4.1.1 Project History

Technology transfer and commercialization - developing research into commercially viable products - has many challenges. On the development side, hurdles include funding, licensing, prototype testing, and manufacturing. Market barriers can range from high start-up costs to regulations or subsidies that do not encourage energy efficiency.

A number of projects tackled these challenges in the late 1990s. Six projects looked specifically at technology commercialization, marketing and technology transfer barriers. An initial survey in 1994 was followed by a 1998 workshop on "emerging energy-efficiency industrial technologies" with a technology deployment database a year later. In 1999, another project evaluated technology transfer and market barriers. These led up to a 2000 green building technology showcase.

2014-18 Strategic Plan Objective:

"Support the development and commercialization of energy efficienct technologies in the areas of power generation and distribution, industry, transport, buildings, and appliances." (with particular attention to smart buildings)

Between 2000 and 2010, few, if any, projects in the database directly support R&D or pilot projects; rather, support for commercialization fell within the larger mission to educate and share information about market barriers that can slow down the uptake of technologies in the market. The 1999 evaluation project identified financial investment risk as a market barrier for energy efficiency projects– the 'project finance gap'. Three projects, in 2004 and 2005, addressed this project finance gap. The first project, proposed by Australia, was a workshop to help APEC members identify market-based solutions. The second, proposed by the United States in 2005, supported the International Energy Efficiency Finance Protocol (IEEFP), designed to help global financial institutions and local banks create a blue print for financing energy efficiency that reduced risk. The third was a green building symposium in Australia.

Another market barrier addressed during this time period was the lack of standards and minimum energy performance standards (MEPs). Standards and MEPs help expand markets for new technologies by requiring users to invest in products with higher efficiency energy use than existing products. Some of the projects described under EWG objective 'Product and Systems Standard' between 2000 and 2010 address this barrier.

The first project to address research and development, proposed by the United States, was in 2009. The project reviewed advanced window glazing technologies and recommended actions like growing national and commercial laboratories for research and development, and technology demonstrations. These recommendations foreshadowed the goal to implement pilot projects and

demonstrations of new technologies announced in 2010 at the launch of ESCI and the Low Carbon Model Town project.

The formation of ESCI led to a quick succession of new projects related to technology development that mention pilot projects. Projects that are not associated with the Low Carbon Model Town, however, are rare and dispersed throughout demand and supply/grid sectors. Eleven of the thirteen projects that mention pilot projects are between 2009 and 2013.

In 2011, technology related projects were for smart gird/supply and industry. Russia proposed a remote area micro-grid pilot (EWG 15 2011A); Thailand proposed a project on new technologies in the industrial sector (EWG 19 2011A); China proposed two projects: new technologies to maximize energy efficiency of coal-burning plants (EWG 21 2011A), and the deployment of electric vehicles (EWG 05 2011A).

In addition, the Industrial Science and Technology Working Group sponsored two projects in 2010 and 2011: a study on smart grid technologies and grid efficiencies, and a symposium on industrial transfer and R&D cooperation for low-carbon strategies in tandem with a tech transfer conference in China (sub-funded by ASF: Energy Efficiency).

In 2012, proposals were for grid energy, building systems, and cross cutting low-carbon issues such as “Smart Cities” and “Low-Carbon” were gaining in popularity. The U.S proposed a workshop on the development of national lighting design centers (EWG 14 2012A); Russia proposed a review of CHP in distributed energy systems (EWG 09 2012), Thailand proposed window thermal performance sim training; and China proposed an analysis of technology feasibility and commercial investment model of the low carbon town models (EWG 11 2012A). The Industrial Science and Technology Working Group (PPSTI) sponsored the Smart City Industrial Cooperation Forum, to explore research and technology collaboration (though not specifically on energy efficiency).

In 2013, projects focused on the Internet-of-Vehicles (IoV) and the integration of electric vehicles into smart grids. Since 2013, technology projects have been diverse, including dust removal at coal plants and PV system installation on islands. In 2017, projects included refrigerators/freezers and electric and hydrogen vehicle technologies.

5.3.4.1.2 Potential Gaps

Table 18. Potential Gaps, Technology Commercialization

All project recommendations included requests for both technical and policy capacity building		
TOPIC	**Lastest projects**	**GAPs**
Technology Transfer and Commercialization	"Workshop to Support the Development of National Lighting Design Centers in the APEC Region", 2012. The first project since 2003 to deal with technology research, the public/private research partnerships, university research centers, the competitive opportunities of supporting technology innovation. A second project evaluated the commercial feasibility of LCMT technologies in Yujiapu CBD	Lack of discussions around the public/private research partnerships in other areas besides lighting -collaboration with research labs, -case study workshops on EE technology development challenges
Innovation	In 2000, a Technology Workshop was set up to encourage private investment in energy efficiency technologies. Markets have shifted radically since 2000 but new innovations in SMART cities – transport, buildings, etc, are emerging quickly. **The Yijuapu project outcomes reveal concerns about getting the commercial market on board with many of the technologies needed to building smart cities.	Focused discussions around emerging or new technologies needed to build smart cities and address urbanization concerns -Workshops on innovation trends in all sectors. E.g. new statements about all-electric fleets by major car manufacturers like Volvo -Technology showcases or expos; Collaborations with groups that promote innovation, such as International Green Building Council (lastest conference in Singapore, Sept. 2017), -Policy workshops on EE energy innovation - tech transfer commercialization trends and barriers (universities)

5.3.5 Improving electric grids

2014-18 Strategic Plan Objective:

"Strengthen the reliability, adaptability, and interoperability of electric grids in the APEC region"

The transformation of the global electricity supply is changing the way demand sectors address energy efficiency. Distributed energy systems, micro-grids, smart grid technologies, and other supply sector disruptors allow the building, transportation and industrial sectors to use energy more intelligently. They can also create opportunities to take advantage of new smart grid development to create new sector-specific energy efficiency technologies, policies and markets such as dynamic demand pricing, improved monitoring and evaluation, or the ROI of best-available-technology investments.

5.3.5.1.1 Project History

There are 20 projects under the category "grid infrastructure" in the EE project database with a seven year gap between 2001 – 2008. The seven pre-2001 projects focused on two topics: investments in power production and the uptake of clean energy technologies. The outcome of the first topic was the *APEC Manual of Best Practice Principles for Independent Power Producers*, structured around institutional and regulatory structures; tender/bid processes and evaluation criteria; power purchase agreements and associated tariff structures; and financing and its implications. Two years later Canada proposed a two-phase project looking at how to promote investments and good policy practices clean energy technology transfer and uptake in the energy sector, in the context of open energy markets.

A workshop in 2000 that investigated mechanisms for financing energy-efficiency programs after electric industry restructuring and the creation of open (liberalized) energy markets was the first project to directly address energy efficiency. Economies that had already restructured (such as Australia), were in the midst of re-structuring (The United States) or has plans for restructuring (Thailand, Korea) attended. Follow-up actions included fostering ESCOs and market transformation programs, and coordinating R&D and best practice sharing to close technology gaps between APEC economies.

After a seven year gap, the 'Fukui Declaration on Low Carbon Pathways to Energy Security' in 2010, and the launch of the APEC Low-Carbon Town Model encouraged a new focus on energy grids - smart grids and distributed grid infrastructure. EWG funded two consecutive workshop proposed by the United States in 2009 and 2010 discussing integrating renewables in the electric grid and the potential of smart grid technologies to promote energy efficiency and renewables. The first, called "Grid Integration of Renewable Energy" focused on the integration of intermittent (i.e. renewables such as wind and solar) energy sources in the energy grid. The second, "Using Smart Grids to Enhance Use of Energy Efficiency and Renewable Energy Technologies" was a survey to support the APEC Smart Grid Initiative (ASGI) and understand the barriers to smart grid technology deployment. In addition to issues of awareness, education and strategic planning, the project highlighted technological interoperability and stated that APEC will develop recommendations for cooperation on smart grid interoperability standards under the APEC Regulatory Cooperation Advancement Mechanism for Trade-Related Standards and Technical Regulations (ARCAM).

The theme continued in 2011- 14, looking at advanced metering infrastructure, rural smart micro-grid pilots, area (and district) energy management systems, smart grid roadmap development, and two projects looking at regulatory planning, financial viability and standardized technical standards

needed to facilitate rapid development and expansion of these types of grid networks in Low-Carbon Towns. Proposing economies for these projects included China, New Zealand, Russia, Thailand, and Chinese Taipei.

The first projects related to smart grids and electric vehicles, proposed by New Zealand, China, and Hong Kong, China, were also launched in 2011. Designed to build interest in the benefits of electric vehicles, the projects looked at policy and infrastructure investments needed to expand network deployment.

By 2014, concerns over networked smart-grid systems and cybersecurity led to the 'Cyber-Energy Nexus Study", proposed by the U.S. The study, published in 2016, looked at the cyber-energy landscape and the challenges of addressing global interoperability, standards, and security together.

5.3.5.1.2 Potential Project Gaps

The efficiency of the demand sectors relies upon an efficient energy grid. Large-scale investments in smart grids, micro-grids, and distributed energy systems (including integrated renewables) all contribute to the efficiency of buildings, transportation, and industry sectors.

Smart Grids, Micro-Grids, Distributed Energy Networks

- **International ISO, IEC and ITU standards.** The grid technologies themselves requires global interoperability standards. Electric vehicles, motors, capacitors, batteries, fuel cells. Etc.
- **Grid Modernization.** In terms of technology research, 3-4 years can see significant changes and opportunities open up. What is on the horizon? Recent case studies E.g.: NREL Energy Systems Integration Facility (ESIF) and the impact on energy efficiency goals
- **Diversifying Smart Grid Resources**. Feasibility of solar and wind renewables in APEC are often limited by geography. Impact on energy efficiency through other smart grid supply investments such as geothermal, hydro, ocean energy, and bioenergy
- **Resilience**. How can smart grids and energy efficiency be best utilized to reduce natural disaster risks? Recent earthquakes and hurricanes in Mexico, the U.S. and the Caribbean point to needed discussions about strategies and roadmaps.
- **Open Energy Markets**. A follow-up to projects from 1999-2003. Are there new issues in regulatory reform (fuel and power subsidizes or lack of market-oriented markets controlled), that were not around 15 years ago impacting energy efficiency investments? Research from other groups such as OECD or IEA that could help APEC economies?
- **Intelligent Transportation Systems**. Privately owned electric vehicles are one – albeit major - element of the transportation system that utilize smart grids and decentralized power systems. How can intermodal transport by trains, buses, and waterways continue to leverage and maximize smart grids technologies.
- **Industrial Sector**. New opportunities for the industrial sector to utilize smart grid technology to increase energy efficiencies in areas like combined heat and power, electric motors, or process innovation? Implications of smart grid expansion for energy efficiencies in the service and light manufacturing sub-sectors. China, Japan, U.S. might have great case studies to share.
- **Smart Building Technologies.** Newest research or case studies on building efficiencies utilizing smart grid integration and metering.

5.4 Economy Participation

5.4.1 Proposals and Participation

Economy participation, either as proposing economy or a participant, helps EGEE&C understand attendance and overall interest. Projects were counted three ways – total proposing, total participating, and total combined. Of the 192 projects in the database, 126 projects list proposing economies, the vast majority from after 2007. Four economies – China; United States; Japan; and Australia - proposed more than 75% of the projects.(Figure 32)

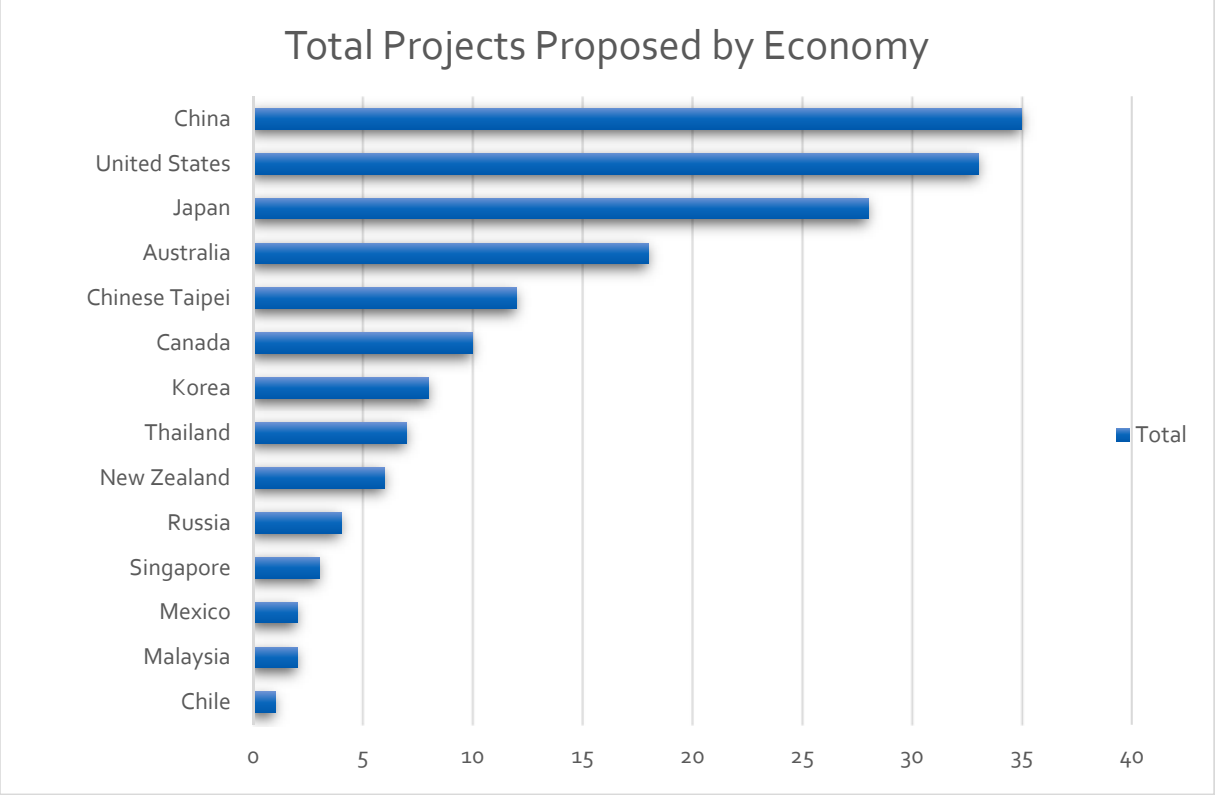


Figure 32. Total Projects Proposed by Economy

Although participating economies are listed in completion reports, the report data was inconsistent and may under-estimate overall attendance trends. The data does offer some general patterns that may help identify drivers but also points to the value of having consistent and thorough completion reports. Economies listed as participants on 10% or less of projects are: Brunei Darussalam; Canada; Chile; Hong Kong, China; Indonesia; Malaysia; Mexico; New Zealand; Russia; Singapore; and, Viet Nam.

When proposed projects were excluded, economy participation rates shifted. It suggests that the United States, Japan and Australia, all strong proposing economies, attend fewer projects by other proposing economies. Economies with the highest participation outside of their own proposals were the Philippines; Thailand; China; and Viet Nam. (Figure 33). When we looked into which projects received the highest participation, the following projects stood out: APEC Workshop on Energy and Green Transport Benefits of Electric Vehicles (17 economies; 2011); APEC Cooperative Energy Efficiency Design for Sustainability (CEEDS) Phase 1 (9 economies; 2009); APEC Cooperative

Energy Efficiency Design for Sustainability (CEEDS) - Phase 2 (8 economies;2010); APEC Energy Efficiency Database Construction (8 economies;1999); and, Survey of Commercialization Strategies for Energy Efficiency and Conservation Technologies (10 economies; 1994).

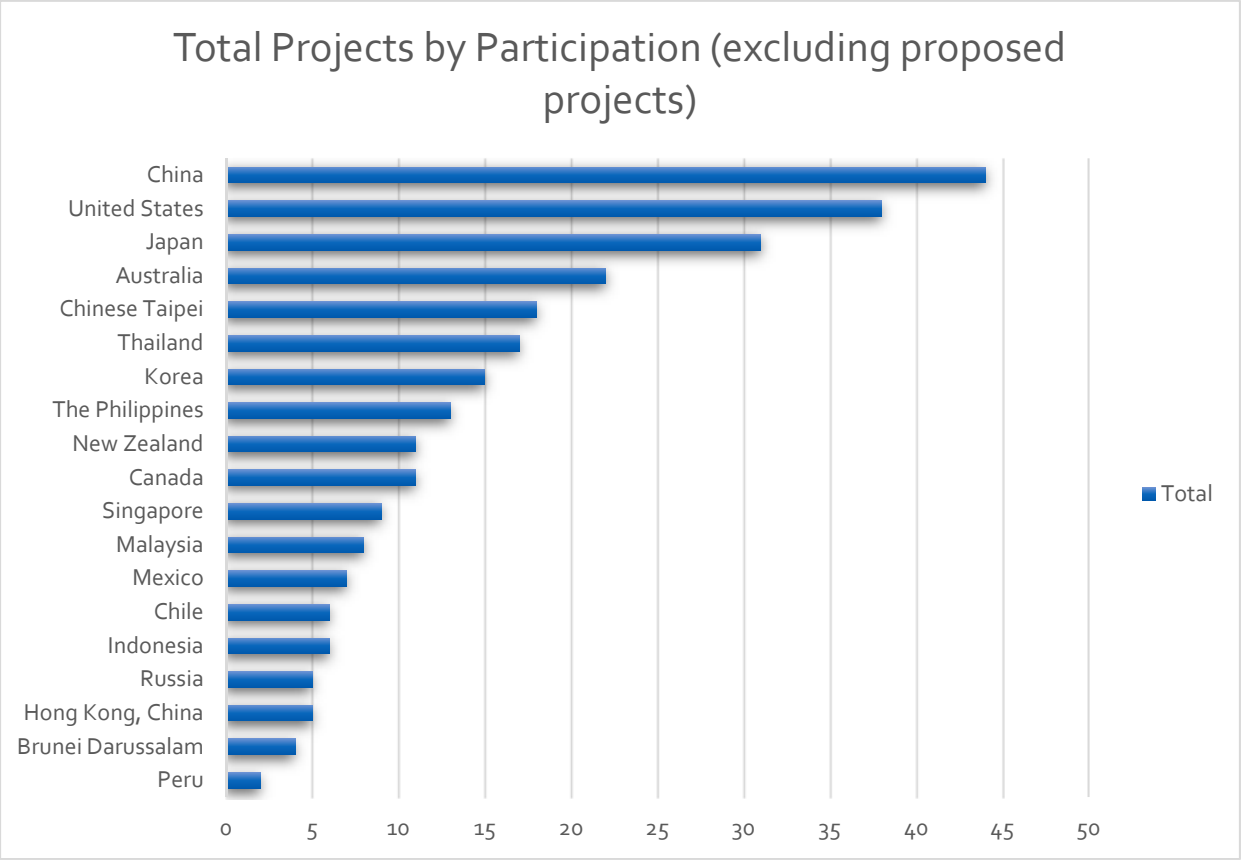


Figure 33. Total Number of Projects, by Participation

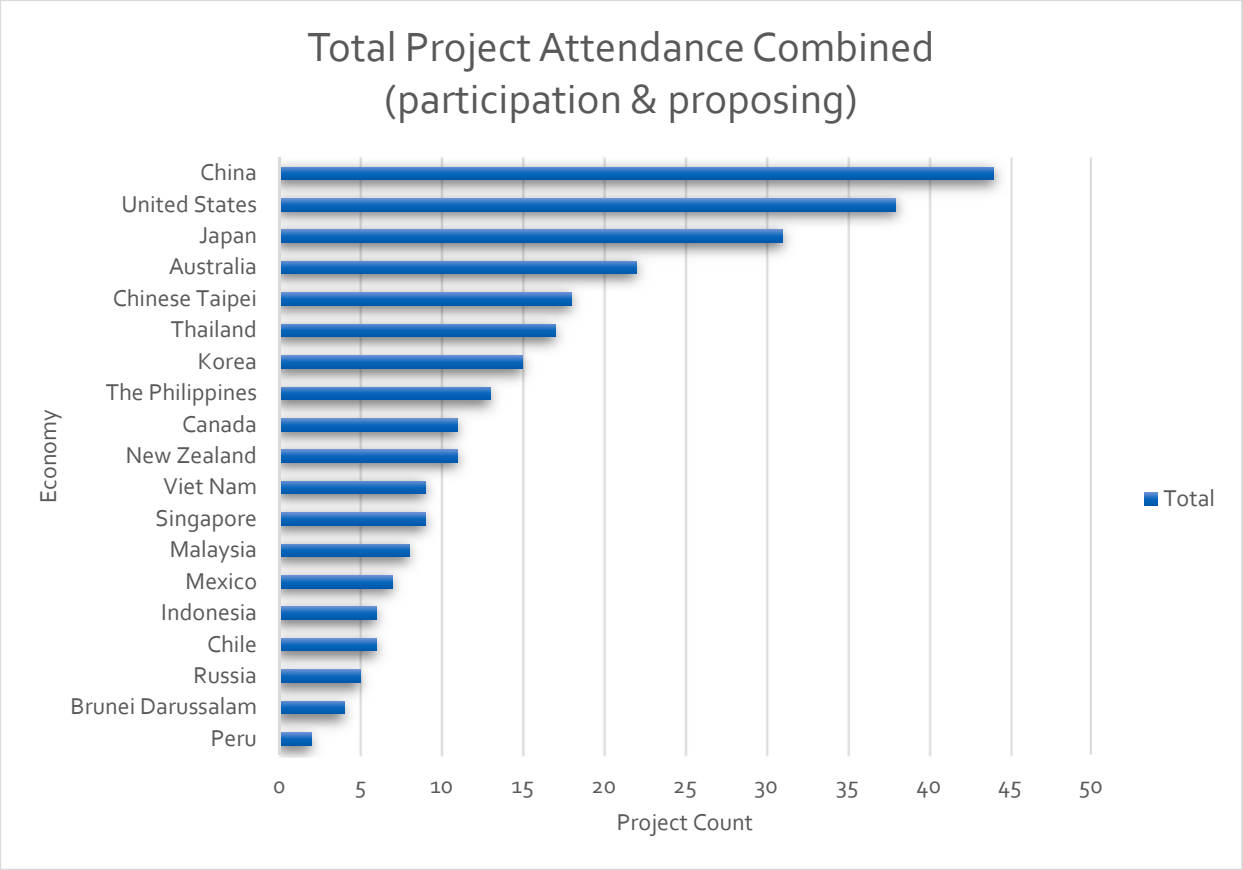


Figure 34. Total Project Participation (Proposing or Participation)

The reasons for lower participation or fewer proposals are not clear from the database. In some cases, project type, like assessments or reports, do not require high participation. In some cases, knowledge dissemination channels such as ESCI-KSP, or the availability of published reports on the APEC website, makes participation indirect. Other reasons for low participation such as funding availability or scheduling conflicts was not available.

One example of the complexity of the issue is the work on standards and harmonization. The United States and Australia have proposed the majority of appliances and equipment projects (65%) and four other economies proposed 1-3 projects a piece (Canada, China, Chinese Taipei, and Japan). Eighteen economies have participated in either one or no appliances/equipment projects over the entire twenty-five year period. Due to the general high rates of standards adoption in APEC, it is hard to say if low participation slowed APEC-wide standard and labeling policy adoption, or if the work done by participating economies with international code organizations set the groundwork for easier adoption by other economies.

Another reason for low participation may be economy interests or priorities. Participation appears to vary by sector. Proposals and overall participation by sector are roughly the same proportion, which suggests economies have consistent sector priorities. Cross cutting dominates at 40%, with appliance and grid projects coming up second and third. Although that data was extremely limited for projects between 1993 and 2005, the ratio of total projects in that period are similarly skewed by sector and reflect a low interest in transportation and industry projects: only two of 96 projects were in transportation, while industry projects faired a better at 12 projects.

Examples of economy priorities: Japan and China have proposed 60% of the cross cutting projects, reflecting an interest in low carbon model town development Australia has focused primarily on the appliances and equipment sector. The United States has a more evenly distributed group of projects.

Many economies that are not active in energy efficiency projects are active in other working groups. A quick review of the APEC-wide project database that includes all working group projects reveals that economies with generally low participation rates in energy efficiency projects are actively proposing projects in other working groups or energy domains. Viet Nam is very active in the Small and Medium Enterprise Working Group (SMEWG) and has proposed three EWG projects related to renewable energy since 2012. Indonesia has been active on a number of working groups, but last proposed an EWG project in 2008 on biofuel. Hong Kong, China has not proposed an EWG projects and has been recently active in the Economic Committee. Papua New Guinea has not proposed any EWG projects. Peru hosted the *10th Senior Disaster Management officials Forum* in 2016 but has not proposed any EWG projects. This year, in addition to recent projects on tsunami emergency preparedness and climate change impact on food, Chile proposed an electromobility EWG workshop.

One strategy for increasing attendance is to emphasize the explicit connections between the energy efficiency benefits and other economy priorities during workshops and other meetings. Connecting energy efficiency efforts to issues such as disaster management or SME business growth could encourage higher participation or new project proposals.

5.5 Sector/Domain Breakdown

5.5.1 Appliances, Lighting, and Other Equipment

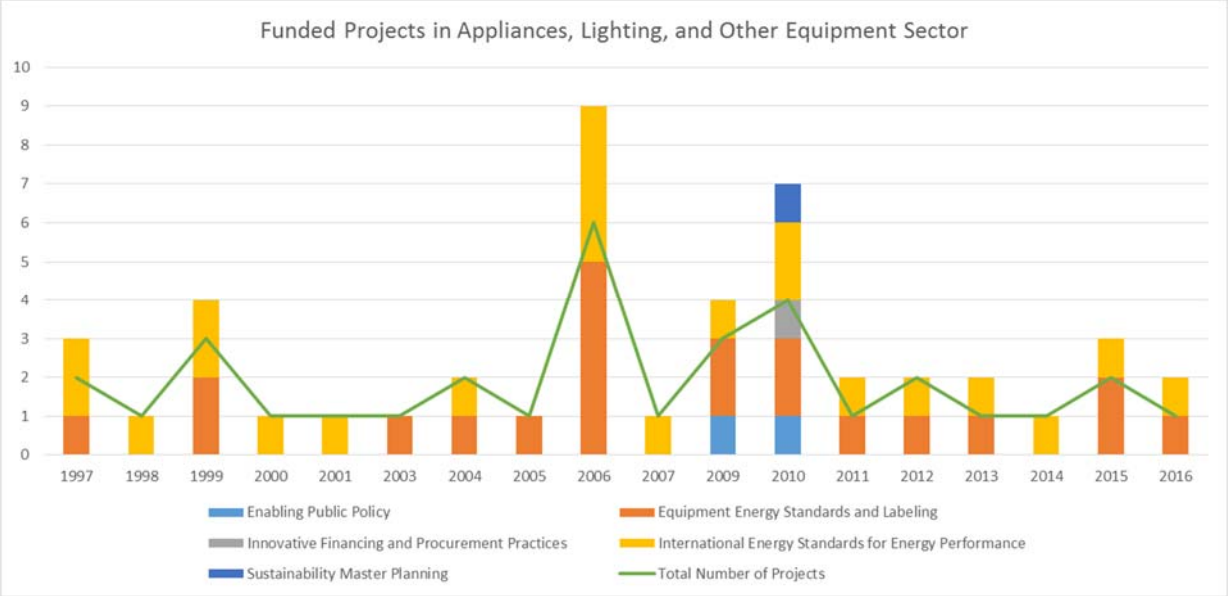


Figure 35. Number of projects funded each year, Appliances, Lighting, Other Equipment sector

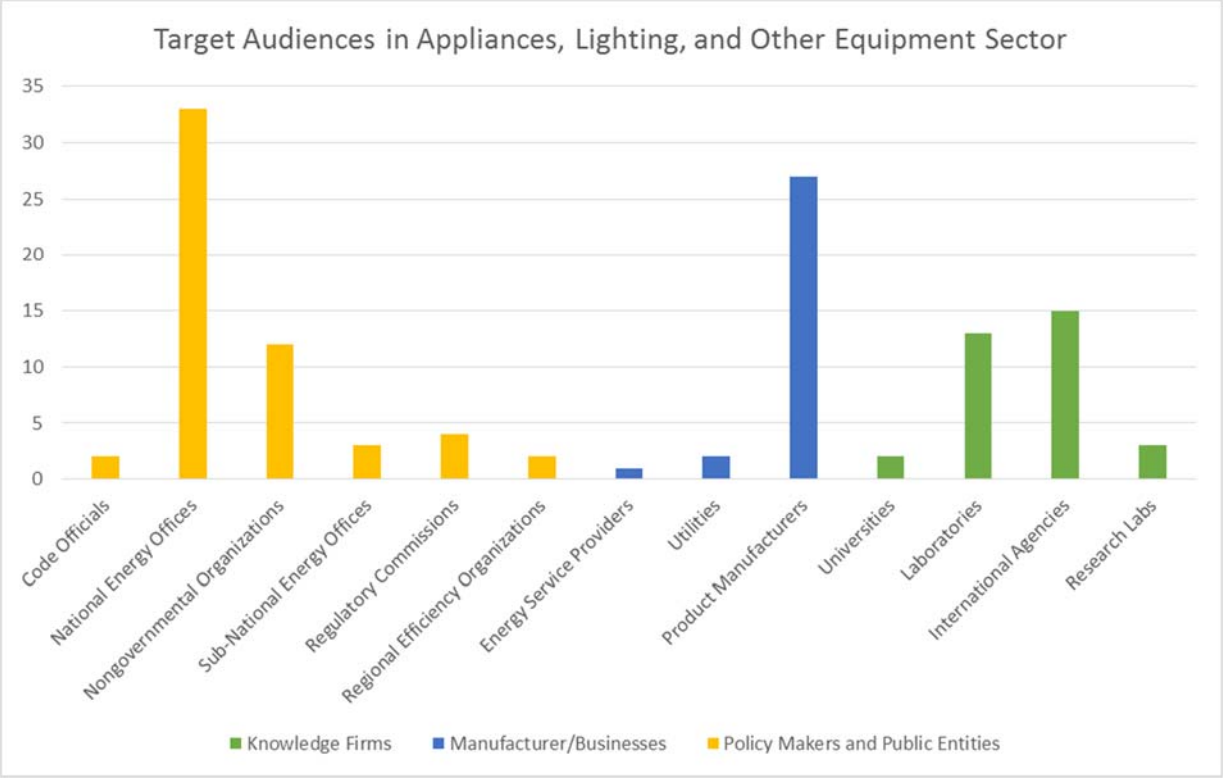


Figure 36. Target audiences for Appliance, Lighting, and Other Equipment projects

Table 19. Deployment Strategies for the Appliances, Lighting, Other Equipment sectors

Deployment Strategies (grouped by category)	Number of Projects
Technology/Practice Transfer Mechanisms	**21**
Databases	1
Technological and Institutional Assessment	12
Tools, Guidebooks, and Other Practice Promotion	4
Website Development and Maintenance	4
Collaborative Energy Technology Exchange Endeavors	**23**
Personnel Exchange Programs	1
Surveys/Questionnaires	6
Workshops, Seminars, and Other Events	16
Minimize Duplicate Effort	**5**
Establish Links with Other International Organizations	5
Cooperate on Joint Projects	**2**
Joint Development and Demonstration Projects	2
Encourage Public Sector Participation	**5**
Promote Exchange of Economies' Programs and Policies	5

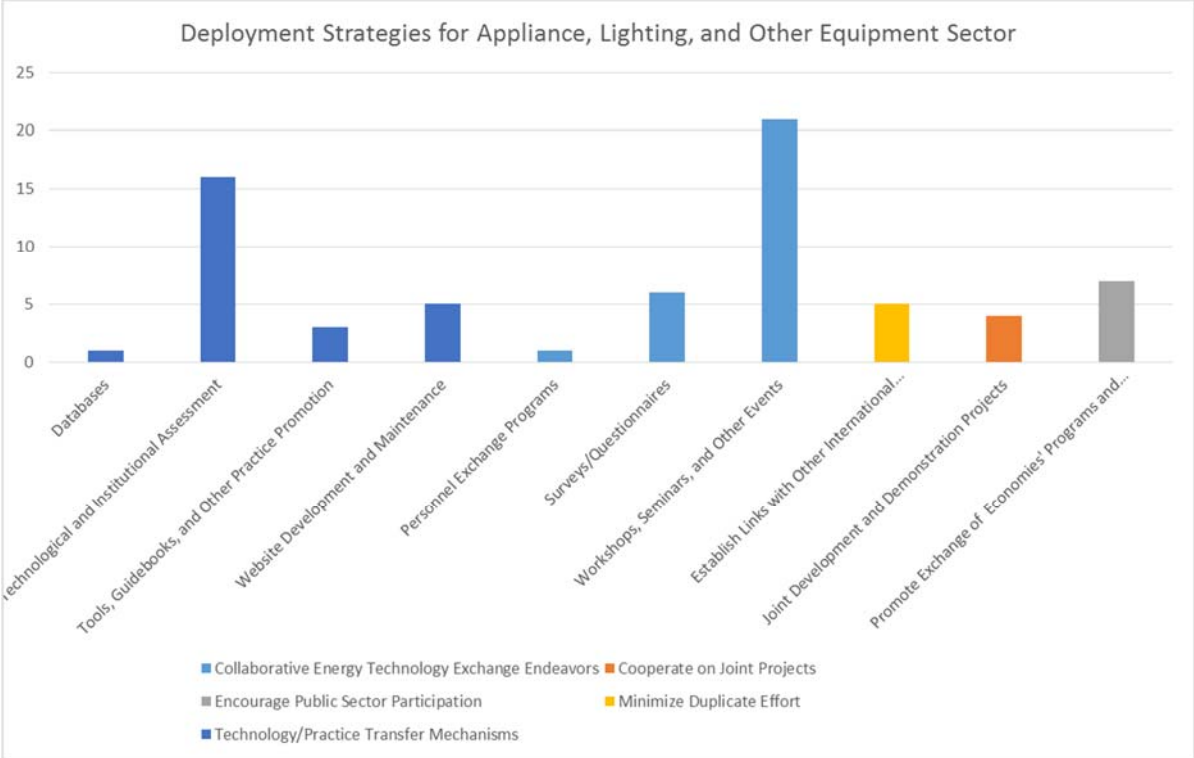


Figure 37. Deployment strategies in the Appliances/Equipment sector

5.5.2 Buildings

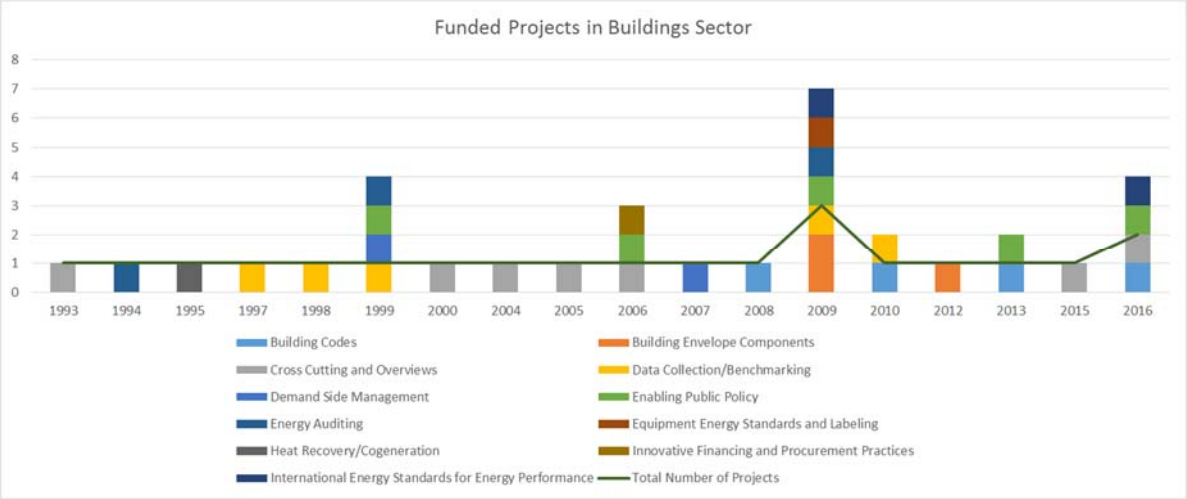


Figure 38. Funding Projected in the Building Sector

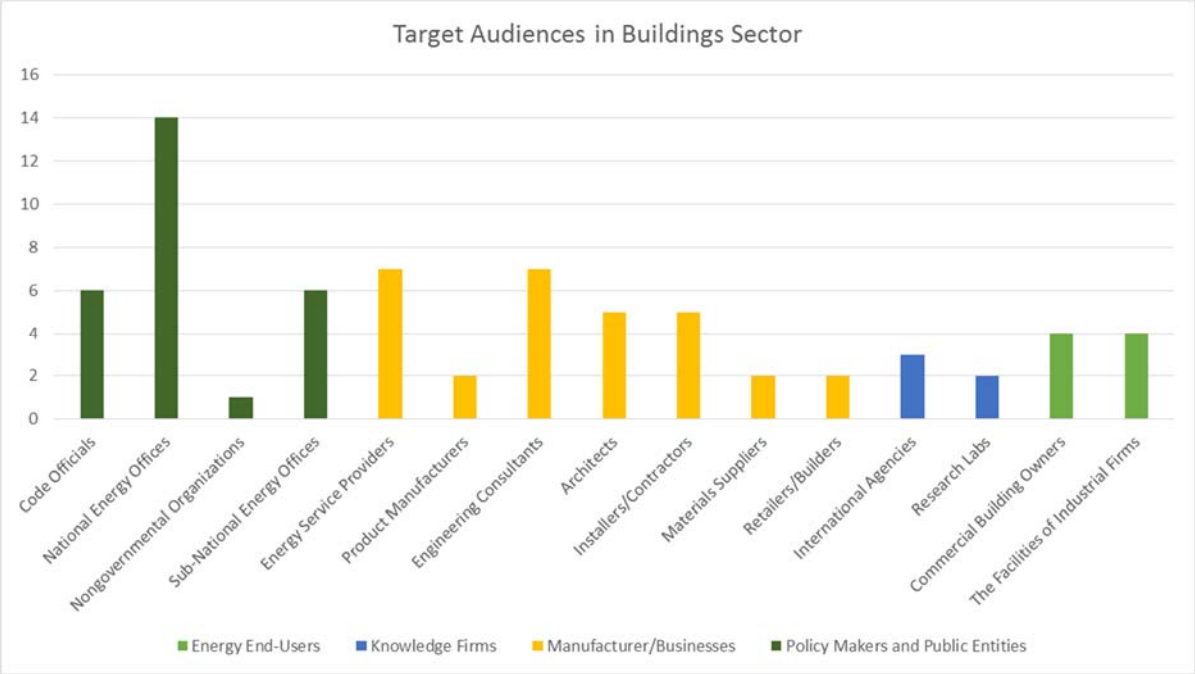


Figure 39. Target Audiences in the Building Sector

Table 20. Building Project Counts, Deployment Strategies, Building Sector

Deployment Strategies (grouped by category)	Number of Projects
Technology/Practice Transfer Mechanisms	**12**
Databases	2
Specific Project Assessment/Case Study Development	3
Technological and Institutional Assessment	4
Tools, Guidebooks, and Other Practice Promotion	2
Website Development and Maintenance	1
Collaborative Energy Technology Exchange Endeavors	**13**
Workshops, Seminars, and Other Events	13
Minimize Duplicate Effort	**2**
Establish Links with Other International Organizations	2
Cooperate on Joint Projects	**2**
Joint Development and Demonstration Projects	2
Encourage Private Sector Participation	**1**
Direct Project Financing	1
Encourage Public Sector Participation	**10**
Promote Exchange of Economies' Programs and Policies	10

5.5.3 Cross-Cutting/Low Carbon Development

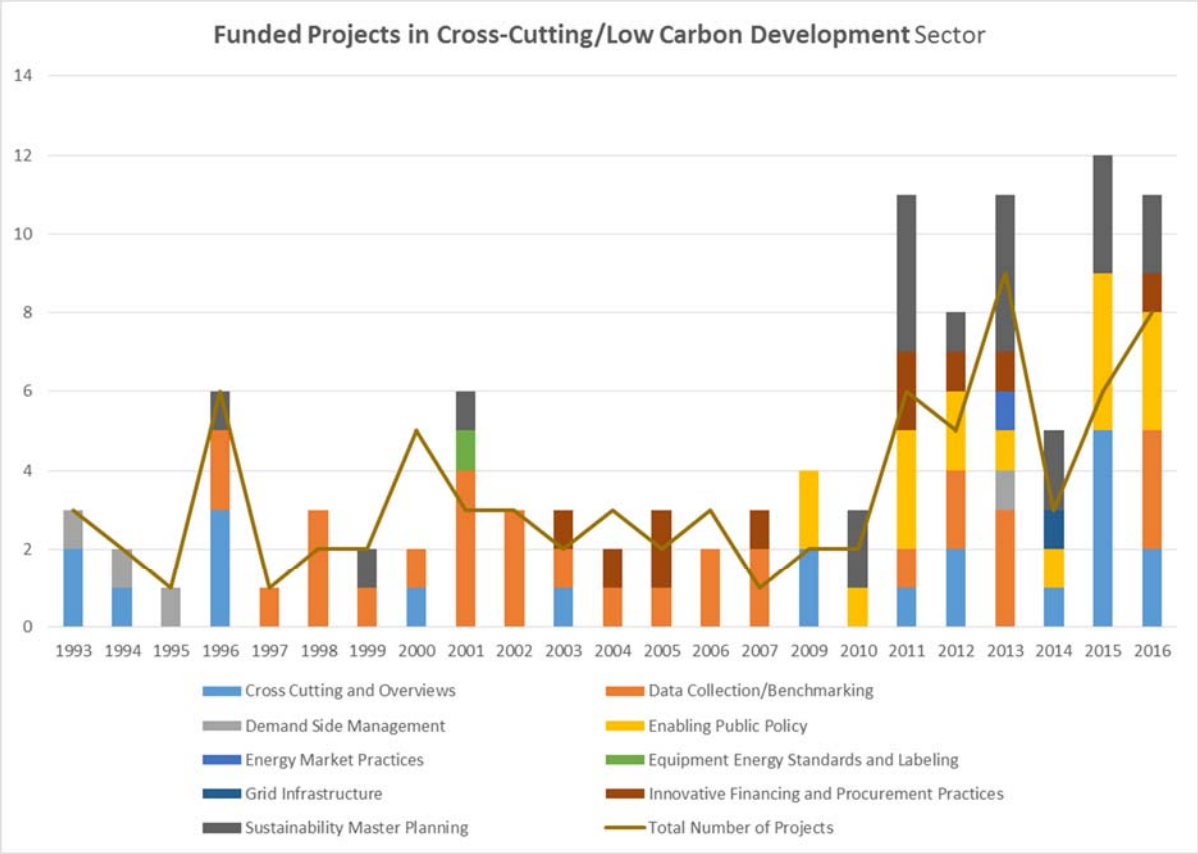


Figure 40. Funded Projects in Cross-Cutting/Low Carbon Development

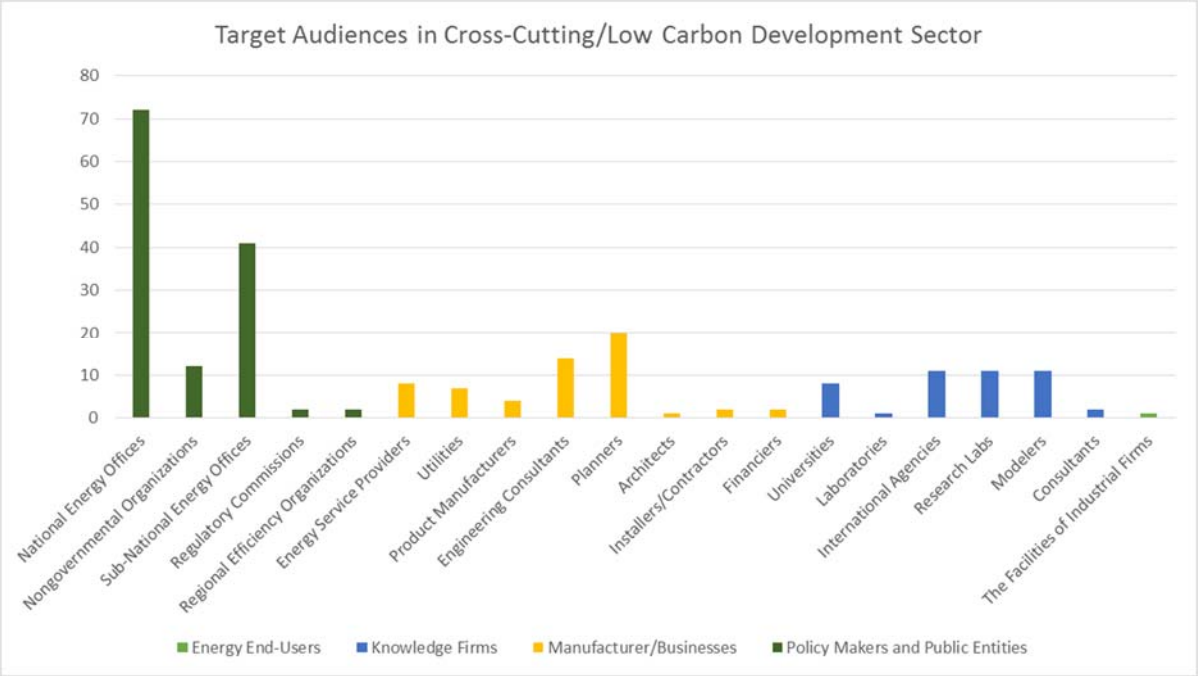


Figure 41. Target Audiences in Cross-Cutting/Low Carbon Development Sector

Table 21. Project Counts, Deployment Strategies, Cross-Cutting, Low Carbon Sectors

Deployment Strategies (grouped by category)	Number of Projects
Technology/Practice Transfer Mechanisms	**73**
Databases	21
Design Competition	1
Product and Services Directories	1
Specific Project Assessment/Case Study Development	16
Technological and Institutional Assessment	17
Tools, Guidebooks, and Other Practice Promotion	16
Website Development and Maintenance	1
Collaborative Energy Technology Exchange Endeavors	**25**
Surveys/Questionnaires	1
Workshops, Seminars, and Other Events	24
Minimize Duplicate Effort	**3**
Establish Links with Other International Organizations	3
Cooperate on Joint Projects	**16**
Joint Development and Demonstration Projects	1
Joint Research Projects	15
Encourage Private Sector Participation	**9**
Direct Project Consulting Services	8
Direct Project Financing	1
Encourage Public Sector Participation	**19**
Promote Exchange of Economies' Programs and Policies	19

5.5.4 Grid/Energy

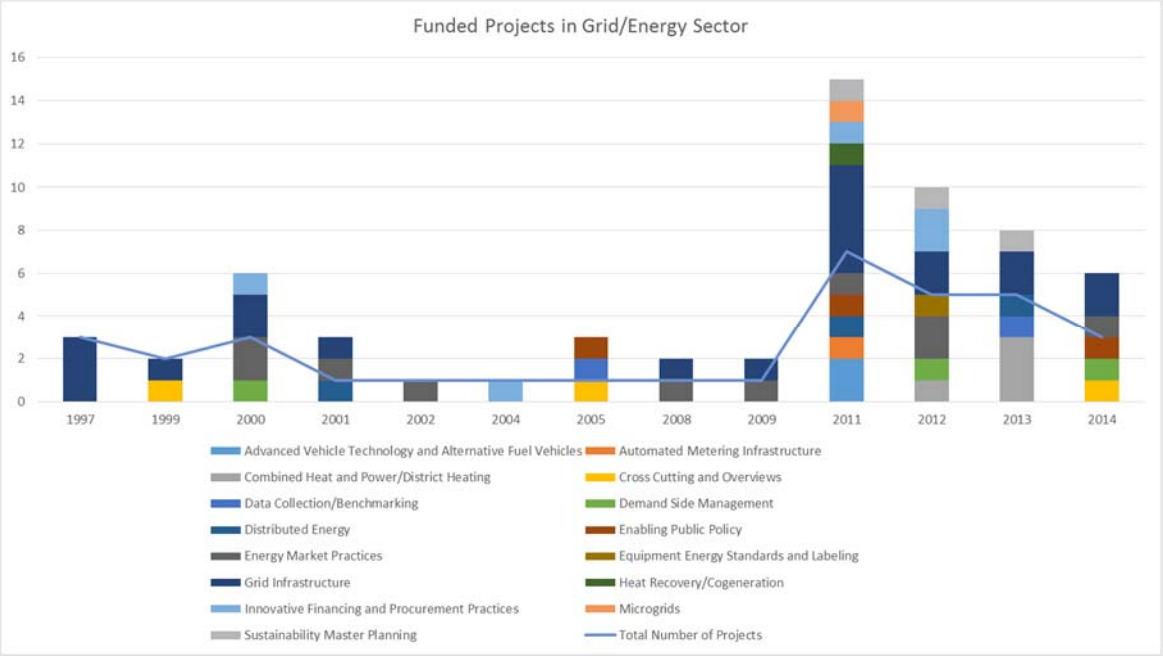


Figure 42. Funded Project Counts, Grid/Energy Sector

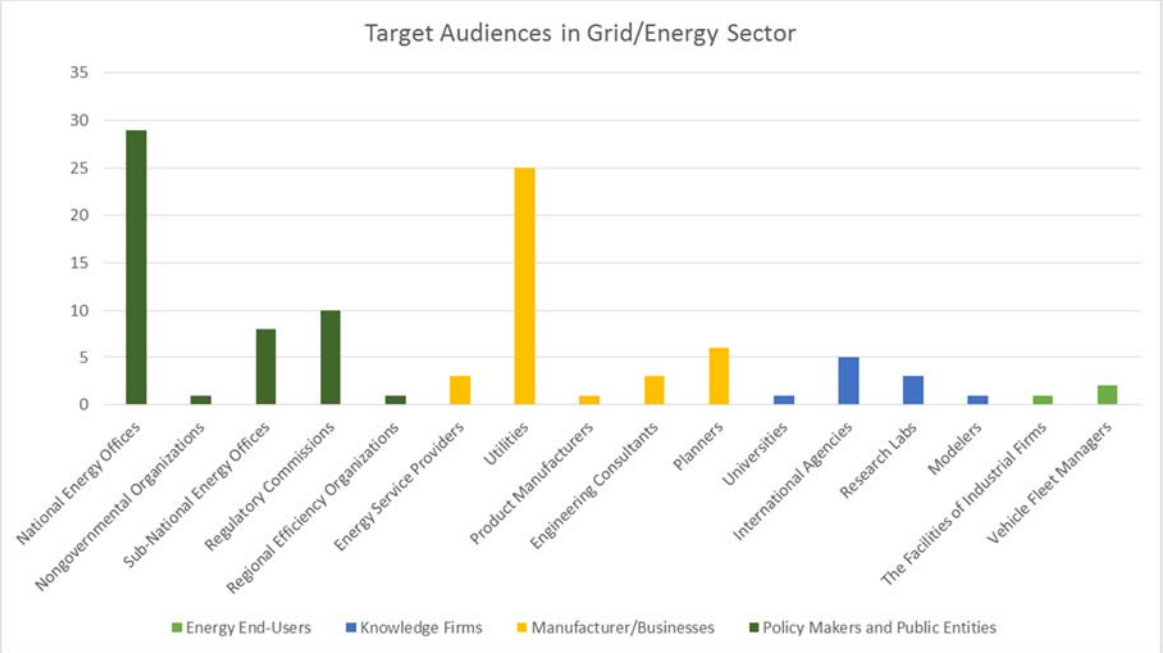


Figure 43. Target Audiences, Grid/Energy Sector

Table 22. Project Counts, Deployment Strategies, Grid/Energy Sector

Deployment Strategies (grouped by category)	Number of Projects
Technology/Practice Transfer Mechanisms	**32**
Databases	1
Specific Project Assessment/Case Study Development	3
Technological and Institutional Assessment	20
Tools, Guidebooks, and Other Practice Promotion	7
Website Development and Maintenance	1
Collaborative Energy Technology Exchange Endeavors	**17**
Surveys/Questionnaires	3
Workshops, Seminars, and Other Events	14
Minimize Duplicate Effort	**1**
Establish Links with Other International Organizations	1
Encourage Public Sector Participation	**10**
Promote Exchange of Economies' Programs and Policies	10

5.5.5 Industrial

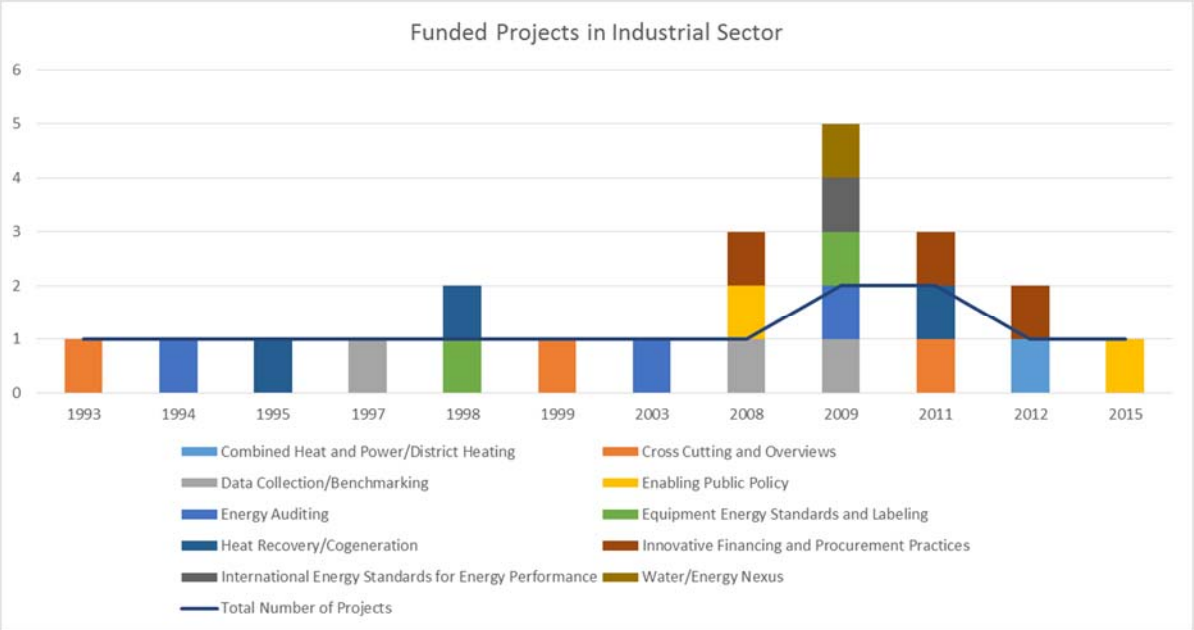


Figure 44. Funded Projects, Industrial Sector

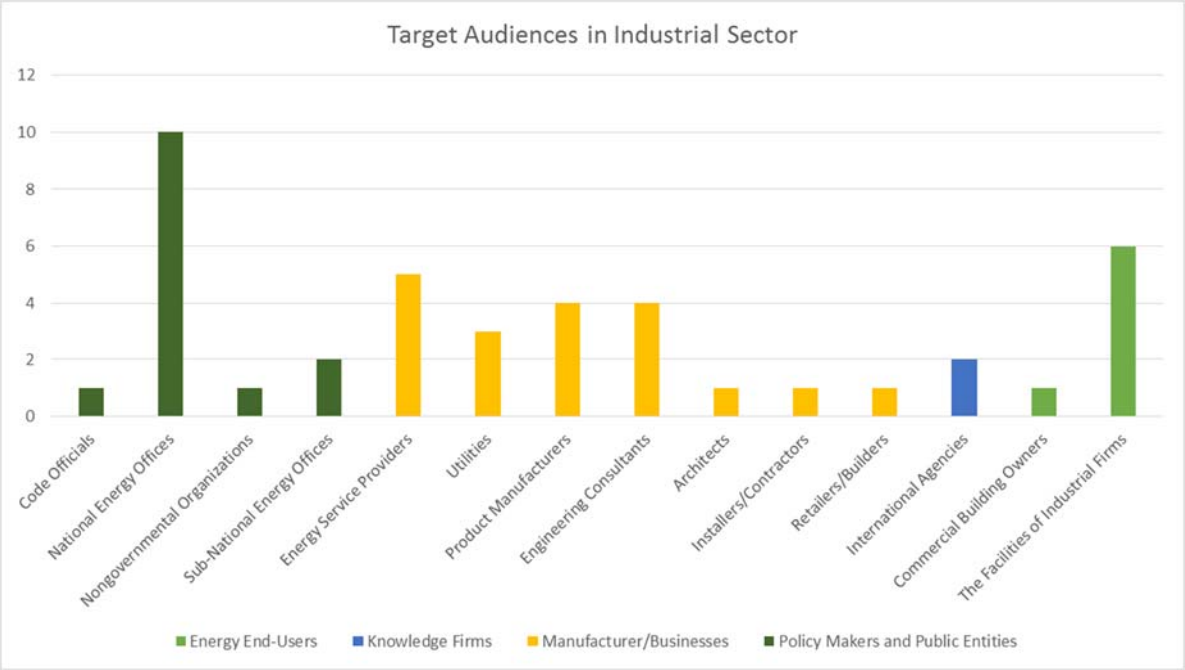


Figure 45. Target Audiences, Industrial Sector

Table 23. Project Counts, Deployment Strategies, Industrial Sector

Deployment Strategies (grouped by category)	Number of Projects
Technology/Practice Transfer Mechanisms	**10**
Databases	2
Technological and Institutional Assessment	5
Tools, Guidebooks, and Other Practice Promotion	3
Collaborative Energy Technology Exchange Endeavors	**11**
Surveys/Questionnaires	1
Workshops, Seminars, and Other Events	10
Minimize Duplicate Effort	**2**
Establish Links with Other International Organizations	2
Encourage Public Sector Participation	**3**
Promote Exchange of Economies' Programs and Policies	3

5.5.6 Transportation

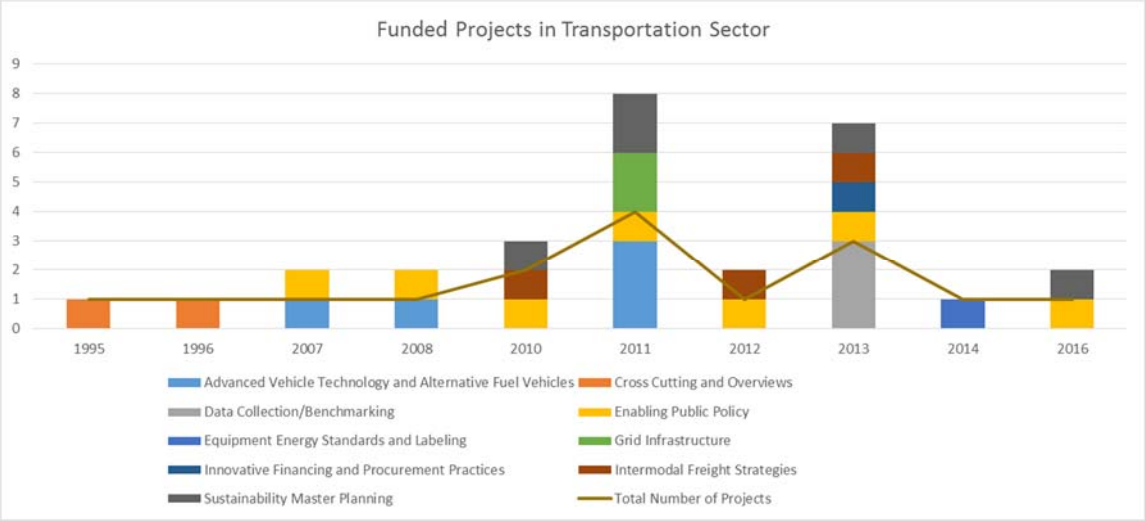


Figure 46. Funded Projects, Transportation Sector

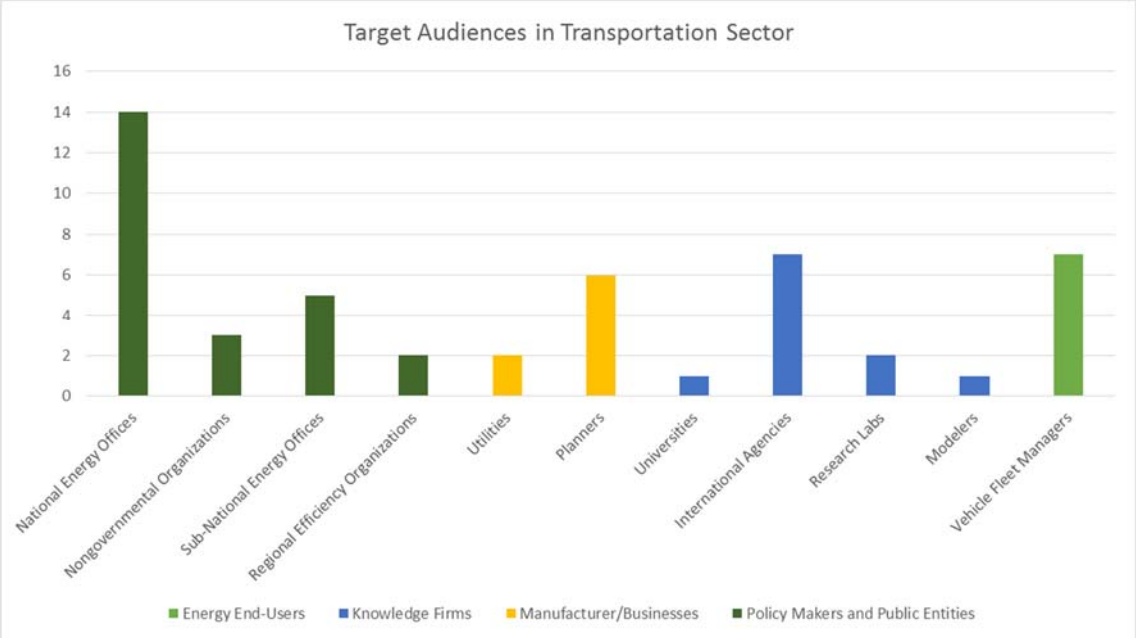


Figure 47. Target Audiences, Transportation Sector

Table 24. Project Counts, Deployment Strategies, Transportation Sector

Deployment Strategies (grouped by category)	Number of Projects
Technology/Practice Transfer Mechanisms	**15**
Specific Project Assessment/Case Study Development	2
Technological and Institutional Assessment	8
Tools, Guidebooks, and Other Practice Promotion	5
Collaborative Energy Technology Exchange Endeavors	**6**
Workshops, Seminars, and Other Events	6
Minimize Duplicate Effort	**1**
Establish Links with Other International Organizations	1
Cooperate on Joint Projects	**2**
Joint Development and Demonstration Projects	1
Joint Research Projects	1
Encourage Private Sector Participation	**1**
Direct Project Consulting Services	1
Encourage Public Sector Participation	**6**
Promote Exchange of Economies' Programs and Policies	6

5.5.7 Funding

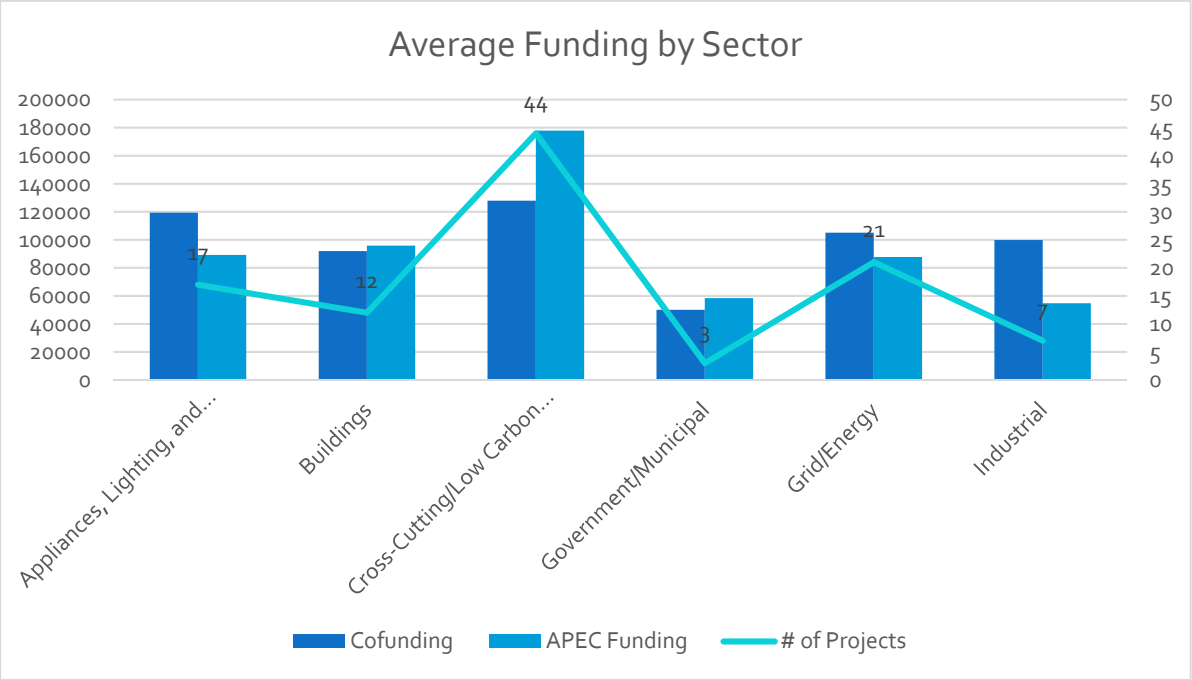


Figure 48. Average Funding by Sector

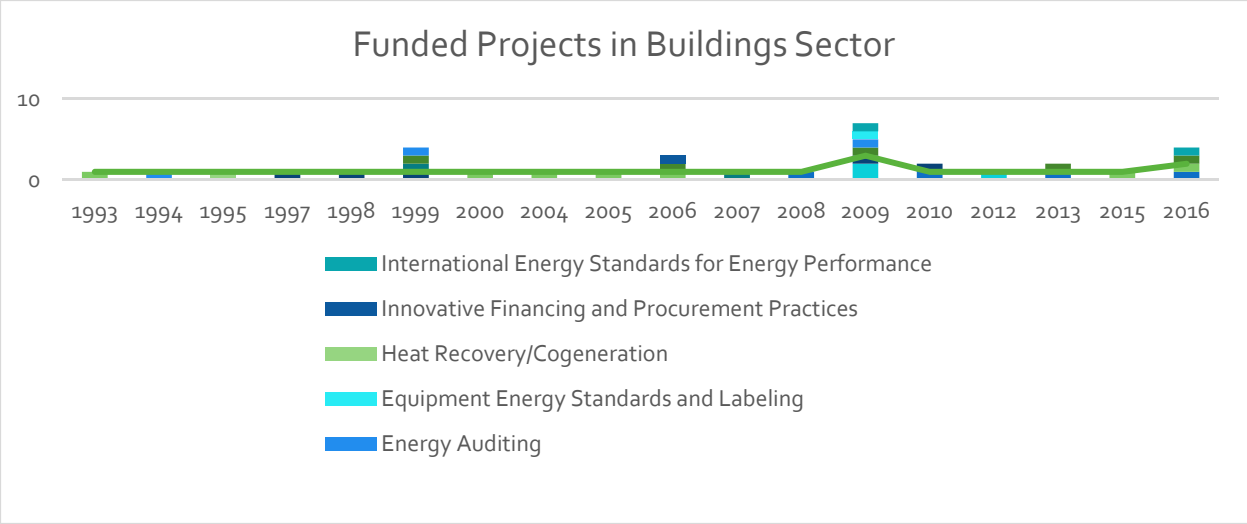


Figure 49. Funded Projects, Building Sector, by Year

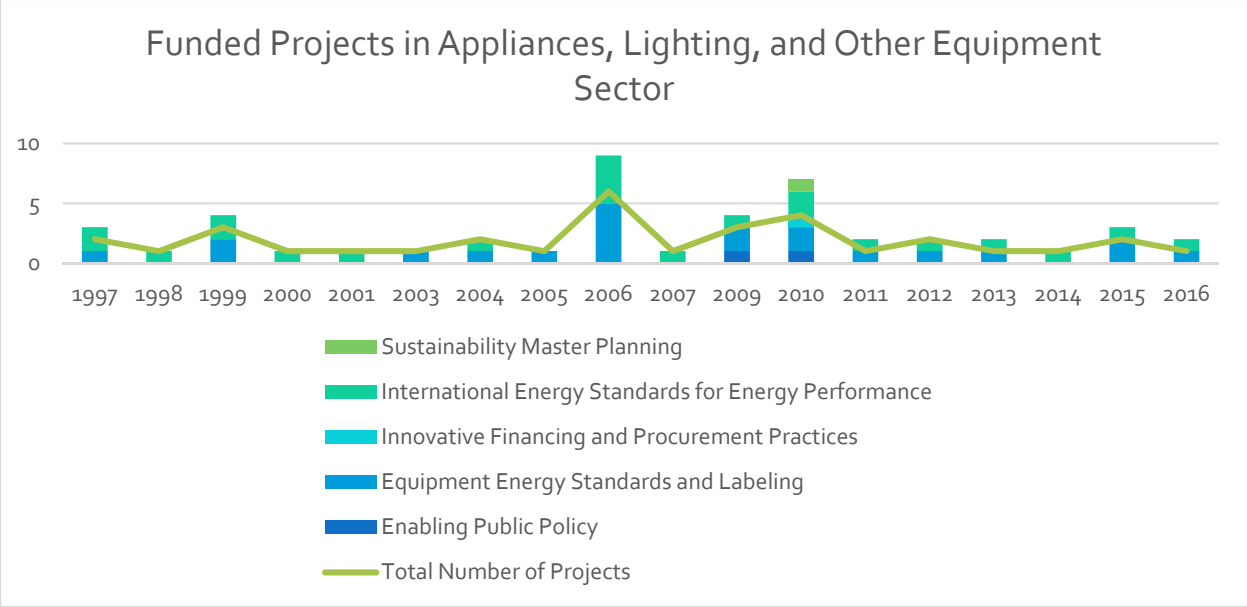


Figure 50. Funded Projects, Appliances and Equipment, By Year

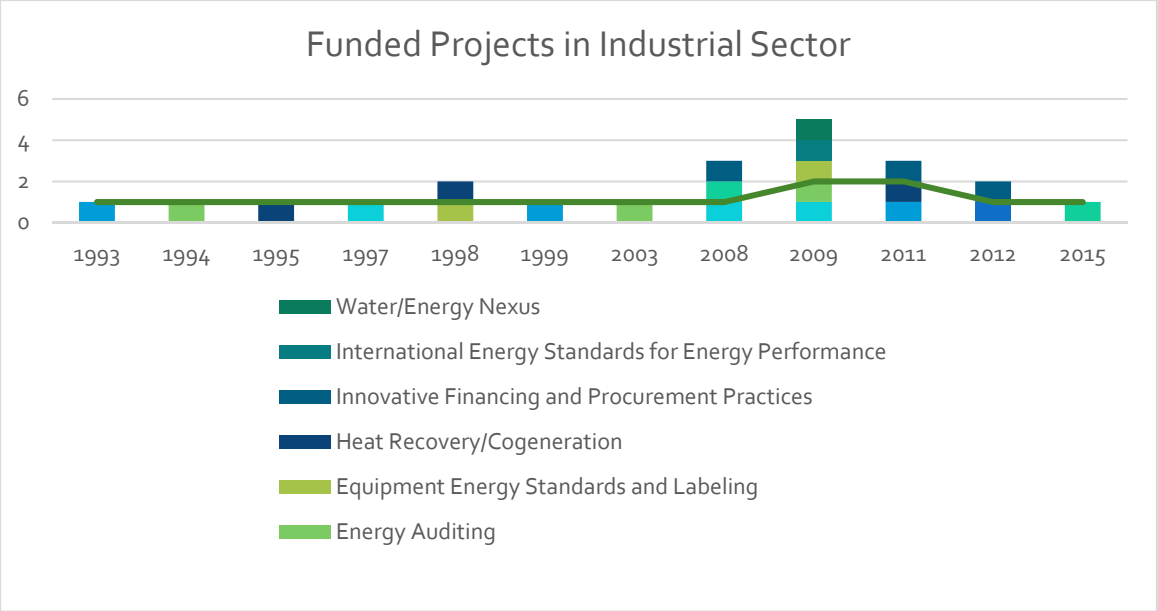


Figure 51. Funded Projects, Industrial Sector, By Year

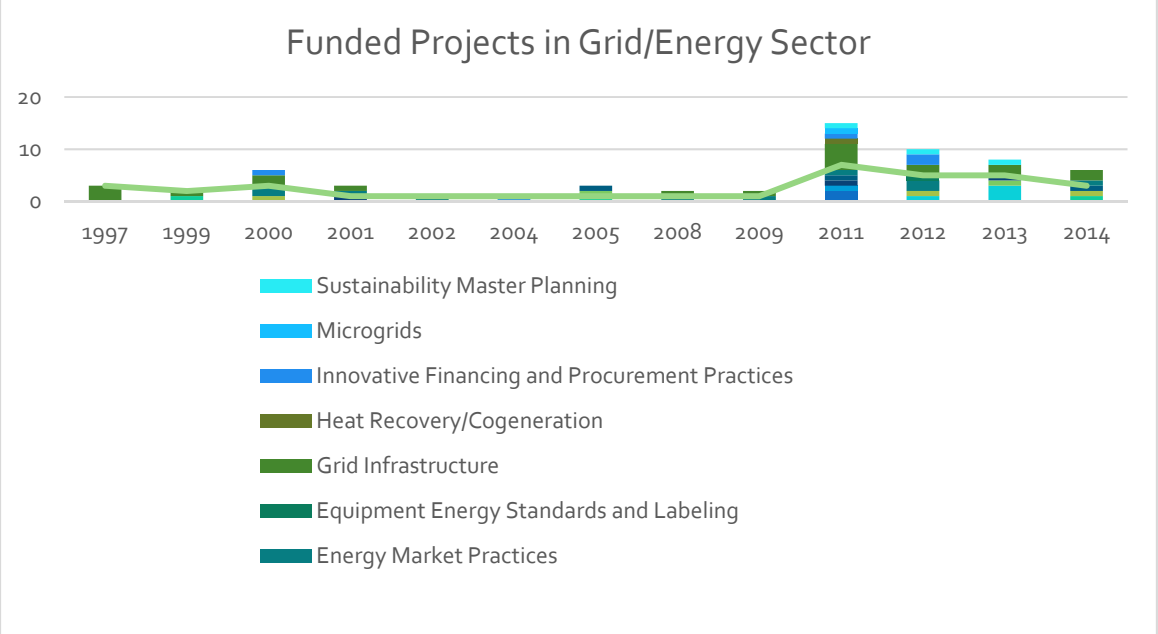


Figure 52. Funded Projects, Grid/Energy Sector, By Year

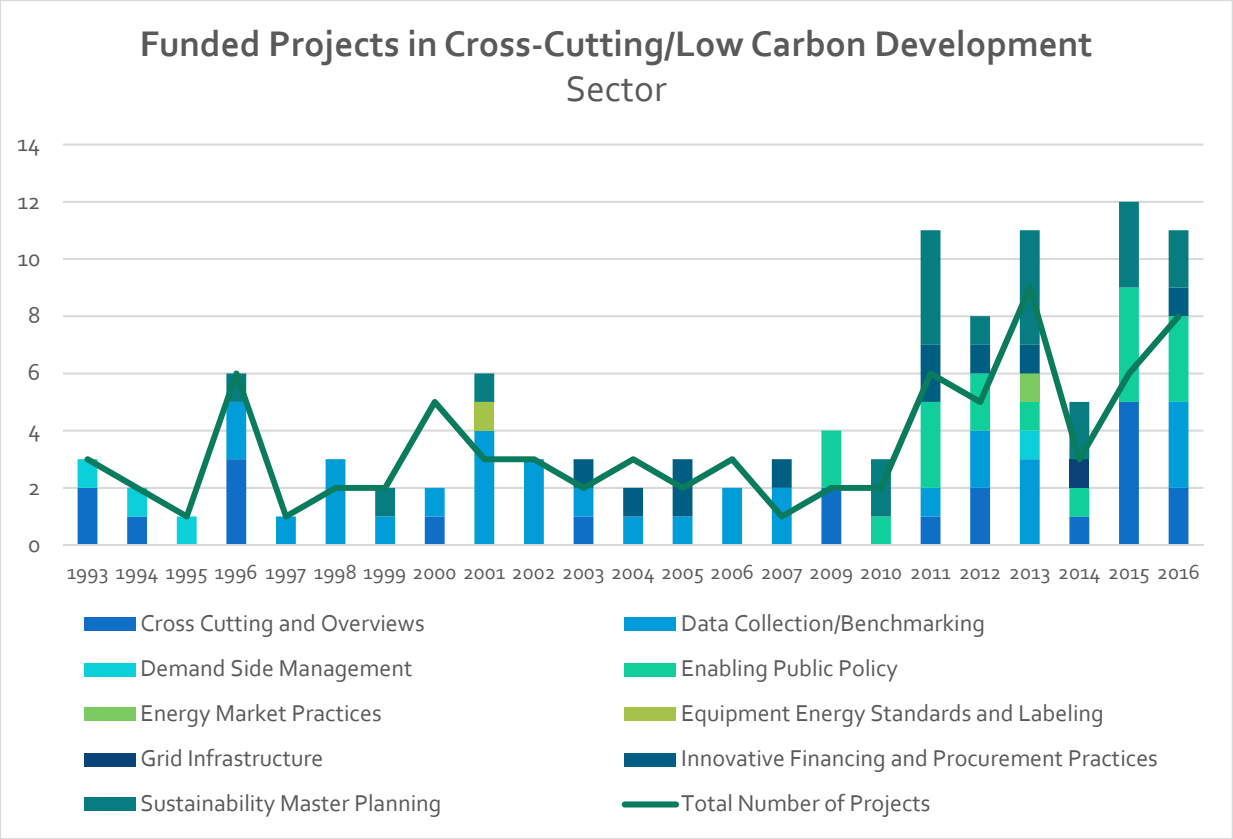


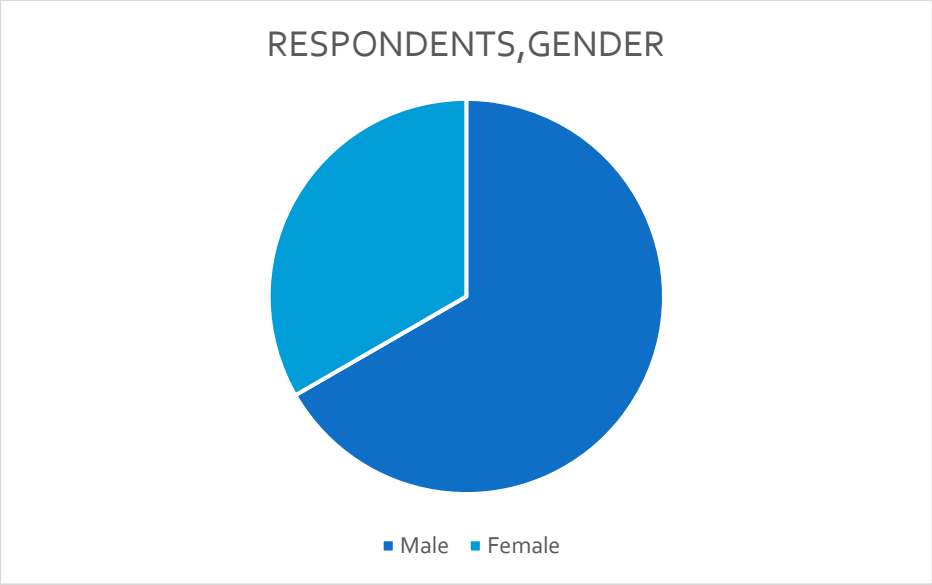
Figure 53. Funded projects, Cross-Cutting, Low Carbon Development, By Year

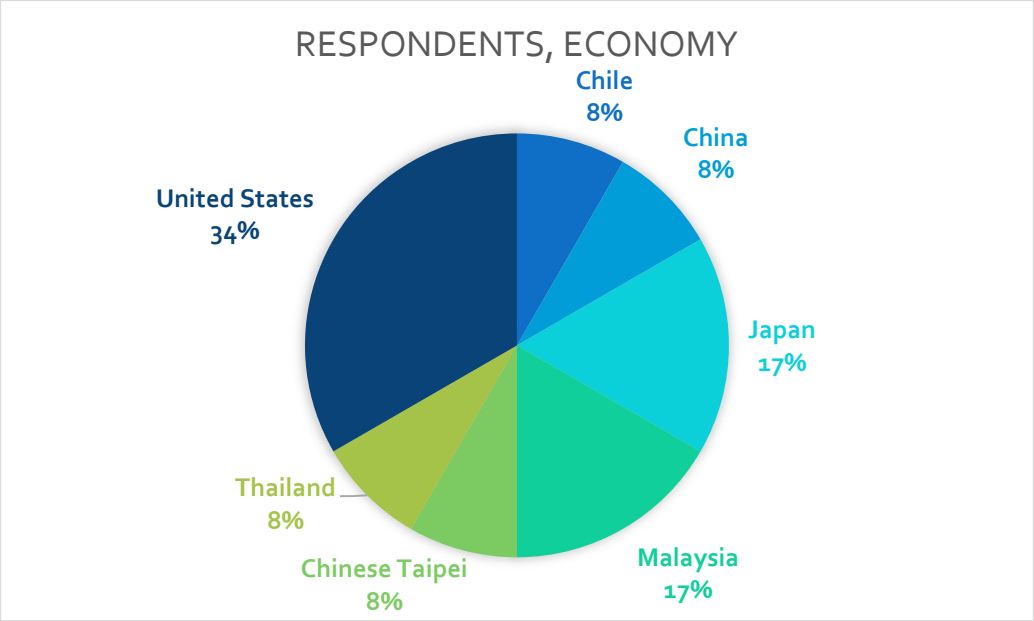
6 Appendix

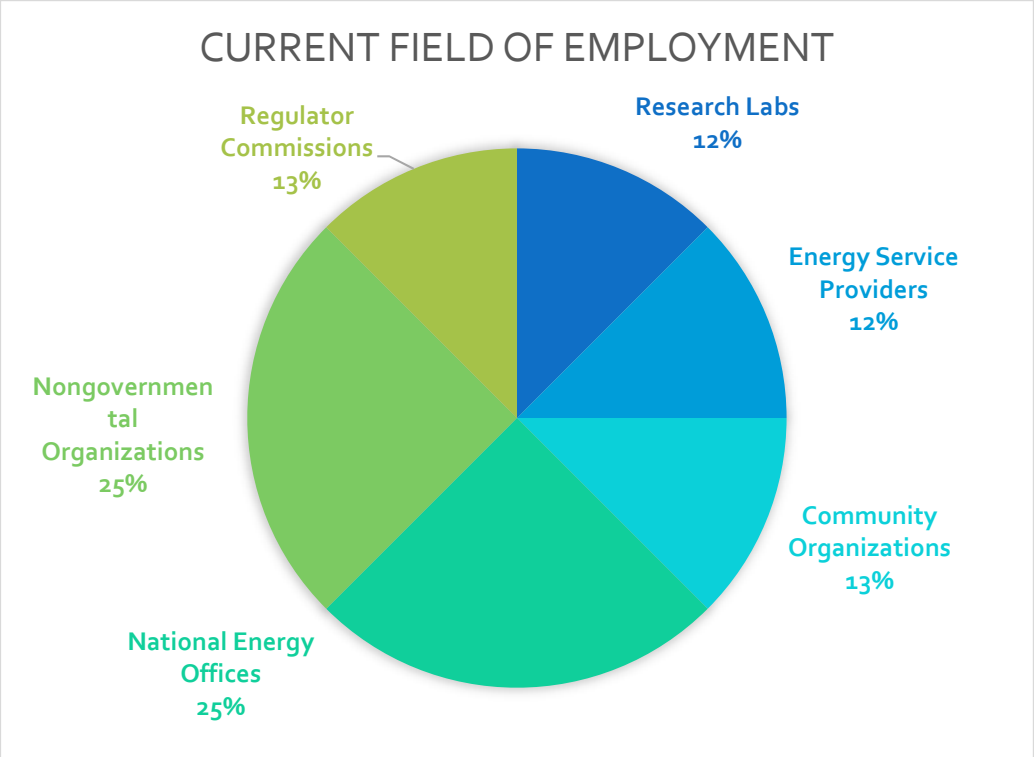
6.1 Survey Results

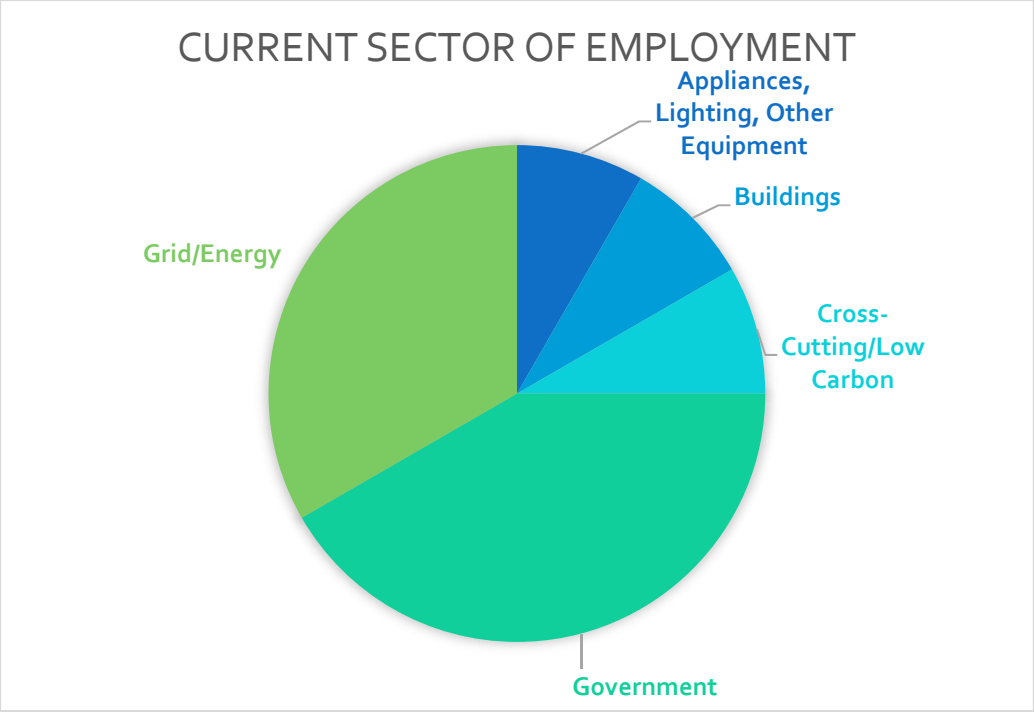
This survey was created for APEC Project EWG 01 2016A -- Gaps Assessment on APEC Energy Efficiency and Conservation Work toward fulfilling the Leaders' Energy Intensity Reduction Goal and will help reflect the views of APEC economies on specific needs for additional efforts to be considered by the EWG. The report's outcomes are designed to help the EWG and EGEEC develop recommendations and research priorities in areas most relevant to the needs facing the APEC region. In the final report, all survey responses are anonymized. The personal information requested in the survey is used to ensure that the research complies with APEC gender equity goals.

Survey Demographics



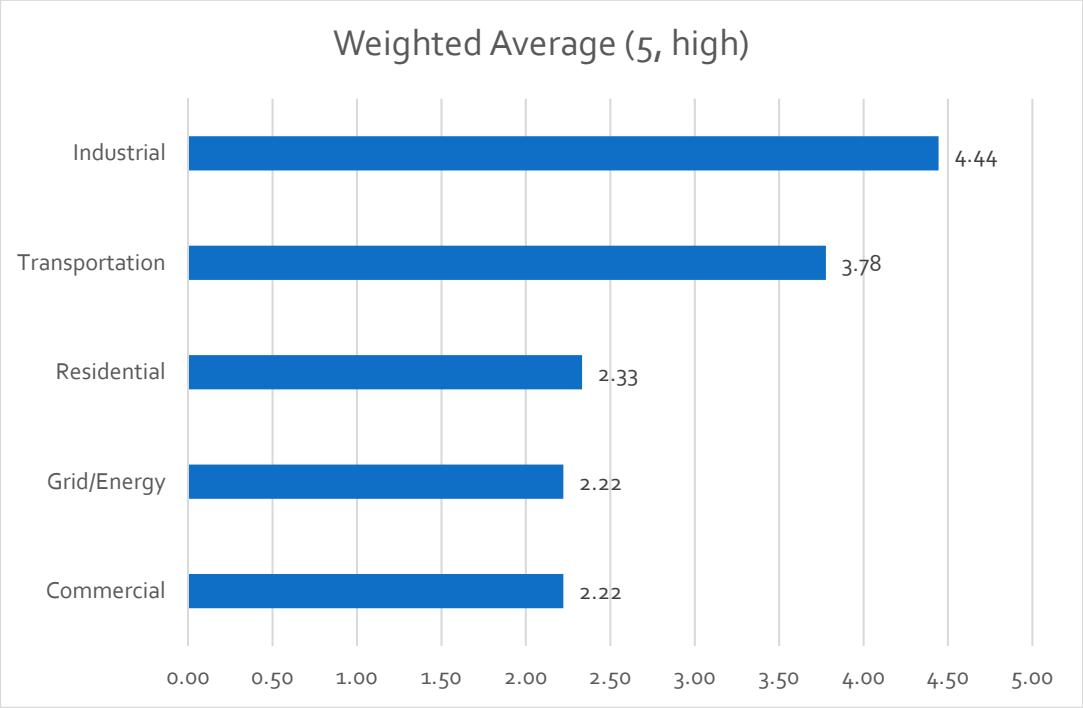

RESPONDENTS, ECONOMY
Chile
8%
China
8%
Japan
17%
Malaysia
17%
Chinese Taipei
8%
Thailand
8%
United States
34%


CURRENT FIELD OF EMPLOYMENT
Research Labs
12%
Energy Service Providers
12%
Community Organizations
13%
National Energy Offices
25%
Nongovernmental Organizations
25%
Regulator Commissions
13%


CURRENT SECTOR OF EMPLOYMENT
Appliances, Lighting, Other Equipment
Buildings
Cross-Cutting/Low Carbon
Government
Grid/Energy

Priorities for Energy Efficiency and Conservation

25% of survey takers skipped this question. The two highest ranked sector are also the two sectors with the lowest number of projects in the efficiency portfolio.



Q: Rate the importance of these technologies and practices for advancing energy efficiency and conservation in your economy.

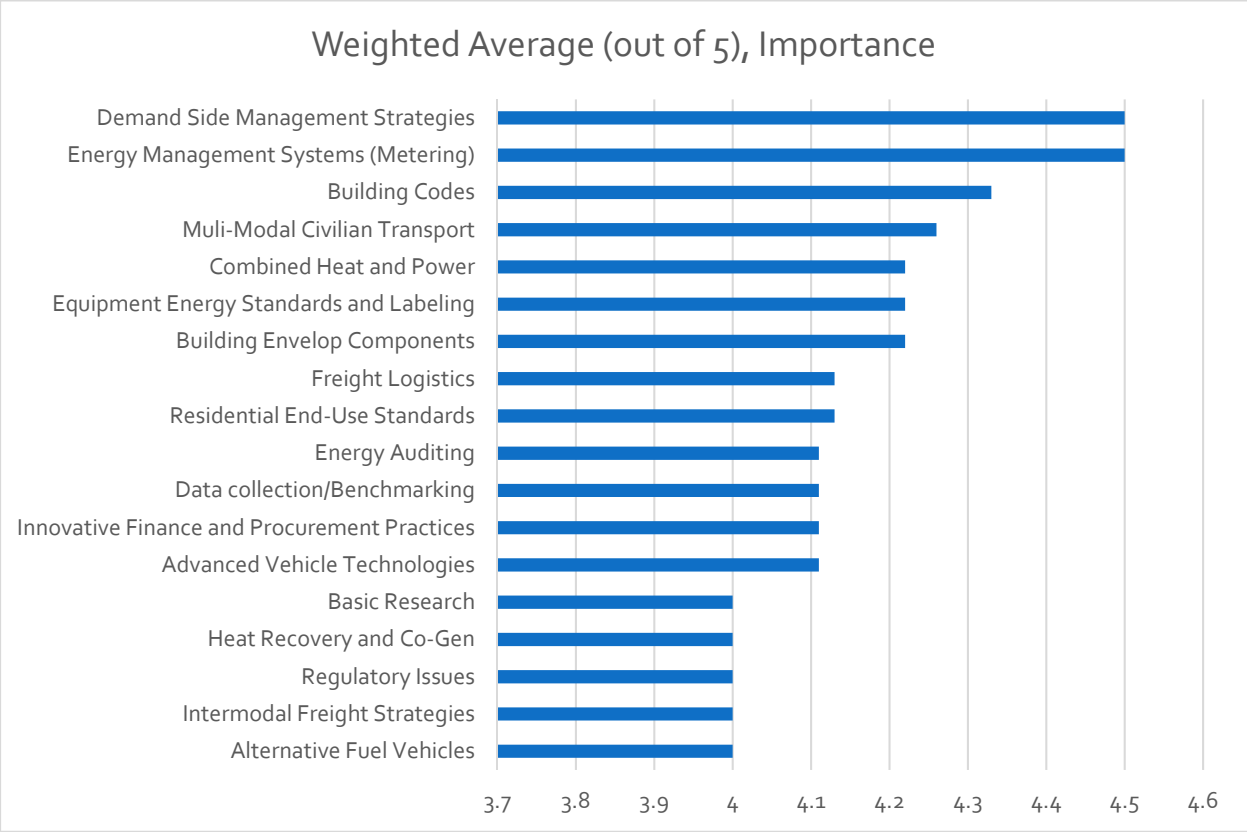
The question included 27 technologies and practices. Respondents were asked to rate them from 1(low) to 5 (high). Three-quarters of the respondents rated all 27 technologies and practices. Very few were rated low (1 or 2) while those ranked neutral were consistently ranked neutral across all respondents. The weighted averages shows the 17 technologies and practices were ranked 4 or higher.

The highest ranked categories were energy management systems and demand side energy management systems. This corresponds well with the overall interest in smart grids reflected in projects over since 2009, and concerns over the complexity of the systems and the wide-range of policy, regulatory and consumer behavior issues that cities and economies must coordinate to make smarter management of energy a reality.

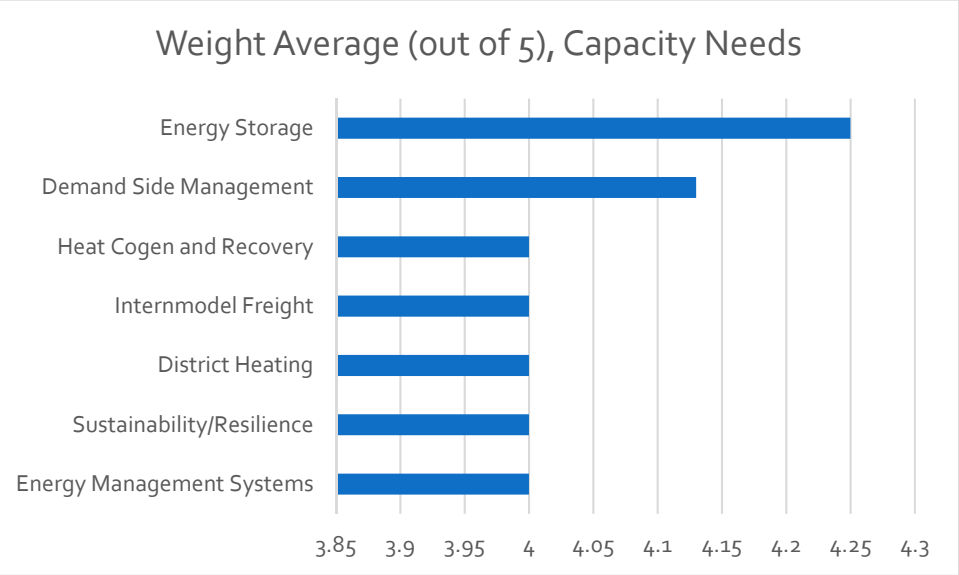
The third and fifth highest concern was building codes. This may also be reflected in the project portfolio, which has a stronger emphasis on building appliances and equipment standards over building envelope components and energy codes.

Other top-rated categories also reflect project gaps or recent interests across APEC. Alternative fuel vehicles and advanced vehicle technologies reflects a strong interest in electric vehicles and their

integration with smart grids. Heat Recovery, combined heat and power, and cogeneration are all issues important to the industrial sector, which has not been a focus of EE projects since the 1990s.



Q. Rate the need for capacity building (education and training) in your Economy for each technology and practice?



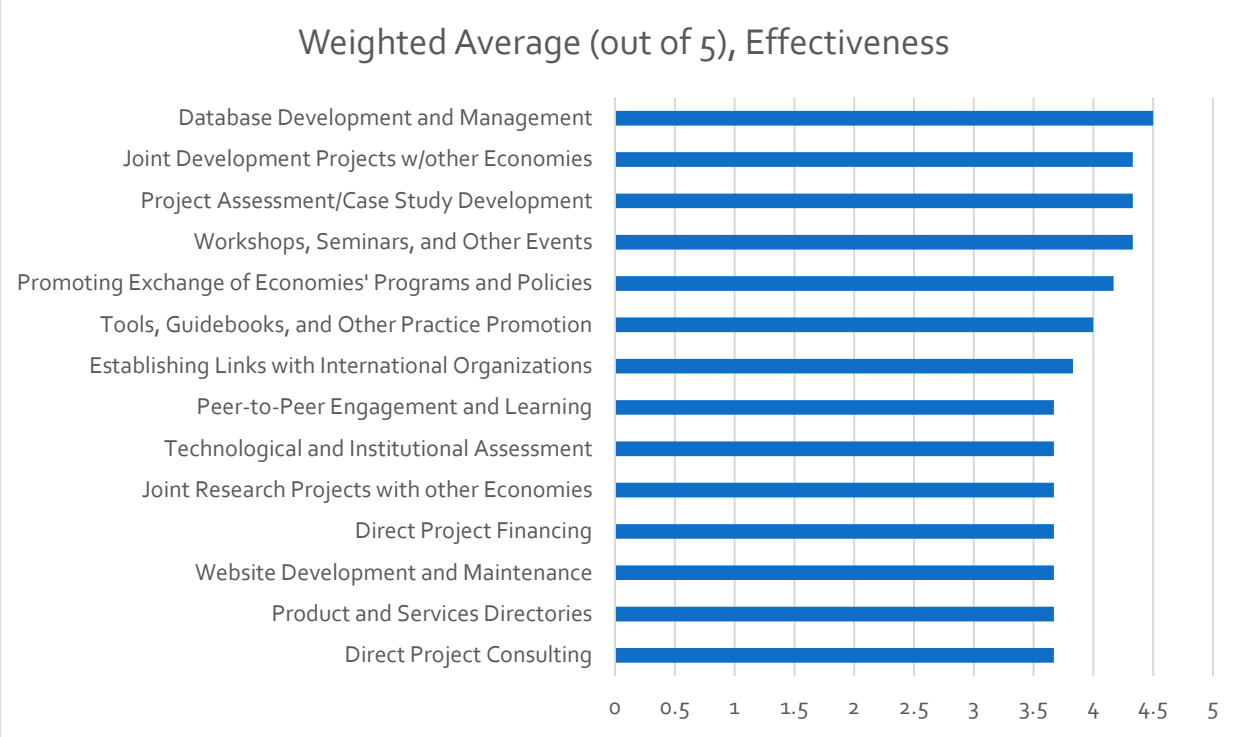
The same 27 technologies were ranked consistently lower in capacity needs than in overall importance. Seven technologies ranked a four or higher, though no technologies or practices ranked below neutral. Both Energy Management systems and demand side management ranked

high in importance and in capacity needs. A new heating category – district heating – rose above four. This issue has been raised in Russia, where aging district heating systems have been identified as a major source of energy inefficiencies. It has also been a general topic of interest for smart grids, sustainability, and next generation supply side business models, particularly in Europe.

The other topic that moved up the rankings was sustainability and resilience. Sustainability/Resilience is a Strategic pathway gap in this report.

Q. Rate the effectiveness of each of the following EWG deployment strategies in improving the knowledge base for your economy and enabling technology and practice adoption.

Six of the highest weighted deployment strategies focus on creating opportunities to share practical knowledge and enhance capacity building through case studies and joint projects that offer concrete examples of policy and regulatory reforms, or technical solutions. That is, strategic and tactical solutions were ranked higher than analytical/research assessments. The only strategy to rank lower than neutral was Surveys/Questionnaires.



Other comments

- Lack of incentives for consumers and businesses to invest in energy efficiency
- Regulatory frameworks that do not support department integration
- Need more education on how to implement
- Relatively low energy prices
- Commercial sector needs attention due to lower responsiveness to prices, consumer awareness

6.2 Economy Summaries

The following economy tables summarize observations from the main body of the report by economy

6.2.1.1 *Australia*

TOPIC	SUMMARY (AUSTRALIA)
ECONOMY	• High Income, High GNI • Estimated 2.8% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Multiple climate zones, largest is semi-arid/desert • A large continent with major urban areas along the periphery coasts
EE POLICIES AND REGULATIONS	• RISE Average: Very High • EE Indicator 7, Incentives & mandates for utilities: Very low • Target: Increase energy productivity by 40% between 2015 and 2030
BUILDINGS	• Yes: Commercial and Residential Building Codes • Yes: Productivity targets, planning; a bit different from typical EE planning • expects up to 42% renewables by 2040;High residential PV solar system coverage, ranging from 18-25% of regional markets; • Lowest sector savings potential in IEE scenario
INDUSTRY	• No: EE Sector Targets • No: Generation or T&D Mandates • Yes: Labeling for Industrial Motors and Equipment • Sector is largest energy user; mining expected to grow • 'Very Large Consumer' Audits have resulted in 40% savings
TRANSPORTATION	• No: Fuel Efficiency Mandates • No: Vehicle Labeling • Relies on truck transportation and air over large continent • Land use patterns contribute to sprawl • Nearly half of IEE savings
OTHER CONSIDERATIONS	
EGEE&C PROJECTS	• Active; focus on appliance and equipment standards

6.2.1.2 *Brunei Darussalam*

TOPIC	SUMMARY (BRUNEI DARUSSALAM)
ECONOMY	• High Income, High GNI • Estimated 1.2% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Tropical Equatorial Climate • Very tiny economy on the island of Borneo • Large energy producer
EE POLICIES AND REGULATIONS	• Targets by 2035 (2005 base) of 10% renewable electricity • Increase gas and oil production to 650 000 bbl/d. • RISE: no rating
BUILDINGS	• New roadmap includes codes, standards and incentives to counter tropical climate's impact on cooling demands
INDUSTRY	• IEE scenario shows no savings in this sector over BAU

	• Major economic driver; oil and gas industries, at two-thirds of GDP
TRANSPORTATION	• Very high GDP per capita, high incomes, subsidized fuel prices and minimal transit options has resulted in a rapid rise in vehicle ownership
OTHER CONSIDERATIONS	• Though only 5,700km2, the economy has the fifth largest GDP per capita in the world due to energy exports • 2014 30-year Energy Efficiency and Conservation (EEC) roadmap specifies a 63% demand reduction by 2030
EGEE&C PROJECTS	• limited

6.2.1.3 *Canada*

TOPIC	SUMMARY (CANADA)
ECONOMY	• High Income, High GNI, Est. Population (2040), 42 million • Estimated 1.7% AAGR (APERC) • Parliamentary system; Strong provincial control of policy making
GEOGRAPHY/CLIMATE	• Largely cold Tundra with more temperate seasonal climate to the south • Large distances between urban centers
EE POLICIES AND REGULATIONS	• RISE: Strong performer across the indicators;. Does have some form of carbon pricing scheme
BUILDINGS	• Largest sector demand in 2013 • 41% of IEE scenario savings due to high heating and cooling loads
INDUSTRY	• 19% savings over BAU • Expects phase-out of coal-fired plants, affecting industry • 28% of GDP (2016)
TRANSPORTATION	• No: Vehicle Labeling • Strong reliance on heavy duty vehicles • One of 4 APEC economies with EE standards for Freight • Large land mass means higher reliance on air
OTHER CONSIDERATIONS	• Largest oil reserves in APEC • 3rd largest hydo-power producer; 78% supply from renewables • Phasing out nuclear • Highly Urbanized. 86% by 2040
EGEE&C PROJECTS	Active. Proposed 10 projects – transport and cross-cutting most dominant

6.2.1.4 *Chile*

TOPIC	SUMMARY (CHILE)
ECONOMY	• High Income, High GNI, Est. Pop (2040) 20 million • Estimated 4.92% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Seven major climate zones, including tundra, tropical, desert • Long Pacific coastline, parallel to the Andes • Limited natural energy resources (imports 90%)
EE POLICIES AND REGULATIONS	• Yes: federal level energy efficiency planning, and new Energy 2050 Plan • RISE: middle performer (50 out of 100) • 6 indicators ranked poor, including lack of labeling systems and building energy codes

BUILDINGS	• Only 14% of IEE scenario savings • Nearly half of housing/cooking is biomass. Urbanization will increase residential electricity access • New Action Plan to include new building standards
INDUSTRY	• The bulk (57%) of projected savings • Dominated by mining
TRANSPORTATION	• Geography makes public regional transport difficult but large potential for Santiago, with 80% of population. • Action Plan include Santiago investments and fuel standards • 29% of the IEE scenario saving
OTHER CONSIDERATIONS	• Highly urbanized. Over 90% rate by 2040 • Energy demand expected to increase 67% by 2040
EGEE&C PROJECTS	• Has not proposed any projects, recorded as participants in 5 projects

6.2.1.5 *China*

TOPIC	SUMMARY (CHINA)
ECONOMY	• Upper-Middle Income, Upper-middle GNI • Est. AAGR 4.9% over outlook period (APERC) • Est. Pop (2040) 1.361 billion
GEOGRAPHY/CLIMATE	• Multiple climate zones, from tropical to arid desert • Geographical hazards range from flooding to earthquakes
EE POLICIES AND REGULATIONS	• RISE score: strong performer • Largest share of energy consumption covered by mandatory EE policies in the world (56%)
BUILDINGS	• The smallest coverage of EE mandates of all the sectors • Low-carbon model towns include extensive building EE policies and practices •
INDUSTRY	• Energy intensity in iron/steel, cement and chemical sub--sectors dropped by 23% from 2005 to 2013 due to policies; however, • APERC projects BAU energy intensity reduction of 65% (2005 – 2035)
TRANSPORTATION	• The largest sector growth in APEC; 250% growth between 2013-2040 • Rapid expansion of public transport systems, regional rail • Stronger fuel standards and emphasis on electric vehicles
OTHER CONSIDERATIONS	• The economy captures 43% of EE savings across APEC • Urbanization rates expected to hit 70% by 2040 • Expected to triple GDP per capita growth • Increased energy demand (TPES) almost = 2013 energy consumption of Russia, Japan, Canada, and Korea
EGEE&C PROJECTS	• 31 Proposed projects; very strong participation

6.2.1.6 *Hong Kong, China*

TOPIC	SUMMARY (HONG KONG, CHINA)
ECONOMY	• High Income, High GNI, Est. • Est. Pop (2040) 8.9 million • Est. AAGR 2.2% over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Small highly urbanized island economy

	• Sub-tropical
EE POLICIES AND REGULATIONS	• RISE: no rating • Yes: Building Codes • No: Transport labeling and standards
BUILDINGS	• At 100% urbanization • 93% of total energy demand today; • Energy Saving Plan 2015-2025+, reduce energy intensity by 40% by 2025
INDUSTRY	• Most heavy industry has moved to mainland China
TRANSPORTATION	• Strong transit systems • High vehicle saturation • No: Transport labeling and standards, but expected to be implemented
OTHER CONSIDERATIONS	• 100% Urbanization rates • Second highest GDP/capita in APEC
EGEE&C PROJECTS	• Hong Kong, China has not proposed any projects. Low participation

6.2.1.7 *Indonesia*

TOPIC	SUMMARY (INDONESIA)
ECONOMY	• Low Middle Income, Low-Middle GNI • Estimated 4.4% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Tropical Climate, • Mountainous archipelago chain, over 13,000 islands • Shares islands with Malaysia and Papua New Guinea
EE POLICIES AND REGULATIONS	• Conservation vision 2025: reduce energy intensity 1% annually and energy elasticity to less than 1% • RISE Average: Low-Middle performance rating • Seven indicators are in the red • Few energy labeling or mandatory standards
BUILDINGS	• No: appliance standards per RISE • Yes: Regulations for A/C MEPS (LCMT phase 5) • Yes: Light Bulb labeling (LCMT Phase5) • Only 19% of IEE savings expected from this sector • half of the pop (254 million, 2013) lives on small islands in rural areas and use kerosene and wood for food and heating
INDUSTRY	• less-intensive sub-sectors account for 79% of the sector's total energy use
TRANSPORTATION	• Motorcycles use almost a third of transportation energy, a large exception to rates typically less than 3-4% LDVs are expected to increase 3x due to urbanization increases
OTHER CONSIDERATIONS	• Due to geography, efficiency initiatives are preferred over renewable options • Urbanizations expected to rise from 52% to 66%
EGEE&C PROJECTS	• Has not proposed projects; stronger participation on cross-cutting projects

6.2.1.8 *Japan*

TOPIC	SUMMARY (JAPAN)
ECONOMY	• High Income, High GNI • Estimated 1.1% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Mountainous Archipelago; • Multiple climate zones from tropical to artic • On the ring of Fire, high risk of earthquakes, tsunami
EE POLICIES AND REGULATIONS	• YES: Federal level and Sectoral Targets and Planning • RISE Average: High Performer • RISE Indicator 6: Incentives & mandates: public sector: Low • RISE EE Indicator 7: Incentives & mandates: utilities: Low
BUILDINGS	• Despite falling population the buildings sector is projected to increase from 50% to 60% of total demand by 2040 • MEPs for majority of residential appliances, heating and cooling equipment
INDUSTRY	• Strong EE measures already in place for high-energy sub-sectors • Industry demand expected to flatten by 2040
TRANSPORTATION	• Subsidies for new technology vehicles As a result, • hybrid vehicles have been the highest selling car in Japan for several years;
OTHER CONSIDERATIONS	• Highly urbanized; 97% by 2040 • Slow population growth • Imports nearly all energy; moratorium on nuclear after 2011 accident affects supply mix
EGEE&C PROJECTS	• Active economy with high proposal and participation rates

6.2.1.9 *Korea*

TOPIC	SUMMARY (KOREA)
ECONOMY	• High Income, High GNI • Estimated 2.2% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Peninsular economy with water on Yellow Sea, East China Sea, and Sea of Japan on 3 sides • Mountainous, with stable geography; typhoon climate
EE POLICIES AND REGULATIONS	• RISE Average: High Performer • Yes: Federal level and sectoral targets
BUILDINGS	• Building energy demand will pass Industry in the next 3 years • High income, small households growing demand • Less than a third of IEE scenario savings
INDUSTRY	• Almost 75% of EE savings since 2000 have been in the industrial sector • Mandatory auditing, ESCOs and tax incentives
TRANSPORTATION	• Maritime sub-sector (25%) • One of 4 economies with freight EE standards • Robust, mature transit system; high-speed rail and six international airports connected by rail
OTHER CONSIDERATIONS	• Economy BAU projected to reach a 43% intensity reduction target • Urbanization will increase to 87% • Maintain nuclear share at 29% of capacity
EGEE&C PROJECTS	• Proposed 1 Project, stronger participation in projects, particularly cross-cutting

6.2.1.10 *Malaysia*

TOPIC	SUMMARY (MALAYSIA)
ECONOMY	• Upper-Middle Income, Upper-Middle GNI • Estimated 4.2% AAGR over outlook period (APERC)
GEOGRAPHY/CLIMATE	• Six main islands and hundreds of minor island • Equatorial tropical climate
EE POLICIES AND REGULATIONS	• RISE average: middle performer • Increas
BUILDINGS	• High cooling demands • One of the fastest growing building sectors in APEC • Expanding building codes, standards and labeling programs
INDUSTRY	• Lack of data; no APERC scenario modeling or savings projects for energy efficiency
TRANSPORTATION	• Does not have fuel standards • Highest sector energy demand • Lack of transit options = strong LDV demand • More than half of the savings in the IEE scenario
OTHER CONSIDERATIONS	• Expected to reach "developed" Higher Income status by 2020 • High growth means will become net importer of energy; energy demand ose fourfold between 1990 and 2013 • 84% urbanization rate by 2040 • Energy subsidy reform initiatives post-2014
EGEE&C PROJECTS	• Proposed 1 project (cross-cutting); moderate participation, mostly cross-cutting

6.2.1.11 *Mexico*

TOPIC	SUMMARY (MEXICO)
ECONOMY	• Upper Middle Income, Upper Middle GNI • Estimated 3.0% AAGR over outlook period (APERC) • Est. Pop (2040) 145million
GEOGRAPHY/CLIMATE	• Both temperate and Tropical Climates • Abundant natural resources including fossil fuels
EE POLICIES AND REGULATIONS	• RISE Average: Strong performer • Yes: Building codes • No: large consumer incentives • Yes: Utility mandates (
BUILDINGS	• Smallest sector due to rural and informal housing energy demand
INDUSTRY	• Mining and fuel generation activities contributed 8.6% of GDP in 2013, but 34% of total primary energy supply • Increase in sector energy use drive by cement and chemicals
TRANSPORTATION	• Largest sector energy demand • Nearly half of the IEE scenario savings • High growth of vehicle ownership has made urban air pollution a serious problem, particularly in Mexico City • 60% of BRT and minibus transit is old and ad hoc
OTHER CONSIDERATIONS	• Mexico City is one of the densest cities in the world • 2040 urbanization rates = 83% • IEE scenario shows 10-fold impact on energy use over other scenarios
EGEE&C PROJECTS	• Proposed 2 projects in Grid/Supply. Moderate Participation, stronger in appliances and buildings

6.2.1.12 *New Zealand*

TOPIC	SUMMARY (NEW ZEALAND)
ECONOMY	• High Income, High GNI • Estimated 2.3% AAGR over outlook period (APERC) • Est. Pop (2040) 5.5million
GEOGRAPHY/CLIMATE	• Isolated island economy • Temperate climate
EE POLICIES AND REGULATIONS	• Government goal is to be 90% renewable by 2025. • No RISE score
BUILDINGS	• Building codes and efficiency programs aimed at appliances, buildings and consumer behavior • Small sector savings 0.38MToe, or 0.1% of APEC's total sector savings
INDUSTRY	• Strong agricultural sector • largest growth industry is food manufacturing, growing to meet Asian demands for dairy products • Nearly half of IEE Savings from this sector
TRANSPORTATION	• Low transit outside of major cities • High 95% saturation of LDV vehicles and HDV vehicles
OTHER CONSIDERATIONS	• No energy subsidies • 75% of energy already from Renewables • 86% urban
EGEE&C PROJECTS	• Proposed 4 projects in Cross-Cutting, transport and grid. Moderately high participation

6.2.1.13 *Papua New Guinea*

TOPIC	SUMMARY (PAPUA NEW GUINEA)
ECONOMY	• Lower-Middle Income, Lower-Middle GNI • Estimated 6.4% AAGR over outlook period (APERC) • Est Pop (2040) 12million
GEOGRAPHY/CLIMATE	• Volcanic Tropical Islands • Geothermal resources • Mineral and metal resources
EE POLICIES AND REGULATIONS	• No RISE score • No building standards or labeling
BUILDINGS	• Residential only expected to account for 9% of energy demand by 2040
INDUSTRY	• 64% of energy demand, fastest growing sector, though absolute demand will remain very low
TRANSPORTATION	• High use of motocycles • 80% of IEE scenario savings • Only 12% saturation by 2040
OTHER CONSIDERATIONS	• Very low access to electricity (15%), all in urban areas • Geothermal proposed as possible energy source
EGEE&C PROJECTS	• No projects

6.2.1.14 *Peru*

TOPIC	SUMMARY (PERU)
ECONOMY	• Upper-Middle Income, Upper-Middle GNI • Estimated 3.9% AAGR over outlook period (APERC) • Est. Pop (2040) 38 million
GEOGRAPHY/CLIMATE	• 3 major climate zones: arid, Andes, and equatorial climate in lowlands • Natural resources include minerals and metals • Geographic hazards include earthquakes, volcanos and El Nino weather systems.
EE POLICIES AND REGULATIONS	• RISE average: Poor performer • Yes: Federal level EE planning • Few incentives or mandates • No labeling requirements, No building codes • The General Directorate of Energy Efficiency (DGEE) was created in 2010
BUILDINGS	• Residential expected to grow 69% as incomes rise and biomass for residential fuel is replaced by natural gas and electricity
INDUSTRY	• Gas and Mining represent 70% of industrial GDP
TRANSPORTATION	• The largest share of rising energy demands due to an expected rapid increase in vehicle saturation from 18% (2013) to 84% (2040) from urbanization and rising incomes • 64% of potential IEE scenario savings
OTHER CONSIDERATIONS	• Highly urbanized (76%) with a third of pop in Lima • One of least energy-intensive economies in APEC • Stated energy goals not directly compatible to APEC intensity goal
EGEE&C PROJECTS	• Low/negligible participation rate

6.2.1.15 *The Philippines*

TOPIC	SUMMARY (THE PHILIPPINES)
ECONOMY	• Lower-Middle Income, Lower-Middle GNI • Estimated 6.0% AAGR over outlook period (APERC) • Est. Pop (2040) 142 million • High oil import dependency
GEOGRAPHY/CLIMATE	• Archipelago of over 7,000 island • Tropical: rainforest, savanna, monsoon, and high altitude • Rich in natural resources, biodiversity • Hazards include Monsoons
EE POLICIES AND REGULATIONS	• RISE score: Moderate performer • National targets but lacking national action plan • Efficiency is an explicit strategy for national energy security • No: transportation or industry labeling and standards • Yes: T&D and DSM Mandates • assistance from central government to guide local action is happening in an ad hoc manner
BUILDINGS	• Strong IEE savings over BAU • Slow conversion from rural use of biomass to urban use of LNG. • Low percentage of overall EE savings
INDUSTRY	• Half of sector already relies on renewables

	• EE schemes, labeling and programs have been identified to continue savings • Industrial sectors accounting for 40.7% of future emissions
TRANSPORTATION	• vehicle saturation will grow over 2.5fold its current rate, it will remain low at 24% by 2040 • Does not have, but plans to implement labeling and standards • Transportation accounts for 47.7% of future emissions
OTHER CONSIDERATIONS	• One of the least energy-intensive economies in APEC • Urbanization rates will remain low at 53% • Energy use projected to remain very low. IEE's MToe/capita is 0.35 in 2040. In comparison, US MToe/Capita is projected at 3.62
EGEE&C PROJECTS	• High participation rate, has not proposed any projects

6.2.1.16 *Russia*

TOPIC	SUMMARY (RUSSIA)
ECONOMY	• Upper-Middle Income, Upper-Middle GNI • Estimated 1.4% AAGR over outlook period (APERC) • Est. Pop (2040) 151 million
GEOGRAPHY/CLIMATE	• Largest land mass (1/10 all land) • Large natural resources including fuel • with variety of climate zones including Steppes and Taiga (3/4) • Access to 2 oceans and six seas
EE POLICIES AND REGULATIONS	• Federal level EE planning and targets • RISE score: moderately strong performer • Low use of MEPs and standards • Required mandates for large consumers, public buildings
BUILDINGS	• Driven by cold climate, district heating systems consumed 46% of the sector energy demand in 2013
INDUSTRY	• Energy supplies drive the sector. • Estimated that large EE investments in energy infrastructure needed to grow energy exports
TRANSPORTATION	• Rising incomes are projected to increase vehicle ownership, from saturation of 54% (2013) to 85% in 2040. • Strong share of HDV due to heavy industry and large distances • Expected fuel economy improvements
OTHER CONSIDERATIONS	• One of top five energy users in APEC • Russia will remain self-sufficient for fuel • 70% urbanization rate by 2040
EGEE&C PROJECTS	• Proposed 2 projects, low participation

6.2.1.17 *Singapore*

TOPIC	SUMMARY (SINGAPORE)
ECONOMY	• High Income, High GNI • Estimated 1.4% AAGR over outlook period (APERC) • Est. Pop (2040) 6.2 million
GEOGRAPHY/CLIMATE	• Highly Urbanize Island economy • Tropical climate, high rainfall
EE POLICIES AND REGULATIONS	• No RISE rating • Strong green standards, audits, and other efficiency programs

BUILDINGS	• Over half of IEE savings from this sector, yet only 12% of energy demand
INDUSTRY	• 0% savings estimated in the IEE scenario over BAU
TRANSPORTATION	• The only APEC economy whose transport sector is expected to have a lower energy demand in 2040 than baseline.
OTHER CONSIDERATIONS	• Already one of the lowest energy intensive, low-carbon economies in the world • 95% energy met by LNG • 100% urbanization rate
EGEE&C PROJECTS	• Only 1 proposed project; Strong participation

6.2.1.18 *Chinese Taipei*

TOPIC	SUMMARY (CHINESE TAIPEI)
ECONOMY	• High Income GNI • Estimated 0.9% AAGR over outlook period (APERC) • Est. Pop (2040) 23 million
GEOGRAPHY/CLIMATE	• Tropical and Sub-tropical Climate • Geological hazards include earthquake, typhoon, flooding, landslides
EE POLICIES AND REGULATIONS	• RISE: no rating • Building, transport and Industry standards and labeling
BUILDINGS	• 2%/year efficiency goal with programs for appliances, lighting, and buildings and mandatory labelling
INDUSTRY	• 50% of IEE scenario savings, one of the highest in APEC
TRANSPORTATION	• The islands have extensive mass transit and high speed rail in the 3 largest cities • Motorcycles are 37% of the sector; incentives to increase electric motorcycles and scooter purchases
OTHER CONSIDERATIONS	• Continued use of Nuclear power
EGEE&C PROJECTS	• 8 proposed projects; very strong participation

6.2.1.19 *Thailand*

TOPIC	SUMMARY (THAILAND)
ECONOMY	• Upper Middle Income, Upper-Middle GNI • Estimated 3.5% AAGR over outlook period (APERC) • Est Pop (2040) 73 million
GEOGRAPHY/CLIMATE	• Tropical savannah climate, heavy rains • limited natural energy resources
EE POLICIES AND REGULATIONS	• RISE rating: Moderate performer • 30% energy intensity reduction by 2036 (2005 base)
BUILDINGS	• Large growth in commercial buildings expected. • IEE estimates that strong building energy codes and MPES could save the economy over 50% from BAU.
INDUSTRY	• No labeling systems for industrial motors or equipment, but there are audits • Focus on high growth by government • Energy reduction targets were identified in energy policies and there are ee mandates
TRANSPORTATION	• Nearly half of IEE savings • Low vehicle saturation (37% in 200) to a high of 91% in 2040 • Transit infrastructure to connect smaller urban centers has been prioritized, including rail (freight and passenger).
OTHER CONSIDERATIONS	• Only 66% urbanization rate by 2040 • Low energy resources plus high AAGR makes EE a priority for energy security
EGEE&C PROJECTS	• No proposed projects but very strong participation

6.2.1.20 *United States*

TOPIC	SUMMARY (UNITED STATES)
ECONOMY	• High Income, High GNI • Estimated 1.6% AAGR over outlook period (APERC) • Est. Pop (2040) 383 million
GEOGRAPHY/CLIMATE	• Multiple climate zones • Geological hazards include flooding, earthquakes, drought
EE POLICIES AND REGULATIONS	• Rise score: high performer • Strong state control over Building codes, standards and MEPS
BUILDINGS	• large existing building stock expected to remain in 2040; retrofit and renovation investments are an important priority • Incentives and mandates vary between states, sometimes significantly. Leader in EE across all sectors is California (6th largest economy in the world, if counted separately)
INDUSTRY	• 70% of total sector demand in 2012 (EIA 2010 survey, released in 2012) are in Petrol and Coal products, Chemicals, and Paper
TRANSPORTATION	• High saturation, with only incremental increases • Increasing electric vehicle market share • Sector has highest energy demand,
OTHER CONSIDERATIONS	• Second highest energy consumption coverage by mandatory EE policies • 2nd largest energy consumer and source of EE savings in APEC
EGEE&C PROJECTS	• High participation and proposing rates

6.2.1.21 *Viet Nam*

TOPIC	SUMMARY (VIET NAM)
ECONOMY	• Lower Middle Income, Lowe-Middle GNI • Estimated 5.5% AAGR (APERC) • Est. Pop (2040) 104 million
GEOGRAPHY/CLIMATE	• Tropical Climate • Long coast with forested highlands, Mekong Delta
EE POLICIES AND REGULATIONS	• RISE score: Strong Performer • Missing transportation labeling and fuel standards
BUILDINGS	• A largely rural residential sector that uses biomass for cooking; increased access to electricity
INDUSTRY	• IEE scenario projects no improvements in IEE scenario
TRANSPORTATION	• Vehicle saturation from 5% to 39%; 680% increase but still very low over all • Motorcycles are 26% of the transport sector
OTHER CONSIDERATIONS	• Second lowest urbanization rate at 2040 at 49%
EGEE&C PROJECTS	• No project proposals; moderate participation

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