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Environmental Services in the APEC Region: Definition, Challenges and Opportunities

APEC Group on Services

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Executive summary

The 1994 Bogor Goals commit APEC economies to, among other things, promote the free flow of services trade in the region, at latest by 2020. The APEC Putrajaya Vision 2040, endorsed by APEC Leaders in November 2020, reaffirms that commitment. Although much progress has been made towards achieving those goals, more work needs to be done.[1] Among the unfinished business identified in the latest *Review of APEC's Progress Towards the Bogor Goals* is further work to trade in environmental services (Kuriyama et al., 2020: 56). This report aims to help APEC's Group on Services in their final push to achieve those goals.

It follows on a long list of other studies previously carried out for APEC, most recently under the Environmental Services Action Plan (ESAP), and concurs with the recommendations of those studies, which focused on ways to build capacity for good regulatory practice, and on the capacity-building needs for technicians and workers (APEC Group on Services, 2020; APEC Policy Support Unit, 2016).

A question that could bedevil negotiations to liberalize trade in environmental services is the lack of a clear definition. The W/120 – linked to the 1991 version of the United Nations' Central Product Classification (CPC) – includes just four categories, which soon proved to be out of date. Hence several WTO members have attempted at various times to propose slightly expanded classifications, mainly for the purpose of trade liberalization.

This report takes a wide view of services that could be considered environmental and identifies where they are listed in the most recent version (Version 2.1) of the CPC. Using an approach analogous to that which has been taken to identify environmental goods in the Harmonized Commodity Description and Classification System, or HS, of the World Customs Organization, the report suggests classifications beyond the most specific level (five-digit "subclasses"), indicated by the designated code followed by "ex out". In all, the study identifies over 65 candidate categories of environmental services at the subclass or ex-out level.

What is known about the actual volume and pattern of international trade in environmental services is patchy at best. Services trade statistics are reported at a high level of aggregation wherein environmental services are lumped together with other services. This makes rigorous analysis of the impact of trade policy on trade in such services difficult. With this caveat in mind, one overarching conclusion is that, although trade in environmental services within the APEC region has grown over the last two decades, environmental services remain mainly produced and consumed locally.

Compiling proprietary firm-level data could fill some of the data gap, but such analysis would be limited to studying the impact of policy changes in individual economies. APEC may therefore wish to consider undertaking a more systematic collection of data, for instance through a harmonized survey of all member economies in order to get a better sense of the volume, value and nature of trade in environmental services.

Opportunities for growth in environmental services trade are many. In particular, increasing recognition of the damage being inflicted on the environment is spurring not only the adoption of more stringent government environmental targets and policies, but also pledges by private-sector actors to improve their environmental performance, particularly with respect to greenhouse gas emissions and the re-usability or recyclability of their products. These changes are, in turn, driving an increased demand for high-quality environmental services.

[1] APEC (2020), "APEC Putrajaya Vision 2040", https://www.apec.org/Meeting-Papers/Leaders-Declarations/2020/2020_aelm/Annex-A.

Such growth is likely to have mixed direct implications for female employment in the environmental services sector, a focus of the report. Growth in environmental services can be expected to lead to more technical jobs related to monitoring and analysis. Women account for a small share of employment in environmental services, reflecting a gender bias in technical occupations in society generally. Encouraging girls to train as technicians in construction, installation, repair and maintenance, as well as engineers, would help improve job opportunities for women in a growing environmental services sector. Because of various social pressures and family obligations, women are less likely than men to participate in services provided via movement of natural persons. But, thanks to digitization and automation of many tasks — which has been accelerated by the COVID-19 pandemic — an increasing share of those tasks can be performed remotely, without requiring foreign travel.

Basic environmental services such as water, sewerage and waste collection vastly improve health and labour market participation for women in poor economies where such services are not universal. Regulatory capacity building should go hand in hand with investment, maintenance and liberalization as a matter of high priority in these economies.

To achieve the full potential that environmental services can offer, however, existing trade barriers need to be reduced. This paper shows that this trade continues to be hampered by various non-tariff measures. Regulatory differences are particularly onerous for firms offering environmental services, which tend to be strongly linked to the stringency of environmental policies. Regulatory collaboration and recognition of standards and qualifications, such as the APEC Engineer Register, are helpful and could be deepened and explored for other relevant professions and occupations for which a license or certificate is required.

There is a large potential for growth in cross-border trade in environmental services as the Internet of things becomes ubiquitous and environmental infrastructure, air quality and water quality can be monitored remotely. Reaping the full benefit of the digital transformation requires cross-border "data flows with trust" as well as movement of people to make the necessary interventions in a timely manner.

Based on the extensive analysis in this report, we make the following recommendations:

- Using CPC Ver. 2.1 division 94 as a basis for defining environmental services, extend the coverage to environment-related services classified under divisions outside of division 94, including those that would fall under the 2007 list of categories prepared by the Friends of the Chair of the EGS Group.
- That statistical agencies in APEC economies make a joint effort to collect data on output, expenditure, imports, and exports of environmental services.
- That APEC explores developing STRIs for environmental services for its membership, in collaboration with the OECD.
- Using firm-register data, systematic time use surveys and household budget surveys, undertake rigorous impact assessment of policy on trade and welfare in a gender perspective to facilitate future APEC-wide and individual economy analysis. The surveys should as much as possible be harmonized with the International Classification of Activities for Time-Use Statistics developed by UN Statistics and ILO.
- That APEC economies explore how green public procurement could contribute to sustainable, cost-effective environmental services using technology suitable for local conditions and needs to guarantee universal access.

- That APEC economies make adequate resources available for maintenance of existing environmental infrastructure and explicitly include future maintenance costs in new investment projects, for example, in a resource budget.
- That APEC economies encourage girls at an early age to choose vocational technical or STEM occupations through role models and technical-oriented activities as part of the school curriculum.
- That APEC economies improve facilities at building sites and other relevant work places to accommodate all genders, and strengthen enforcement of work safety and workplace legislation at building sites, with increased focus on discrimination and sexual harassment.
- That APEC economies liberalise market access, particularly in the areas of cross-border dataflows, temporary movement of people and public procurement in environmental services, based on an expanded definition and scope of environmental services (as outlined above in an earlier recommendation).
- That APEC economies strengthen regulatory cooperation, aiming for mutual recognition of standards, regulatory equivalence, and where possible regulatory harmonization.
- That APEC economies ensure that data from sensors monitoring the performance of environmental goods and infrastructure in real time can flow freely across borders subject to protection of privacy and security.
- That APEC economies reform with a view to eliminating fossil fuel subsidies, which artificially reduce incentives to conserve energy and improve energy efficiency and undermine markets for non-fossil alternatives for providing heat or electricity.
- That the APEC Business Travel Card be maintained and improved over time to keep up with technological advances, and is made available to workers travelling to provide maintenance in another member economy who are paid in their home economy.
- That APEC economies consider developing schemes similar to the APEC engineer scheme for other relevant regulated occupations and, in particular, for occupations relevant to environmental services for which certification is required.
- That APEC economies further strengthen capacity building in the area of public procurement for environmental services.

1 Introduction

APEC economies have long recognized the importance of trade in facilitating the diffusion of environmental goods and services, which has the potential to lead to improved environmental outcomes. This agenda has been advanced through initiatives such as "the APEC Environmental Goods and Services Work Program" identified by APEC Leaders as part of APEC's sustainable growth agenda,[2] the Leaders' commitment declared in the Yokohama Vision in 2010[3], and the Leaders' agreement set out in the Annex C of the Honolulu Declaration in 2011.[4]

In 2015, APEC Ministers endorsed an Environmental Services Action Plan (ESAP) to promote liberalization, facilitation, and cooperation in environmental services, aiming for an interim progress review by 2018 and a final review in 2020. That review (Kuriyama et al., 2020), sets out several recommended steps for the next stage of APEC work to support the goal of liberalizing trade in environmental services. These are:

1. Agree upon a definition for environmental services
2. Categorize barriers to trade in environmental services
3. Assess the costs and benefits of liberalization
4. Conduct regional surveys [of key officials in APEC economies]
5. Develop regional capacity-building initiatives; and
6. Produce frameworks for regulatory review

This study mainly addresses the first and second of these tasks, with some recommendations regarding the sixth.[5]

In the following sections, the study examines the relationship between environmental goods and environmental services and identifies complementarities between them. It subsequently considers formal classifications for environmental services, including the most comprehensive classification scheme for services, the United Nations' Central Product Classification, Version 2.1 (United Nations, 2015), before offering a new, updated model list as a suggested basis for discussions of regulatory and other barriers that currently impede trade in environmental services. In order to offer a theoretical underpinning for such an expanded list of environmental services, the study proceeds to discuss the range of tasks that have environmental benefits.

The study then considers the availability of and employment opportunities in environmental services through a gender lens, before identifying and critiquing the available data on current trade in environmental services in the APEC region. The study reveals opportunities for potential future trade in environmental services and identifies barriers to these services' provision and availability. Finally, it makes several key recommendations on how opportunities can be exploited to advance ongoing work

[2] APEC (2009), "2009 Leaders' Declaration", https://www.apec.org/meeting-papers/leaders-declarations/2009/2009_aelm.aspx.

[3] APEC (2010), "The Yokohama Vision – Bogor And Beyond", https://obamawhitehouse.archives.gov/the-press-office/2010/11/13/apec-leaders-declaration-yokohama-vision-bogor-and-beyond.

[4] APEC (2011), "Annex C - Trade and Investment in Environmental Goods and Services", https://www.apec.org/Meeting-Papers/Leaders-Declarations/2011/2011_aelm/2011_aelm_annexC.aspx.

[5] The discussion of a definition is without prejudice to the manner in which commitments are listed in trade agreements. Whether the listing is negative or positive, a definition is helpful for a discussion and possible stand-alone agreement on trade liberalization of environmental goods and services.

on environmental services, including in relation to the definition and scope of environmental services, data, gender, and trade policy, before offering some concluding remarks.

2 The scope and nature of environmental services

Emerging from the COVID-19 pandemic, the world, including the APEC economies, will be confronting two major crises: economic and environmental. According to the IMF (2021: 1), global growth contracted by an estimated 3.5% in 2020. This contraction hit women, youth, the poor, and the informally employed especially hard. Meanwhile, the latest Global Risks Perception Survey of 650 experts (WEF, 2021: 7), conducted by the World Economic Forum, ranked environmental risks such as biodiversity loss, natural resource crises and climate action failure among the top long-term risks facing the world for the second year in a row.

Addressing these two challenges at the same time is the organizing principle behind many governments' plans to "build back sustainably". That involves speeding the transition away from fossil fuels and towards cleaner sources of energy, which in turn will improve air quality (itself a co-morbidity factor in respiratory diseases, including COVID-19); improve sanitation, through both expanding the availability and improving the quality of drinking water and decontaminating wastes; upgrade resilience to natural disasters; and protect vulnerable natural areas, including their flora and fauna.

Implementing such a recovery will invariably necessitate a significant increase in the deployment of environmental goods. But such goods also require their complements, environmental services, in order to be successfully and efficiently employed.

2.1 Complementarity between environmental goods and environmental services

That environmental goods and environmental services are strongly complementary has been recognized for decades and was implicit in paragraph 31(iii) of the November 2001 Ministerial declaration of the World Trade Organization (WTO), which called upon its members to undertake negotiations on "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods *and* services" (emphasis not in the original).[6]

One way to illustrate the links between environmental goods and services is to examine how different types of services are used prior to installing goods at a permanent facility that either is itself or uses an environmental good, such as a piece of equipment for controlling pollution.[7] Various services will be performed often prior to the selection and design of the piece of equipment, during its installation phase, after it is up and running, and finally once it reaches the end of its useful life (Figure 1).

Services may contribute not only to environmental benefits of using the final product, but also to its characteristics such as recyclability over its life cycle. Thus, R&D contributes to sustainable material technology, more energy-efficient production processes, and less waste. The initial product design determines the choice of materials and standards as well as the product durability and repairability as opposed to design for obsolescence. Distribution, marketing, and installation are essential links in the supply chain involving transport and often cross-border movement of people for installing the equipment when it is exported.

Many environmental goods that form parts of installations are delivered with sensors that monitor their performance. Systematic use of data generated from the sensors helps in scheduling maintenance, thereby reducing down-time, and prolonging the lifespan of the product. Data also feeds into R&D and

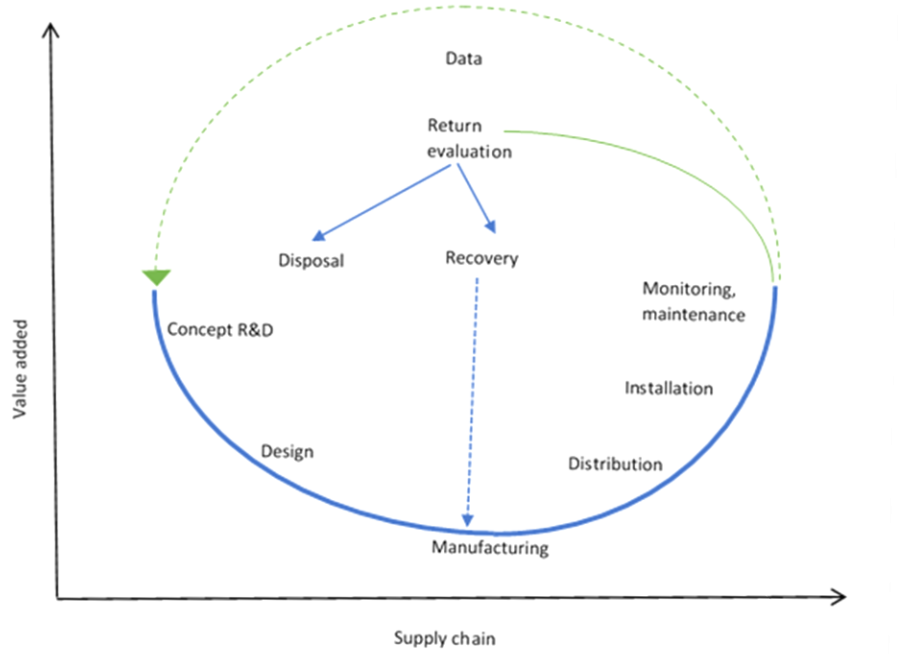
[6] WTO ministerial Delaration adoption 14 November 2001
https://www.wto.org/english/thewto_e/minist_e/min01_e/mindecl_e.htm#top

[7] In a 2013 study carried out on behalf of APEC's Group on Services (Liping et al., 2013), almost 70% of the 883 "environmental- services-related technologies" compiled for the study were found to be in the three categories related to pollution control.

design and contributes to better products in the future — hence the feed-back loop from monitoring to R&D and design.

Finally, reverse logistics refer to all operations related to the reuse of the product or the materials of which it is made. Return evaluation is an important service for sorting products and materials into those that can be recovered and reused and those that need to be disposed of. Recovered material goes back into the manufacturing process, often in products different from the one from which it was recovered.

Figure 1: Linkages between environmental goods and services



The complementarity between environmental goods and services can also be estimated econometrically. For instance, Section 7 finds that on average a 10% increase in exports of machinery and equipment is associated with about 4% increase in maintenance and repair services.[8] An in-depth study of the relationship between goods and services could explore these relationships further using more granular data at the firm level.

2.2 Modes of services provision

Environmental services, like all services, are traded internationally through any of four modes of supply. The WTO has defined those modes according to where and how the service is delivered to the final customer (Table 1). The leading mode — measured by value — for most services, including environmental services, is mode 3.[9] With the advent of the Internet, and ever-more sophisticated digital equipment that is designed to be able to be monitored and controlled remotely, the range and amount of services delivered via mode 1 is expected to grow substantially post-COVID-19.

[8] The gravity model relates bilateral trade flows to market size and trade costs. Exports of machinery and equipment was added as a driver of demand for maintenance and repair. See Table 9 in Section 7 for the details.
[9] See Trade in services data by mode of supply (TISMOS)
https://www.wto.org/english/res_e/statis_e/trade_datasets_e.htm#TISMOS

Table 1: Modes of supply of services traded internationally

Mode	Description	Examples
1	*Cross-border trade:* services that are supplied from the territory of one economy into the territory of another economy.	A user in the importing economy receives services from abroad through its telecommunications or postal infrastructure -- e.g., consulting, engineering drawings, distance training, or remote operation of an instrument or facility.
2	*Consumption abroad:* services supplied in the territory of one economy to the service consumer of another economy.	An individual of the importing economy travel abroad to take part in technical training in how to operate or maintain a piece of equipment, such as a wind turbine.
3	*Commercial presence:* services supplied by a service supplier of one economy, through commercial presence, in the territory of another economy.	The service is provided within the importing economy by a locally established affiliate, subsidiary, or representative office of a foreign-owned and controlled company (environmental laboratory, construction company, site-remediation service, etc.).
4	*Presence of natural persons:* services supplied by a service supplier of one economy, through the presence of natural persons of this economy in the territory of any other economy.	A foreign individual provides a service within the importing economy as an independent supplier (e.g., consultant, specialist) or employee of a service supplier in the exporting economy (e.g., consultancy, construction company, or demolition company) posted to the importing economy as an intra-corporate transferee or a contractual services supplier.

Source: Adapted from https://www.wto.org/english/tratop_e/serv_e/cbt_course_e/c1s3p1_e.htm

Many environmental tasks are one-offs and do not require constant or frequent intervention by service providers. The retrofitting of thermal or acoustic insulation in buildings, the dampening of noise or vibrations, and the cleaning up of a chemical or oil spill are just three of many examples. However, these activities often involve the temporary movement of specialized equipment and persons to the job site.

Some types of environmental services do not involve the sale or leasing of environmental goods but require goods to perform the task itself. Typical at one end of this spectrum are services connected with environmental assessments, or the occasional measuring of air pollutants, effluents, or the ambient environment. The service providers will temporarily import measuring devices or instruments, but those will not normally be left with the firm or government purchasing the service.

At the other end of the spectrum are companies with a commercial presence in the importing economy that require specialized equipment but sell only their services. Companies that service or empty septic tanks, or that collect and process hazardous waste, would be examples in this category.

3 Defining environmental services

What qualifies as an environmental service has been defined both formally and informally over the last three decades. A common reference for defining environmental services generically derives from a definition of the "environmental goods and services industry" developed by the joint OECD and Eurostat Informal Working Group three decades ago (OECD/Eurostat, 1999: 9). Narrowing the scope to just services, that definition can be restated as follows:

> Environmental services embrace activities that measure, study, prevent, limit, minimise or correct environmental damage to water, air, soil, or ecosystems more broadly, including the management of problems related to waste or noise. They include the design, installation, operation, maintenance and, where applicable, recycling or decommissioning of technologies or products that reduce environmental risk and minimise pollution and resource use.

Not answered in this definition is: what exactly is "the environment" in this context? For the most part, the word has two connotations: the *natural* environment, and the *indoor* environment.[10] The *natural* environment pertains to the external world in which humans live and carry out productive activities. The interactions are two-way: humans affect the natural environment through hunting and gathering; through their physical displacement of earth and water (for example, in connection with quarrying, mining, grading, plowing, channelling, or daming), and pollution. The natural environment, in turn, acts on humans and their structures through the forces of wind, water, heat and cold, biology, and seismic activity.

The *indoor* environment refers to those confined spaces, in which the circulation of air, the provision of water, the regulation of temperature, the exclusion of unwanted biota, and protection from the brute forces of nature (and anthropogenic pollution arising from within the space) is controlled largely by humans.

Over time, expert discussions in APEC, the OECD, the WTO and other fora have converged on defining environmental services. Generally, they are those services that can be separately identified as: measuring the state of the environment, whether outdoors or indoors; predicting, measuring, preventing, limiting, minimising, or correcting damage caused to the natural environment by human activity; or predicting, measuring, preventing, limiting, minimising, or correcting damage from natural forces — especially of the extreme kind — to humans, their structures, or parts of the natural environment they want to protect.

The practice of the private sector also is suggestive of what services are considered to be "environmental". For example, the combined N-EXPO (New Environmental Exposition) and GWPE (Global Warming Prevention Exhibition), held annually in Tokyo, the largest trade fair for the environmental industry in Asia, includes among its exhibitors those involved in[11]:

- waste collection, recycling, or disposal; organic waste processing; demolition;
- hazardous waste treatment;
- production of bioplastic packaging;

[10] This similar division was suggested earlier by Liping et al. (2013: 7) as a possible framework for classifying environmental services, except that services related to the natural environment were further divided into "outdoor environmental services" and "global environmental services". The latter relates particularly to emissions of greenhouse gases.

[11] See, for example, the list at https://www.nippo.co.jp/eng/n-expo019/ne19_g.htm

- water treatment and purification;
- soil remediation;
- environmental measurement and analysis;
- electric power production from alternative or renewable energy; energy saving;
- noise and vibration countermeasures; measurement and analyses related to noise and odour regulations;
- civil engineering; construction;
- countermeasures against intense heat and other natural disasters.

What does not seem to be considered specifically environmental, however, are activities that may help mitigate environmental damage but that are performed by companies or individuals as part of a broader set of tasks. Thus, the installation of thermal insulation or energy-efficient windows in the walls of a new building that a construction company is erecting in its entirety is not counted as an "environmental service". It is only the retrofitting of better insulation to a building that seems to be regarded as such. Similarly, the routine installation of street gutters and storm sewers by a company building a city street is not seen as an environmental service, though the subsequent installation of structures or facilities to treat the stormwater might be.

3.1 Formal classifications of environmental services

3.1.1 CPC prov., the WTO's Sectoral Classification List, and others

Formal classifications of environmental services can be traced back to the first, "provisional" version of the United Nations Central Product Classification (hereinafter the "CPC prov.") – adopted in 1989 and published in 1991 – which identified seven classes (and subclasses) of environmental services:

94010: Sewage services

94020: Refuse disposal services

94030: Sanitation services

94040: Cleaning of exhaust gases

94050: Noise abatement services

95060: Nature and landscape protection services

95090: Other environmental protection services n.e.c.[12]

This classification system then became the basis for the WTO's Sectoral Classification List (MTN.GNS/W/120, 10 July 1991, hereinafter "W/120"), which foreshortened the list of environmental services for its purposes to just four sub-sectors in Section 6:

6.A.: Sewage services (CPC prov. 9401)

6.B.: Refuse disposal services (CPC prov. 9402)

6.C.: Sanitation services (CPC prov. 9403)

6.D.: Other

[12] The abbreviation "n.e.c." stands for "not elsewhere classified".

The "Other" category has generally been interpreted as comprising the remaining elements of the CPC's environmental services category at the time, namely the Cleaning of exhaust gases (CPC prov. 9404), Noise abatement services (CPC prov. 9405), Nature and landscape protection services (CPC prov. 9406) and Other environmental protection services n.e.c. (CPC prov. 9409).

A few years later, the joint OECD and Eurostat Informal Working Group, which was formed to define the "environmental goods and services industry" for the purposes of data collection, identified three broad groups, with six products or services categories listed under the pollution management group (OECD/Eurostat, 1999: 10):

Pollution management group

Air pollution control

Wastewater management

Solid waste management

Remediation and clean-up of soil and water

Noise and vibration abatement

Monitoring, analysis, assessment

Cleaner technologies and products group

Resource-management group

Since the beginning of the WTO discussions on advancing negotiations to achieve a higher level of market opening, as mandated in Article XIX of the General Agreement on Trade in Services (GATS), which began in 2000 under the original mandate contained in the GATS and became part of the Doha Round at the 2001 Doha Ministerial Conference[13], several WTO members have complained that the W/120 classification scheme has not kept up with new developments in the market and have proposed modifying it, or adopting other schemes.

Two of the earliest of these proposals came from the European Union, on 22 December 2000 (WTO, 2000a), and Switzerland, in May 2001(WTO, 2001a). The EU's and Switzerland's proposed restructuring of the sector would create seven categories based on the environmental media targeted by the service (air, water, soil, waste, noise, etc.), given that many services providers tend to specialize along these lines (Table 2). The changes would introduce new headings and subheadings, but remain defined by reference to the CPC prov.

Several APEC economies also weighed in on this issue during 2000 and 2001. In its initial negotiating proposal on environmental services, Australia expressed support for broadening the current classification and endorsed in principle the approach that had been proposed by the EU (WTO, 2001b). Canada (WTO, 2001c) and the United States (WTO, 2000b) leaned more towards liberalizing the activities contained in the core list of environmental services as they had been defined in W/120. Some non-APEC economies, such as Colombia, considered it would be useful to establish a model list incorporating new services not already included in W/120 (WTO, 2001d).

As the WTO Secretariat has explained on numerous occasions, WTO members are not obliged to make reference to either the W/120 or the CPC prov. when making specific commitments on services. Nevertheless, in its most recent communication on the status of discussions on trade in environmental services (WTO, 2010), the Secretariat noted that:

[13] Negotiations of specific commitments take place in the Special Session of the Council for Trade in Services.

Most Members have listed their commitments according to W/120 structure and headings, with references to corresponding CPC definitions. However, a few Members have used W/120, but have not included CPC definitions; and, in some cases, alternative definitions have been provided. Some Members have opted for minimal descriptions: (i) one Members simply refers to "CPC: 9401, 9403"; (ii) another Member has listed commitments on "CPC 940", without further specifications; (iii) one schedule contains a mere reference to "Environmental Services", and (iv) another one to "[s]ub-sectors A-D".

Table 2: Comparison of the EU's and Swiss initial proposal to the WTO for amending the W120 classification of environmental services

CPC prov.	**EU proposal of 22 Dec. 2000**	**Swiss proposal of May 2001**
Sewage services *CPC 9401*	Water for human use & wastewater management *Part of CPC 18000 & CPC 9401*	Wastewater management
Refuse disposal services *CPC 9402*	Solid/hazardous waste management *CPC 9402 & 9403*	Waste management
Sanitation services *CPC 9403*		
Cleaning services of exhaust gases *CPC 9404*	Protection of ambient air and climate *CPC 9404*	Protection of ambient air and climate
Noise abatement services *CPC 9405*	Noise and vibration abatement *CPC 9405*	Noise and vibration abatement
Nature and landscape protection services *CPC 9406*	Remediation and cleanup of soil & water *Part of CPC 9406*	Remediation and cleanup of soil and water
	Protection of biodiversity and landscape *Part of CPC 9406*	Protection of biodiversity and landscape
Other environmental services n.e.c. *CPC 9409*	Other environmental and ancillary services *CPC 9409*	Other environmental and ancillary services

Source: WTO (2010)

In parallel with the WTO multilateral negotiations on environmental services, negotiations to identify an agreed list of environmental goods were taking place in the WTO's Committee on Trade and Environment — Special Session (CTE-SS). Although the focus of these negotiations was on goods, they were intended to complement those taking place on services, particularly as many require the construction or installation of facilities using those goods, or trained people to operate them. Thus, the scope of those and subsequent trade negotiations relating to environmental goods provide insight into what areas of environmental abatement, protection and monitoring various economies consider "environmental".

In a non-paper submitted to the CTE-SS in April 2007, six APEC economies (Canada, Japan, Korea, New Zealand, Chinese Taipei, and the United States), along with the European Communities, Norway, and Switzerland — the self-styled Friends of the Chair of the EGS Group — proposed twelve categories under which environmental goods could be classified:

1. Air pollution control
2. Management of solid and hazardous waste and recycling systems

3. Clean up or remediation of soil and water
4. Renewable energy plants
5. Heat and energy management
6. Waste water management and potable water treatment
7. Environmentally preferable products, based on end use or disposal characteristics
8. Cleaner or more resource efficient technologies and products
9. Natural risk management
10. Natural resources protection
11. Noise and vibration abatement
12. Environmental monitoring, analysis and assessment equipment

A notable new category without antecedent was that of environmentally preferable products, or EPPs. These are products "that are widely recognized to have lower environmental impacts than like products with a similar function" (USTR, 2016: 23). Examples often cited are circle hooks and turtle-excluder devices, both of which help to prevent bycatch in the fishing industry. It is a relatively contentious category because what qualifies as environmentally preferable can be a moving target, especially as technologies change. It is also arguably less directly related to services, as many EPPs are simply sold to final consumers and do not require associated services. However, some EPPs, like bicycles or electric vehicles (environmentally preferable technologies to gasoline- or diesel-powered motorbikes or automobiles), can involve on-going services, such as those associated with the operation of bicycle or vehicle-sharing services.

The 2007 list, in turn, served as the basis for a very similar, albeit shorter, list used for classifying the 54 product categories slated for tariff reductions agreed to by APEC Leaders in 2012, listed here in the same order as in the 2007 proposal:

- Air pollution control
- Management of solid and hazardous waste and recycling systems
- Renewable energy production
- Waste water management and potable water treatment
- Environmentally preferable products
- Natural risk management
- Environmental monitoring analysis and assessment equipment

When, in 2014, a group of 17 WTO members launched negotiations to forge a plurilateral Environmental Goods Agreement (EGA), they built upon the OECD-Eurostat and 2007 categorization, consolidated down to nine categories:

- Air pollution control
- Cleaner and renewable energy
- Energy efficiency
- Environmental monitoring, analysis and assessment

- Environmental remediation and clean-up
- Environmentally preferable products
- Noise and vibration abatement
- Solid and hazardous waste management
- Wastewater management and water treatment

Notably missing from the EGA categorization are "Natural risk management" and "Natural resources protection". These exclusions may simply reflect the small number of goods used for these activities that can be considered uniquely or predominantly "environmental". The categories certainly have specific meaning when considering services, by contrast.

Finally, regional, and bilateral free-trade agreements (FTAs) have also in a few cases addressed environmental services. Both the negatively listed Korea-Australia FTA (KAFTA) and the United States-Mexico-Canada Agreement (USMCA), for example, call on parties to strive to liberalize trade in environmental services (and goods). Neither of the agreements seeks to establish an exact scope of the environmental services sector (APEC Group on Services, 2020: 12).

3.1.2 CPC Version 2.1

The Central Product Classification, which informed the WTO's Sectoral Classification List, has itself been revised several times since the CPC prov. was first published. The latest version, Ver. 2.1, was released in 2015 (United Nations, 2015). Like Version 2.0, it provides much more specificity at the subclass (five-digit) level in Division 94 ("Sewage and waste collection, treatment and disposal and other environmental protection services"), but still focuses mainly on the collection, treatment, or disposal of liquid or solid wastes, with a few subheadings for remediation services (Appendix 1).

One of the most significant changes between previous versions of the CPC and Versions 2.0 and 2.1 has been the disappearance of the three sub-sectors "cleaning services of exhaust gases", "noise abatement services" and "nature and landscape protection services". CPC Ver 2.1 seems to have subsumed the first two under "other environmental services n.e.c." (94900). Inexplicably, the Explanatory Notes for that subclass specify that among the services it covers are those connected with monitoring, controlling and damage assessment associated with acidifying deposition (i.e., acid rain), but not noise-abatement services, except in a catch-all category "other environmental protection services not elsewhere classified". Services associated with nature and landscape protection are now dispersed among several other Divisions, including 83, 95, and 96.

3.2 Towards a more comprehensive listing of environmental services

As underscored by the Final Review of APEC's Environmental Services Action Plan (ESAP), its Phase 1-1 study examined environmental services covered by Division 94 of CPC Version 2.1 and concluded that its current coverage could usefully be amended to include a more detailed set of environmental services, as well as complementary services that affect the ability of businesses to deliver environmental services in foreign markets. Such a wider definition "would facilitate more complete understanding of the relevant regulatory measures in place" (CTI, 2020: 3).

For the purpose of advancing APEC understanding existing barriers to trade in environmental services, and working towards greater market openness for them, this paper proposes using CPC Ver. 2.1 as a base but defining environmental services to include many other services normally classified under divisions outside of division 94, inspired by the 2007 list prepared by the Friends of the Chair of the

EGS Group. The foregoing discussion found that the scope of environmental services is broad, hence it follows that, when considering what barriers may exist to trade in environmental services, regulators or trade negotiators they work from a list that is also comprehensive.

Appendix 3 provides a possible list of services, identified by their five-digit subclass code in CPC 2.1, compiled by the authors. The additional subclasses of services more than double the 28 that are enumerated in division 94. Several subclasses, such as General construction services of sewage and water treatment plants (54253), are directly ancillary to services listed under division 94. Others, such as General construction services of power plants (54262) and Engineering services for power projects (83324), are clearly necessary for the diffusion of power plants based on renewable energy, but not specific to them at the subclass level. Accordingly, the environmentally relevant services within these broad subclasses are specified within brackets and the five-digit class code is followed by "ex", analogous to the use of "ex outs" when identifying environmental goods beyond the subheading (i.e., six-digit) level of the Harmonized Commodity Description and Coding System (HS).

Other services, such as several of those classified under Financial and related services (Div. 71) and Legal and accounting services (Div. 82), are certainly used in connection with environmental projects, particularly those that require a commercial presence in the importing economy. But distinguishing strictly legal or financial services of an "environmental" nature from those that are not would be impractical, and hence they are not included in the list. Leaving them out of the definition of environmental services is also consistent with the criterion of relativity posited by Sauvage and Timiliotis (2017: 19), who argue that performance of such services has only a small bearing on how the core service itself is carried out.

The right-hand column in the table in Appendix 3 matches each service with one or more categories of environmental goods and services (of a total of 12 broad categories). These categories are similar to those developed by the Friends of the Chair of the EGS Group, except that the terms from the EGA negotiations have been used in place of "Renewable energy plant" and "Heat and energy management", and "waste water management" has been separated from "water treatment". Water treatment in this case relates to the treatment of water from either a natural waterbody (aquifer, lake, river, or sea) — whether freshwater, brackish water, or saltwater — to a higher standard, whether for industrial use or drinking quality.

An additional category, "Protection of biodiversity and landscape", has also been added. This category harkens back to "Nature and landscape protection" in CPC prov., which was defined in the Explanatory Notes (United Nations, 1991) as follows:

> Ecological system protection services, e.g., of lakes, coastlines and coastal waters, dryland, etc., including their respective fauna, flora, and habitats. Services consisting in studies of the interrelationship between environment and climate (e.g., greenhouse effect), including natural disaster assessment and abatement services. Landscape protection services not elsewhere classified.

For the purposes of this paper, services covered under the "Protection of biodiversity and landscape" category include those covered by the first and third sentences in the above definition. Those mentioned in the first half of the second sentence are covered by 949 (Other environmental services), per WTO (2010); those relating to natural disaster assessment and abatement services are covered by the collective category "Natural risk management".

These categories have been created without prejudice to any possible decisions within APEC about liberalizing trade in particular services, environmental or otherwise.

3.3 Exploring the range of environmental services

It is important to acknowledge that the boundaries between the categories of environmental services used in Appendix 3 overlap in a number of cases, and this is clearly demonstrated in the table itself. For ease of analysis, we explore below the range of services that could be considered "environmental" within the following, slightly amended categories:

- The collection or analysis of environmental data.
- The extraction or treatment of water for agricultural, human, or industrial use.
- The control and avoidance of air pollution and of greenhouse gases.
- The control of liquid industrial effluents.
- The collection and treatment of human sewage.
- The collection, processing, and disposal of solid waste.
- The clean-up and remediation of damage to the natural environment.
- The provision of a healthy indoor environment for people, including in workplaces.
- The protection of people and property from natural disasters.
- The management of natural areas.

These categories, which underpin the list in Appendix 3, are not mutually exclusive in terms of their effects on the environment. For example, services that improve the thermal insulation of buildings not only help reduce the extremes of cold or heat for people working indoors, but at the same time can reduce noise in the building, and also reduce energy use, which in turn may reduce emissions of air pollution and greenhouse gases. Similarly, services involved with the collection and processing of solid waste may have knock-on effects on natural areas, by reducing waste that washes up on, for example, protected beaches. The following section explains the types of services carried out in each category.

3.3.1 The collection or analysis of environmental data

Data collection and analysis forms an integral part of most stages of an environmental service, from the planning to the decommissioning stage and afterwards. In some cases, such tasks are carried out by a service provider as part of a broader set of tasks, but in others specialists in monitoring and data analysis are engaged to carry out sub-tasks. These tasks are usually performed by technicians trained as chemists, biologists, geologists, hydrologists, oceanographers, or atmospheric scientists.

Tasks relating to pollution from ongoing industrial facilities, such as steam-generating power plants, steel plants, sewage-treatment plants, or incinerators, typically require first studying the affected environs, and pollution streams. Monitoring the performance of equipment is also an important task during the operational phase of a pollution-control or waste-treatment facility. Some of that task may be undertaken by the workers at the plant, but increasingly such sensors are connected to the Internet and monitored remotely (mode 1) by specialists who are trained in being able to identify patterns that indicate likely problems ahead. Many small biomass digesters installed on farms across Europe rely on such service providers to monitor those facilities from afar, for example (Steenblik and Geloso Grosso, 2011). Finally, at the end of the useful life of a facility, additional site remediation, especially of contaminated soil, may be necessary, which also necessitates monitoring.

A related group of services are those performed on the monitoring and analytical instruments themselves. These include the periodic calibration of instruments to specified standards, and the

upgrading or refurbishment of instruments. Provision of these services involve all modes. For example, some monitoring instruments that are connected via the Internet can be checked and recalibrated remotely (mode 1). Others may be shipped across borders for calibration or refurbishment (mode 2), or a foreign affiliate may provide the service (mode 3), or personnel may cross borders and perform the calibration at the monitoring site (mode 4).

3.3.2 The extraction, treatment, and management of water for agricultural, human, or industrial use

Services related to the provision of fresh water, as opposed to the treatment of polluted water, have not always been included in discussions of environmental services, perhaps because of political sensitivities related to who owns or controls access to something as vital to human survival as water, and the dominance of local and regional governments in this activity.

Yet this exclusion of piped water provision, and services related to it, has overlooked many services that supply water privately — unconnected to municipal water systems — such as to institutions, isolated rural communities, and to industries that require water of a higher quality than is available from their local municipal water system.

Services provided in this area include analytical services of a geologic or hydrologic nature, as well as chemical analysis of the water source, prior to the laying of pipelines or well-drilling. In some cases, service providers operate the treatment plants themselves; in others, companies providing the equipment do the initial installation but then train locals in how to operate the equipment.[14]

In addition, over the last decade, there has been an emergence of companies that work with municipal water systems to detect, analyse, and recommend interventions in response to network events and incidents such as leaks, bursts, faulty assets, telemetry and data issues, and operational failures. Such services have helped reduce water loss by as much as 30%, improved the reliability of potable water supply, and saved municipal water systems millions of dollars a year (see, for example, TaKaDu, 2020). The value-add of these companies is the expert insights they bring to the management of water systems; the ownership and management of the systems is still retained by the municipalities.

3.3.3 The control and avoidance of ambient air pollution and greenhouse gas emissions

The technical means to reduce or avoid ambient air pollution and the build-up of greenhouse gas concentrations in the atmosphere overlap to some extent but differ in many ways that are relevant to the types of services that are needed to accomplish the two objectives. Pollution released to the ambient (outdoor) air generally relates to atmospheric contaminants such as particulate matter, oxides of sulphur (SO_X) and of nitrogen (NO_X), ground-level ozone (O_3), carbon monoxide (CO), and a myriad of other, more exotic, pollutants, such as benzene, formaldehyde, polycyclic aromatic hydrocarbons, and volatilized mercury. Greenhouse gases refer particularly to carbon dioxide (CO_2) and methane (CH_4), but also nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

3.3.3.1 Air pollution and greenhouse gas emissions from stationary sources

Most environmental services relating to emissions of air pollutants are performed in connection with large stationary sources, namely electric power plants and energy-intensive manufacturing plants, such

[14] See, for example, the case study on Yamaha Motor Co., Ltd., at http://www.unido.or.jp/en/technology_db/1674/.

as those processing metallic ores or refining petroleum or natural gas. Generally, the higher the level of abatement, the more complex and sophisticated the control technology employed.

Soot or dust, for example can be removed with a cyclone dust collector, or separator, which is basically a mechanical device with few moving parts, is relatively straightforward to install and operate, and is used extensively by small- and medium-sized enterprises. High-efficiency particulate air (HEPA) filters are also commonly used, separately or in combination with cyclones, at small facilities. In order to treat gas streams that involve greater volumes, or attain higher levels of particulate removal, particularly of very small particulates, devices such as fabric filters (also known as baghouses) or electrostatic precipitators are commonly used, which are much more complex, both to install and to operate. Assuring optimal design and operation is particularly necessary when particulate-control equipment is used in tandem with equipment used to remove sulphur oxides from flue-gas streams.

Flue-gas cleaning of particulates and sulphur oxides does not necessarily render that matter harmless, but only concentrates it in another form (liquid solution, solid paste, or powder), which then requires another environmental service: the management of solid or hazardous wastes. The ultimate fate of particles removed from dust filters depends on the nature of the particles. Some are sent to landfills, some incorporated into asphalt, and yet others incorporated into aggregates, like concrete. Sulphur oxides removed via flue-gas desulphurization units are usually further processed, especially if it is high in mercury (a common contaminant of coal and municipal solid waste) and must be disposed of safely and securely.[15]

Reducing greenhouse-gas emissions from existing stationary sources of emissions is still a developing science. Traditionally, the easiest way to reduce air pollutants has been to switch the plants to burning cleaner fuels, such as natural gas, or to improve the thermal efficiency of a plant, either of which usually results in lower CO_2 emissions. For example, compared with a super-critical coal-fired power plant (the most thermally efficient and cleanest coal-fired power plant design), an F-class heavy-duty combined-cycle natural gas turbine (HDGT) power plant emits less than half the NO_X and CO_2 per megawatt-hour, and almost no SO_X (Gonzalez-Salazar et al., 2018: 1506).

To reduce emissions from existing, fossil-fuel or biomass-fired plants even further, however, researchers have been experimenting with technologies for stripping CO_2 emissions from the flue gas, and then either using the captured CO_2 or storing it in some form, such as in underground geological strata. Looking ahead, it is likely that if these so-called carbon capture and storage or sequestration (CCS) technologies prove to be technically reliable and affordable, service providers specializing in CCS will emerge to design, install, and operate such systems.

Methane (CH_3) is a powerful greenhouse gas that is 25 times more potent than CO_2 in terms of its global warming potential over 100 years, and 84 times more potent than CO_2 over 20 years.[16] Human activities account for around 60% of methane emissions to the atmosphere, dominated by emissions associated with fossil fuels, livestock, and municipal solid waste (Figure 2).

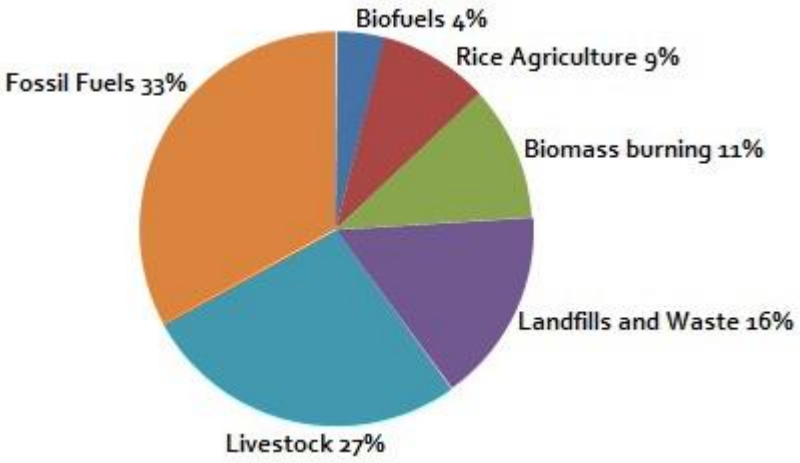
Tighter management of methane emissions is increasingly being required of operators of oil wells, natural-gas infrastructure (wells, storage facilities, and transmission and distribution pipelines), underground coal mines, and landfills. Such management involves services to quickly identify and repair leaks or establish systems for collecting and processing (or flaring) the methane, as well as measure the ambient air around such facilities. Control of methane from agriculture is less advanced,

[15] Limestone-based flue-gas desulphurization units can produce a synthetic gypsum that can be used to manufacture drywall or other industrial products.

[16] United Nations Economic Commission for Europe, https://unece.org/challenge.

except where the anaerobic digestion of manure and crop waste is economically viable. Companies have emerged in recent years that offer a full spectrum of turnkey services, including remote monitoring, that enable livestock farmers to turn such biomass into so-called "bio-gas", which may be used on-farm or sold as fuel (Steenblik and Geloso Grosso, 2011; Jain, 2019).

Figure 2: Shares of main sources of anthropogenic methane emissions globally



Note: No date is given for these data, but they likely refer to the situation around the year 2015.

Source: United Nations Economic Commission for Europe (https://unece.org/challenge).

The main way that both air pollutants and CO_2 emissions from combustion are likely to be reduced or eliminated (at least those from large emitting plants themselves) is through the replacement of fossil fuels with electricity generated from renewable energy harvested from sunlight, geological heat, the power of falling water, or the motion of waves, tides, or the wind — collectively known as "renewables".

A wide gamut of services are involved when building renewable-energy power plants, starting with site evaluation, design, and installation, through operation and maintenance, and ultimately decommissioning. Some of the service providers are vendors of the equipment themselves, or large energy companies (including state-owned electric utilities). But many independent firms have emerged that specialize in developing plants (as "parks" or "farms" in the case of solar arrays or wind turbines) of a particular technology. The expansion of such facilities has taken off particularly rapidly in economies that allow independent power plants to sell electricity to the electric grid.

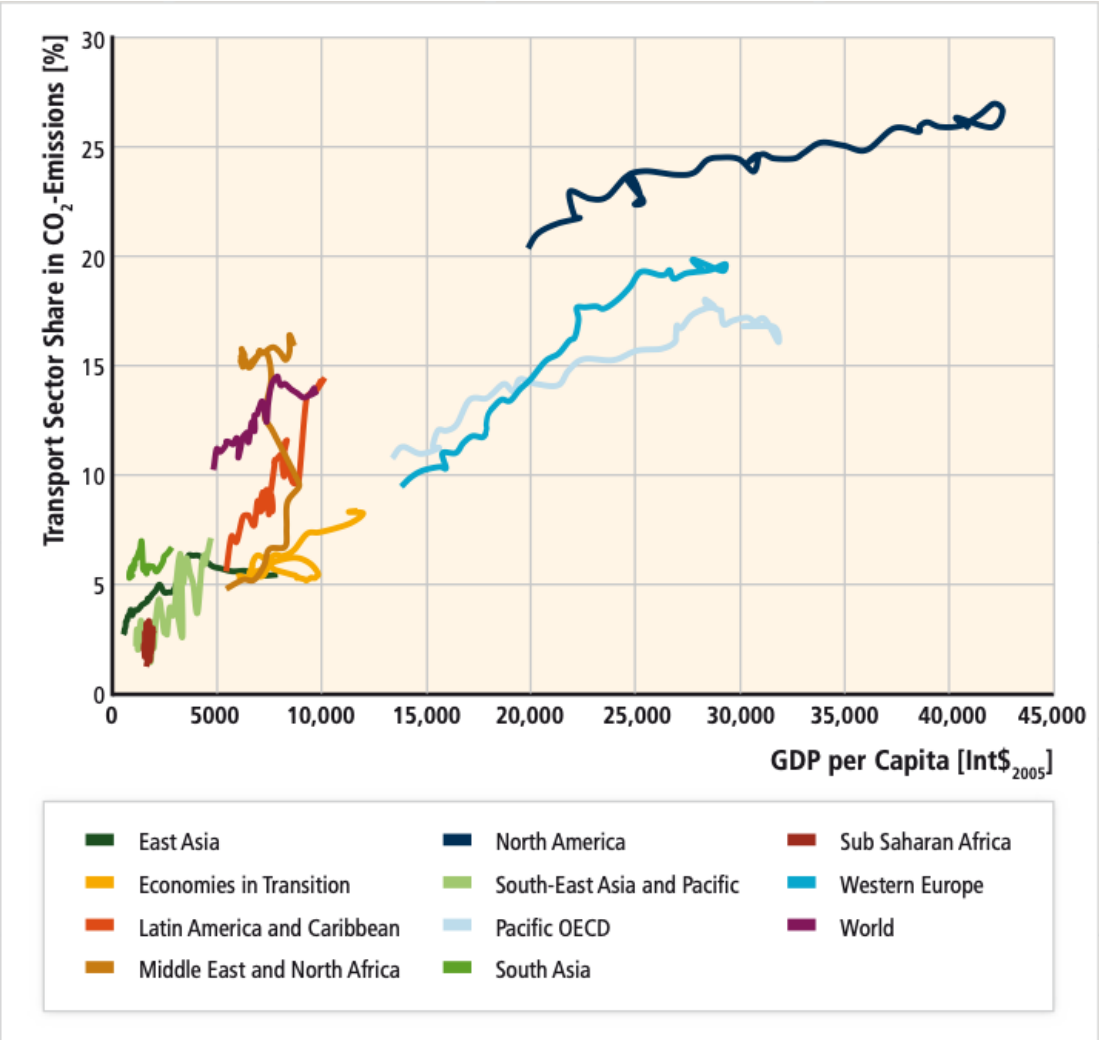
3.3.3.2 Air pollution from mobile sources

Mobile sources of air pollution powered by internal combustion engines (or ICE) vehicles — motorized scooters and cycles, passenger cars and vans, trucks, buses and coaches, and diesel-electric locomotives — account for a significant and growing share of urban air pollution in most economies of the world, especially so-called local pollutants such as particulate matter (PM2.5 and PM10), nitrogen oxides (NO_X) and, in some economies, sulphur oxides (SO_X). In coastal areas, maritime traffic contributes additional pollutant loading.

In many economies, the combustion of fossil fuels in transport is the second-largest contributor to greenhouse gas emissions, after electric-power generation (Figure 3). Within the APEC region, that share had already exceeded 25% by 2010 in North America and ranged between 15% and 20% in Pacific OECD (i.e., Australia, Japan, Korea, and New Zealand). In most other APEC economies, it ranges between 5% and 15%.

Environmental services relating to transport are generally of three kinds: the monitoring of ambient air quality, particularly in urban settings; the measurement of tailpipe emissions from vehicles, ships and aircraft; and rental services for electrified transport alternatives.

Figure 3: The relative share of total greenhouse gas emissions for transport relative to GDP per capita from 1970-2010, by world region



Source: Insert to Figure 8.3 in Sims et al. (2014: 608).

There is, of course, a large overlap between the type of ambient air-quality monitoring carried out in the neighbourhoods of large point sources and air-quality monitoring undertaken to measure air pollutants mainly emanating from mobile sources. Some of the target pollutants may differ. In addition to pollutants associated with any combustion process (NO_X, SO_X, and total suspended particulates), monitoring stations targeting transport-related pollutants will frequently measure ambient concentrations of carbon monoxide (CO) and ozone (O_3). Such data are used to build a long-term understanding of the locality's air quality, as an aid to planning, and to determine whether it is in compliance with domestic air quality standards.

The backbone of ambient air-quality monitoring in large cities are so-called reference stations, which make highly accurate measurements of air samples every 30 to 60 minutes. Because they are large and costly, however, most cities can only afford limited numbers of them. Los Angeles, for example, a conurbation of some 18 million people, has only around 40 such stations in place (Aeroqual, n.d.).

To deal with the limitations of widely dispersed reference stations, a growing number of cities are "filling in the gaps" between those stations by installing smaller measurement devices that are calibrated with, and cross-reference, the reference stations. Such devices can also help guide the siting of reference stations and be moved around to study particular problem spots.

Another type of service that could be deemed environmental involves the renting of cleaner transport alternatives, such as bike-share systems. Bike-share systems, as exist in many large cities of the world, comprise the shared bicycles themselves, in some cases with docking stations with a telemetrically connected interactive terminal, and a control centre. Fleets of vans are also needed to maintain and repair the bicycles and redistribute them among the stations. Similar infrastructure is involved in the case of shared rental systems for electric scooters and electric automobiles.

3.3.4 The control of liquid industrial effluents

The treatment of liquid waste from industrial plants varies widely and hence so do the means for treating them. Effluents from small factories, if relatively innocuous, are often discharged directly into municipal sewage systems. If they include high concentrations of organic chemicals or heavy metals, those waste streams will often receive pre-treatment prior to being discharged (Abou-Elela et al., 2008). The services provided to such companies will typically involve a review of the plant's operations, perhaps to reduce some of the waste via a change in the production process, and a recommendation on a suitable technology, such as an anaerobic digester or trickling filter, for treating the waste.

Larger industrial plants usually require bigger and more bespoke treatment plants, and many outsource the operations of those plants to a company specialized in industrial water treatment, in return for some assurance that the plant will meet whatever regulations on effluents apply to it (MarketsandMarkets, 2019). When factories are grouped together in an industrial park, effluents are often provided privately by centralized facilities, which offer opportunities for sharing the infrastructure (UNIDO, 2019). The market research firm, MarketsandMarkets (2019), describes a broad spectrum of services provided by such service providers:

> These types of services include, but are not limited to, laboratory testing, facility troubleshooting, routine maintenance, parameters monitoring, statistical process control, and report generation. The smooth functioning of unit operations, such as separation, floatation, settling, filtration, neutralization, absorption, adsorption, ion exchange, and chlorination, is ensured through proper monitoring.

3.3.5 The provision of a healthy indoor environment for people, including in workplaces

This category joins two types of services that have been singled out in various classification schemes for environmental services over time. It does not cover all services that promote a healthy environment for people in their homes and workplaces, but it does relate to two of the most important ones: temperature and noise level.

3.3.5.1 Noise and vibration abatement

The surveying and abatement of noise and vibration are two of the oldest services provided to industrial clients. The two are grouped together, because noise is often a consequence of the vibration of machinery, and vibrations themselves are a common source of noise. But they can contribute to many other problems. As described by Wright (2010):

> Unchecked machine vibration can accelerate rates of wear (i.e., reduce bearing life) and damage equipment. Vibrating machinery can create noise, cause safety problems and lead to degradation in plant working conditions. Vibration can cause machinery to consume excessive power and may damage product quality. In the worst cases, vibration can damage equipment so severely as to knock it out of service and halt plant production.

Whether the problem is noise or vibration at an industrial site, the first step in dealing with the problem is a site visit and inspection, to identify the root cause of the problem. Typically, an engineer or other expert will use a portable decibel meter or vibration sensor or will install sensors on or near the equipment to obtain a read out over a period of time. A recommendation for how to reduce or eliminate the noise or vibration will then be developed on the basis of these data.

Specialists in noise and vibration abatement are also employed increasingly by road departments in order to reduce traffic noise, and sometimes vibration. Similar portable equipment is installed, followed by an analysis and recommendation. In the case of traffic, noise reduction can range from changing the road surface to erecting acoustic screens or sound barriers.[17]

3.3.5.2 The improvement of energy efficiency

One of the fastest-growing services in the field of energy are businesses that design or implement energy-saving projects in buildings or industries. A particular type of energy efficiency service provider (ESP) is an energy service company, or ESCO, which usually shares some of the responsibility, and some of the benefits, of the project. ESPs include both privately and government-owned firms, and even non-profit organizations.

Energy-efficiency improvements fall broadly into two classes: passive and dynamic. Passive improvements typically involve installing or injecting thermal insulation within or onto walls and ceiling or roof spaces and installing insulated doors or thermo-pane windows. Dynamic improvements relate to heating equipment or machinery, such as pumps. When thermal insulation or thermo-pane windows are installed in new buildings, the services usually form part of "General construction services of buildings" (CPC Ver. 2.1, Group 541). Sometimes, however, owners of buildings will engage an ESP to retrofit the insulation, windows, or both, plus various controls. Perhaps one of the most prominent examples of that is the deep retrofit of the 81-year-old Empire State Building in New York City, energy savings from which have been estimated at USD 4.4 million in annually (Cole, 2012).

The APEC Policy Support Unit (2017) has identified seven business models for ESPs, ranging from simple consulting to full-service ESCO (Figure 4). In general, with increasing level of engagement and equipment ownership, the responsibility of the ESP and its level of risk increases. Also, the shares of different modes of the services change, from modes 1 or 4 (technical consultant) to mode 3 (plus perhaps others) in the case of higher-level services.

Owners of office buildings are important clients for ESPs. But so, too, are governments, many of whom have set targets for improving the energy performances of their offices. Governments are also major owners of low-income housing stock in many economies. As the APEC Policy Support Unit (2017: 17) points out, contracting with ESPs under a model in which the companies are paid for their services through savings can be an attractive, low-risk proposition for government agencies that are cash-strapped.

[17] See Isolation Technology Services, "Road traffic noise reducing device", at https://www.its-acoustique.fr/en/acoustical-insulation-soundproofing/road-traffic-noise-reducing.html.

Figure 4: Business models for energy-efficient services

Source: Adapted from APEC Policy Support Unit (2017: 5), based on World Bank (2010) and MP Ensystems & IIEC (2017).

3.3.6 The protection of people, property, and ecosystems from the consequences of natural disasters

Natural disasters — major adverse events resulting from natural processes such as tornadoes, typhoons and other storms (which in turn cause wind damage, landslides, or flooding), droughts, volcanic eruptions, earthquakes, tsunamis and other geologic processes — have long afflicted humankind. But they have grown in importance in recent decades due to ever more people and property being placed in harm's way. Climate change itself is considered to have increased both the frequency and severity of storms and, through changes in rainfall patterns and maximum summer temperatures, the susceptibility of some areas to wildfires. Moreover, by causing sea levels to rise, the potential for damage to coastal regions from storms and tsunamis has increased.[18]

Not only people and property have been afflicted by natural disasters, droughts, forest fires and increases in ocean temperatures; so have natural ecosystems. A local rise in ocean temperatures in seawater temperatures of just 1–2°C, for example, if sustained over several weeks, can lead to the bleaching of corals, as they expel the symbiotic algae living within their tissues. If the situation persists over a prolonged period, the corals eventually die (Heron et al., 2017).

Natural disasters — particularly those of a geologic origin — cannot normally be prevented by humans, but their damage can be mitigated to some extent, through a well-planned and comprehensive program. A major study published three decades ago by the U.S. National Committee for the Decade for Natural

[18] For a mapping of every peer-reviewed extreme-weather attribution study published through March 2020 (over 300), see https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world.

Disaster Reduction (National Research Council, 1991: 1-2), reads as relevant today as it did then; only the technologies available have changed since then:

> [This] decade presents an opportunity to reassess the approach to natural hazards and to develop strategies for reducing losses by stressing prevention and preparedness while sustaining and enhancing essential disaster response, relief, and recovery capabilities. The Committee proposes a multidisciplinary program that integrates the following elements: hazard and risk assessments; awareness and education; mitigation; preparedness for emergency response, recovery, and reconstruction; prediction and warning; strategies for learning from disasters; and international cooperation. These seven elements must be developed in unison so that, collectively, they can provide a framework for hazard reduction over the next 10 years and beyond.

A first step in preparing for natural disasters is to undertake a thorough hazard and risk assessment. As defined by the Committee (National Research Council, 1991: 1), such assessments "combine information on natural hazards with information on human activity to determine vulnerability to natural disasters."

Monitoring of the environment, typically with electronic instruments, is critical during several of the aforementioned steps. The information thereby gathered informs the hazard and risk assessments themselves. It also enables predictions and early warnings that allow people more time to take action to reduce their vulnerability to suffering harm. And it can provide important input into the planning of new constructions or the upgrading of existing protective infrastructure.

Effective monitoring to mitigate the adverse effects of natural disasters starts with biological, chemical, topographical, hydrological, meteorological or seismic studies, both to inform decisions as to the design of the monitoring network, and the nature of the actions that would need to take place in response to an imminent disaster. So designed, the next steps involve installing sensors and other monitoring devices at designated locations and connecting them to some central command. Thereafter, somebody has to monitor the incoming information, and periodically calibrate, repair and, if need be, replace the equipment.

The kinds of protective structures that are built to protect people, their property, and the environment from the ravages of natural disasters are as diverse as the natural disasters themselves. Protecting buildings from wind, rain and earthquake damage generally means following local building codes at the time the building is constructed. Many special structures to make a multi-story building more resistant to damage from earthquakes — such as vibration isolators installed in the building's foundation, diaphragms, moment-resisting frames, and pendulum dampers — are installed during the building's construction. Others, such as vibrational control devices attached to the exterior of buildings, are often retrofitted.

Protecting populations from flooding, by contrast, tends to concentrate on large structures that channel or block floodwaters. These range from simple earthen levees or dams, to seawalls, to complicated, multi-billion-dollar constructions, such as the systems of movable barriers that protect the Dutch Province of Zuid Holland, and Venice, Italy's lagoon, from sea-water surges.

To a large extent, these kinds of tasks are the responsibility of governments, but very often are provided under contract by private service providers.

3.3.7 The collection and treatment of sewage

Dealing with wastewater has been a challenge for communities since humans first gathered in permanent settlements. Today, human wastes from flush toilets and drains are typically collected in small septic systems[19], or channelled via a system of pipes and pumps to treatment facilities. Smaller amounts of waste end up in chemical toilets, such as the portable toilets used at construction sites, and the toilets used on passenger coaches, trains, ferries, and aircraft. In some coastal cities in the APEC region, raw sewage is simply discharged directly to the ocean, untreated.

Septic (holding) tanks and their drain fields are usually installed at the time of constructing a building. The main tasks after they are put into use is to periodically pump out sludge from the holding tank ("emptying and cleaning"). Occasionally, if a problem occurs, a diagnosis may need to be performed to determine whether, for example, too much grease is entering the septic system, there is a build-up of sulfites, or the tank or drainfield has been invaded by tree roots. An appropriate intervention often follows.

The excrement and other waste material contained in or removed from a septic tank or chemical toilet ("septage") must itself then be treated. In some cases, it is transported by specialized tanker trucks to a waste treatment plant and combined with the sewage piped in from a municipal sewer system. In other cases, independent, for-profit companies treat the septage, often using cesspools, which rely on chemical or biological processes to break down the effluent. In yet other cases the solids are filtered out and dumped in an approved landfill, or sold to farmers as fertilizer.

The treatment of piped sewage can vary from simple primary treatment, which mainly removes material that will either float or readily settle out by gravity, to sophisticated tertiary treatment that results in water that meets drinking-water standards. In *primary* treatment, the raw sewage is first screened to remove large debris, which is then sent to a landfill. That stage is followed by the gravity removal of sand and similar solids ("grit"). A large part of the remaining suspended solids ("sludge") is removed from the wastewater in the final stage by sedimentation tanks, also called primary clarifiers.

Secondary treatment removes nutrients (namely phosphate and nitrogen), and soluble and suspended solids, through bacterial decomposition of these wastewater constituents. *Tertiary* treatment of effluent from secondary treatment is provided generally when high levels of pollution reduction are required. Modern tertiary processes can remove more than 99% of all the impurities from sewage, producing an effluent that is almost to drinking-water standards, but they are very expensive (Ambulkar and Nathanson, 2020).

Finally, all the sludge that emanates from any of these three stages also has to undergo additional processing before it is disposed of, both to reduce its volume and to stabilize the organic materials entrained therein.

3.3.8 The collection and processing of solid waste

Modern societies generate mountains of waste each year, much of it connected with packaging. Collecting and processing that waste has accordingly developed over time into a massive industry, of various degrees of sophistication, particularly to treat wastes that are potentially hazardous to humans or the natural environment, and to separate other wastes into its recoverable or recyclable, as well as its non-recyclable, components.

[19] According to the American Groundwater Trust, about one-third of all homes in the United States use on-site wastewater treatment systems, namely septic systems. Source: https://agwt.org/content/septic-systems.

The main distinction at the front end of the business -- waste collection, consolidation and storage -- is between hazardous and non-hazardous materials. Hazardous wastes are the by-products of industries that process or use heavy metals, toxic organic chemicals, radioactive materials, or biohazards from laboratories and medical facilities. Such waste streams require more careful and secure handling than does non-hazardous waste, also often referred to as municipal solid waste -- i.e., what is discarded by households, offices, and retail shops. Some waste streams involve mixes of hazardous and non-hazardous waste, and often involve specialized collectors and processors. These include ones that break down or dismantle ships, junked automobiles and trucks, or electronic waste.

The task of collecting waste and transferring it to a central location for temporary storage, typically involves trucks and small rubbish bins for non-hazardous wastes, or transfer facilities to which clients transport and dispose of their waste. Hazardous waste is more often collected by specialized vehicles directly from the waste source. Once brought to the consolidation point, non-hazardous waste is separated into recyclable and non-recyclable materials for further processing.

The treatment of *hazardous materials* involves reducing, eliminating, or rendering harmless the waste. These treatments can involve biological, chemical, or physical processes, or incineration, ending with two streams: recyclable material and disposable residuals.

Solid waste that is not able to be recycled, because of its intrinsic properties, or is too expensive to recycle, typically ends up being incinerated or disposed of in a sanitary or other landfill.

The preparation and consolidation of non-hazardous *recyclable materials* usually involves some combination of cleaning, sorting, volume reduction and bailing, at or prior to transportation to an appropriate facility that processes recyclable materials. The technologies and processes for taking sorted waste and transforming it back into a material that is similar to a virgin material, or into something of lower quality or reduced functionality but still commercially valuable (also called "downcycling"), vary widely. Technologies for recycling glass, paper and cardboard, and scrap or waste metals, are the simplest. Those that recycle electronic waste, batteries, and plastics require much more specialized and sophisticated equipment.

Generally, the treatment of solid waste requires a commercial presence. However, as pointed out by the WTO (2010: n31), some waste itself crosses borders — i.e., is sent abroad for treatment. In such cases, it points out, economies that import waste are exporters of waste-treatment services, via mode 2, and the exporters of waste for treatment in another economy importers of that service.

A growing category of waste management is communal composting. Composting — the decomposition of organic materials such as vegetable scraps into simpler organic and inorganic compounds by the activity of microorganisms or earthworms — is a practice as old as farming. The collection and composting of household organic waste in an organized way is a relatively recent phenomenon, by comparison. The companies that offer these services are generally small and local but growing in number. The web site Compostnow.org, for example, lists almost 170 such services in Canada and the United States alone.[20] It is not inconceivable that larger companies will emerge to offer these kinds of services, through commercial presence, in multiple APEC economies in the future.

3.3.9 The remediation of human damage to the natural environment

Natural disasters are not the only cause of environmental damage. Human activities also take their toll, through the deposit or disposal — inadvertent or otherwise — of toxic substances on the soil or into

[20] See CompostNow, "Compost Pickup Services", https://compostnow.org/compost-services/ .

waterways, and through other activities that end up degrading these environmental media, such as mining.

Over the last several decades, scientists and civil engineers have sought to remedy such damage, through various means. Examples include:

- Removing or neutralizing substances, such as heavy metals or persistent organic chemicals from soil or lake sediments.
- Containing and cleansing soil or water bodies of spilled petroleum.
- Restoring vegetation on land disturbed by open-cast mining.
- Stabilizing eroded slopes

The border between natural-disaster protection and recovery and the remediation of human damage to the environment is not always distinct. For one, damage caused by a natural phenomenon, such as a typhoon, can precipitate an industrial accident — for example, causing an oil tanker to flounder and leak its cargo. Also, many of the types of services used to detect a natural disaster, or to treat its consequences, have parallels in each category of remediation.

3.3.9.1 Soil and groundwater remediation

Soil remediation is frequently undertaken to clean up or isolate chemical or heavy-metal contamination that has accumulated over many years. Several techniques are currently in use (Table 3). Some remediation techniques require excavating the soil prior to treatment; others are done in situ. When the contamination has been caused by a leaky underground storage tank, it usually has to be dug out and disposed of. Normally, prior to the commencement of any work, a feasibility study is undertaken to identify the boundaries and nature of the contamination, and to prescribe the most appropriate treatment.

Similar techniques are used for treating contaminated groundwater.

Table 3: Common forms of soil remediation techniques

Type of remediation	**Target contaminant(s)**	**Treatment**	**Required equipment**
Bioremediation with bacteria	Hydrocarbons	Aerobic and anaerobic bacteria specifically engineered for the target contaminant(s) are injected directly into the soil, consuming and thereby breaking down the hydrocarbons.	Bacteria injectors
Bioremediation using fungi (myco-remediation)	Polycyclic aromatic hydrocarbons (PAH), heavy mineral oil hydrocarbons (C10-C40) and other toxic xenobiotics	Excavated soil is augmented with specially selected fungi, which break down the contaminants.	Soil excavators; chemical monitoring equipment
Thermal soil remediation	Hydrocarbon compounds such as petroleum products	The soil is extracted and subjected to a high temperature, volatizing the contaminants, which are then captured and cooled.	Oven; conveyor belt
Air sparging	Toxic gases or vapors	Large volumes of pressurized air or oxygen are injected directly into the soil or groundwater, removing volatile organic compounds.	Pressurized air injectors

Type of remediation	Target contaminant(s)	Treatment	Required equipment
Encapsulation	Reserved for the most difficult-to-remove contaminants.	The soil is encapsulated by a mix of lime, cement and concrete.	Lime, cement, concrete mixer

Sources: Based on information at Spokane Environmental Solutions, LLC (https://www.spokaneenvironmental.com/soil-remediation-types-technies/) and Novobiom (https://www.novobiom.com).

3.3.9.2 Oil-spill prevention, containment, clean-up and recovery

The global market (goods and services) for oil-spill management has been estimated by one market-research report to have been worth USD 150 billion in 2019 (ReportsandData, 2021). Pre-spill oil management usually involves installation of protection-management technologies such as blow-out preventers on oil wells, pipeline leak detection devices, or double-hulls on oil tankers. Experts then carry out regular check-ups and strict monitoring of the oil facilities or conveyances, to avoid heavy losses in the event of a leak or spill.

Once a spill has occurred, multiple techniques are typically applied, appropriate to the scale of the spill, extant weather conditions, and the turbulence of the waterbody into which the oil is spilled. Deployment of containment booms is often the first step. These are flexible floating or semi-submerged booms that are set out from boats in order to surround the surface oil and keep it from spreading. Oleophilic and hydrophobic sorbents – insoluble materials or mixtures of materials – may be applied to the spilled oil to also slow its spreading and keep it from descending into deeper layers of water, thus enabling it to be recovered more readily.

Skimmers are then used to suck up the oil, delivering it to temporary storage tanks for separation from the water and transport and treatment elsewhere. Modern skimmers are self-propelled and can be controlled remotely, either from a ship or from the shore.

Whereas pre-spill oil management does not necessarily require a commercial presence, because of the need to be able to respond rapidly, especially in the case of a large spill, post-spill oil interventions are usually provided by a company based locally, or in a nearby economy.

3.3.10 The management of protected natural areas

The management of natural areas perhaps differs more than any other of the environmental tasks mentioned above. The International Union for Conservation of Nature (IUCN) uses the term "protected area", which it defines as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" and classifies them within six categories; see Box 1 (Dudley, 2008: 8). It further classifies protected areas in terms of four categories of governance. At least two of them allow for management by private entities, either government-delegated management (for example, to an NGO) under behalf of the government owner ("Governance by government"), or by non-profit organisations (NGOs, universities, cooperatives) on behalf of for-profit organizations for a private owner ("Private governance").

Whichever type of protected area and governance structure is involved, the term management "assumes some active steps to conserve the natural (and possibly other) values for which the protected area was

established" (Dudley, 2008: 8).[21] It typically entails a mix of activities such as policing (particularly against poaching); the monitoring of biological, hydrological or geo-physical parameters; veterinary interventions; the maintenance of access trails and roads, and of buildings; and reporting on these activities and the state of the protected area to its owner(s). The permanent presence of at least some equipment, tools, and people is required.

The IUCN classification system clearly extends to marine protected areas, such as marine reserves, marine sanctuaries, marine parks, and locally managed marine areas. Although the basic nature of the services employed in the management of such areas have counterparts with services used in the management of land-based protected areas, the skills and equipment used can differ considerably.[22]

Box 1. The IUCN's classification of protected areas

Ia *Strict nature reserve:* Strictly protected for biodiversity and also possibly geological or geomorphological features, where human visitation, use and impacts are controlled and limited to ensure protection of the conservation values.

Ib *Wilderness area:* Usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, protected and managed to preserve their natural condition.

II *National park:* Large natural or near-natural areas protecting large-scale ecological processes with characteristic species and ecosystems, which also have environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.

III *Natural monument or feature:* Areas set aside to protect a specific natural monument, which can be a landform, sea mount, marine cavern, geological feature such as a cave, or a living feature such as an ancient grove.

IV *Habitat or species management area:* Areas to protect particular species or habitats, where management reflects this priority. Many will need regular, active interventions to meet the needs of particular species or habitats, but this is not a requirement of the category.

V *Protected landscape or seascape:* Where the interaction of people and nature over time has produced a distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

VI *Protected areas with sustainable use of natural resources:* Areas which conserve ecosystems, together with associated cultural values and traditional natural resource management systems. Generally large, mainly in a natural condition, with a proportion under sustainable natural resource management and where low-level non-industrial natural resource use compatible with nature conservation is seen as one of the main aims.

Source: Dudley (2008: ii).

[21] In some cases, as Dudley (2008: 8) points out, "management" can involve simply leaving the area untouched if that is determined to be the best conservation strategy.

[22] An example of a privately managed marine protection area is the Anambas archipelago, an area of 255 islands located between Singapore and Indonesia, which is managed by the Bawah Anambas Foundation. See Baker (2020).

3.3.11 Summary

The foregoing exposition on the scope and nature of environmental services shows that they involve a multitude of tasks, from those that involve the application of scientific expertise, such as the chemical analysis of water or wastes or flue gases, to the design and construction of simple or small structures, to the operation of some of the most sophisticated material-processing plants in existence. Meanwhile, thanks to the ever-increasing processing power of computers, and instruments and control devices connected to them, the range of services that can be provided digitally, across borders, continues to expand. Nonetheless, clearly some presence of natural persons will always be required. And commercial presence is still likely to be necessary for delivering services that involve heavy equipment.

The discussion also underscores that developments in policies and technologies are constantly shaping and reshaping the market for environmental services, and the ways that they are traded. This permanent evolution suggests the necessity for any efforts to liberalize trade in environmental services, and to keep those markets open, to be flexible and responsive to change. That has implications for how environmental services are formally classified.

4 The gender dimension of environmental services

Water, sewage and sanitation are indispensable for health and wellbeing. Where universal access to such services is not guaranteed, the burden of housework, typically carried by women, can be heavy and time consuming. In addition, inadequate quality of services in these areas is associated with infectious diseases (Montgomery and Elimelech, 2007). This section first relates access to basic environmental services to women's health, education and labour force participation, before studying the job opportunities for women in the environmental services sector.

Simple regressions using the World Bank database on gender dimensions show that access to sanitation, measured as a share of households practicing open defecation, is associated with significantly higher maternal mortality rates as well as below five mortality rates. Water on premises is also associated with lower maternal and children under five mortality rates. Furthermore, water on premises is associated with a greater lower-secondary school enrolment rate and the association is slightly stronger for girls.

Table 4 shows simple regressions relating health and education variables to water and sanitation. All regressions control for GDP per capita, which is an important determinant of health and education (as well as water and sanitation). The regressions do not imply causality but illustrate a strong correlation between water and sanitation on the one hand and health and education outcomes on the other. These could be further analysed in depth to assess gender aspects of improved access to water and sanitation in the developing members of APEC.

Table 4: Relationship between environmental services and gender-related outcomes

Indicator	Coefficient	Stand. Dev.	N	R2
Maternal mortality rate				
Open defecation	9.36	0.29	4000	0.43
Water on premises	-6.84	0.51	181	0.52
Mortality rate under 5, female				
Open defecation	1.43	0.04	4132	0.52
Water on premises	-0.95	0.08	265	0.44
Mortality rate under 5, male				
Open defecation	1.56	0.04	4132	0.52
Water on premises	-1.05	0.09	265	0.46
Secondary school gross enrolment rate, female				
Water on premises	0.51	0.06	165	0.66
Secondary school gross enrolment rate, male				
Water on premises	0.45	0.06	165	0.64

Note: Water on premises refers to the percentage of households that have water on premises. Open defecation represents that share of households without access to sewage. The regressions are run using OLS with robust standard errors. All regressions include GDP per capita as a control variable.

There is strong evidence that maintenance is at least as important as investment for access to improved water and sanitation in developing economies. For instance, Gibson and Rioja (2017) find that an additional dollar spent on maintenance improves welfare and equality more than a dollar spent on investment in several Latin American economies. However, investment in infrastructure in developing economies is often financed through concessionary loans, while maintenance is typically financed by tax revenue and user fees at the municipality level. When competing for scarce local resources, maintenance does not always secure sufficient resources.

Lack of maintenance has been a major reason for deteriorating quality of services in many developing economies, including among APEC members. Incorporating maintenance into investment plans as well as pricing schedules is essential for ensuring that environmental infrastructure is kept in good repair. Considering local conditions when choosing technology also helps. Finally, open markets and APEC collaboration on technical standards, where relevant, would support these local efforts and make the best solutions available at lower costs.

Further analysis of the gender aspect of environmental services could be undertaken using time use surveys.[23] Most economies conduct such surveys at more or less regular intervals. The surveys gather information on time use by gender, household characteristics and individual characteristics, and catalogue time spent in paid and unpaid work such as housework, education, leisure, and rest. The United Nations Statistical Commission has adopted the International Classification of Activities for Time-Use Statistics. It is consistent with the System of National Accounts and with the International Conference of Labour Statisticians framework for statistics of work. Matched to local data on access to water, sanitation and waste collection, rigorous analysis of the relationship between the quality and quantity of environmental services and labour force participation, domestic work and education by gender could then be done.

On the supply side, environmental services offer employment opportunities for women. The International Labour Organization (ILO) compiles information from its member economies' labour force surveys on employment by gender and sector at a two-digit ISIC rev 4 level. While the average share of women in total APEC employment was 43% in 2019, the share in environmental services is much smaller, as indicated in Table 5. Among the APEC economies covered in the database, the Philippines had the lowest female share of employment in environmental services (12%), while Thailand has the highest share (22%).

The World Bank's gender disaggregated database offers additional information on employment by gender and skills. It covers all the APEC economies, but information is limited to the year 2014 at a relatively aggregate sector classification. We notice that the female share of employment is quite small in construction (Figure 5). However, relatively more women than men working in the sector are skilled. In Russia, for instance, 71% of the women employed in construction are skilled, compared with 38% for men. Thus, women are more likely than men to work in white-collar occupations, such as engineers, architects, and administrative staff in the construction sector.

Furthermore, the skills premium (the ratio of skilled wages to unskilled wages) is higher for women than for men in most APEC economies, with the notable exceptions of the North American economies and to a lesser extent China and Russia (Figure 6). This suggests that women are relatively more likely to work in the highest skill categories, such as engineering and architecture, in this sector.

[23] United Nations Economic Commission for Europe, "Time Use Surveys", at https://unece.org/statistics/video/time-use-surveys.

Table 5: Female share of employment, APEC average, maximum and minimum

Sector code	Sector name	APEC average	APEC min	economy min	APEX max	economy max
C33	Repair, installation	11.0%	2.0%	PHL	25.9%	USA
E36	Water	22.3%	10.6%	PER	50.8%	BD
E37	Sewerage	20.3%	12.2%	VN	39.7%	THA
E38	Waste collection	32.1%	12.6%	PHL	62.1%	VN
E39	Remediation	20.5%	12.7%	USA	45.6%	VN
F41	Building construction	7.5%	1.4%	PHL	18.7%	BD
F42	Civil engineering	11.0%	2.8%	PHL	21.7%	THA
F43	Specialized construction	5.7%	1.1%	PE	15.9%	BD
M71	Architecture, engineering, technical testing	28.4%	14.7%	PE	40.8%	MEX

Note: Averages, min and max are calculated on data for the period 2012-2019. APEC economies included in the ILO database on employment by 2-digit sector and gender are Brunei Darussalam (BD); Indonesia (INA); Mexico (MEX); Peru (PE); the Philippines (PHL); Thailand (THA); the United States (USA); and Viet Nam (VN).

Source: ILO.

Figure 5: Employment by gender and skills, construction, 2014

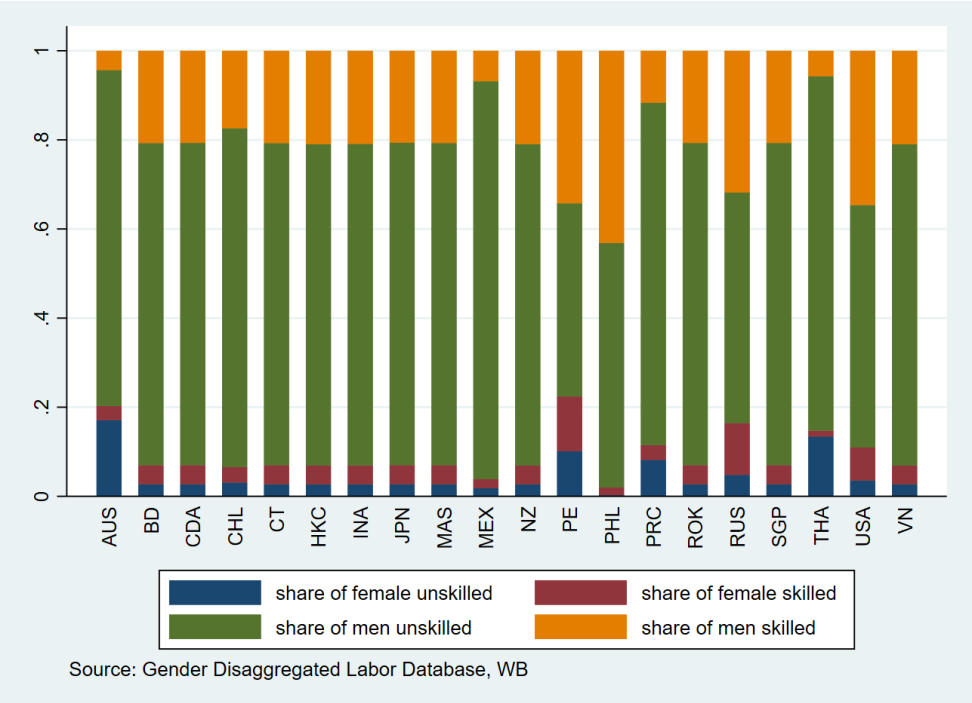


Figure 6: Skill premium by gender, construction, 2014

The data show that environmental services have a strong gender bias in employment. Those sectors depend more than average on movement of natural persons for trade (see next section). Given existing gender biases, and the fact that women are typically less mobile due to domestic responsibilities such as childcare and care for elderly family members, trade in environmental services is not likely to generate a lot of new job opportunities for women unless underlying biases are dealt with.

Academic studies have found that gender differences in abilities and interest in science, technology, engineering and mathematics (STEM) subjects are mutable and influenced by family, teachers, culture and role models from early childhood onwards. These influences are complex, intertwined and deeply embedded in society, and can be fully addressed only through multifaceted policies and campaigns by governments, businesses and other stakeholders. Robust analysis identifying concrete policy measures or programs with documented long-term effects are few and far between.

Girls and women are discouraged from choosing courses, occupation and workplaces where there are few other women (Kahn and Ginther, 2017). Thus, reaching a critical mass of female students and employees could attract more girls and women to the STEM occupations going forward. In this regard, individual schools, colleges and workplaces could set examples that could be used in campaigns.

The low share of women in construction is also attributed to work safety, jobsite sanitation and outright discrimination and harassment (Regis et al., 2019). Strengthening the enforcement of safety and workplace legislation could thus lower the barriers for women to enter the construction sector.

The most skills-intensive environment-related services sectors — architecture, engineering, and technical testing — are somewhat less, but still substantially gender biased.[24] Such services are

[24] ILO statistics on employment by gender and occupation confirms that the higher-skilled occupations are less gender biased. Thus, the average female share of employment in ISCO08 category 21 (Science and Engineering Professionals) was 27% during the period 2008-2018, compared with 17% for category 31 (Science and Engineering Associate Professionals). Source: Authors' calculations based on ILO.

increasingly being traded over electronic networks, a trend expected to accelerate into the future. The digital transformation of these services leads to greater flexibility and more opportunities for teleworking both within and across borders. Female engineers and technicians may benefit from this more than men, given the aforementioned existing gender biases in domestic responsibilities. Trade liberalization in skills-intensive digitized environmental services may thus boost jobs for women. However, if exclusive rights to offer professional services extend to online provision, the potential gains for female employment may not materialize. It is therefore important that liberalization of environmental services within APEC goes together with strengthened mutual recognition of qualifications, such as the APEC Engineer accreditation.

5 Trade in environmental services: key statistics

A descriptive analysis of trade in environmental services requires piecing together information from multiple sources. Furthermore, providing a consistent and coherent comparison across economies and sectors is hampered by the fact that different sources cover different sets of economies, different time periods and different levels of aggregation. Finally, it is not possible to match trade data to the sector and product classification discussed in section 3. With these caveats in mind this section paints a broad picture of trade in environmental services and identifies the gaps in the statistics that need to be filled for a more accurate and rigorous analysis of the relationship between trade and trade policy in environmental services.

Starting with trade intensity, environmental services are mainly produced locally for local consumption. Estimates using the World Input Output Database (WIOD) shows that in most economies the export share of gross output is less than one percent. WIOD covers ten APEC economies (Australia, Canada, China, Indonesia, Japan, Korea, Mexico, Russia, Chinese Taipei and USA) and five sectors that include environmental services (Repair and installation of machinery and equipment; Water collection, treatment and supply; Sewerage, waste collection, treatment and disposal activities, materials recovery, remediation activities and other waste management services; Construction; and Other professional, scientific and technical activities and veterinary activities). The export share of gross output ranks between close to zero and 65%, with the lowest shares in construction, water, and sewerage, and the highest in other professional, scientific, and technical activities, followed by repair and installation.

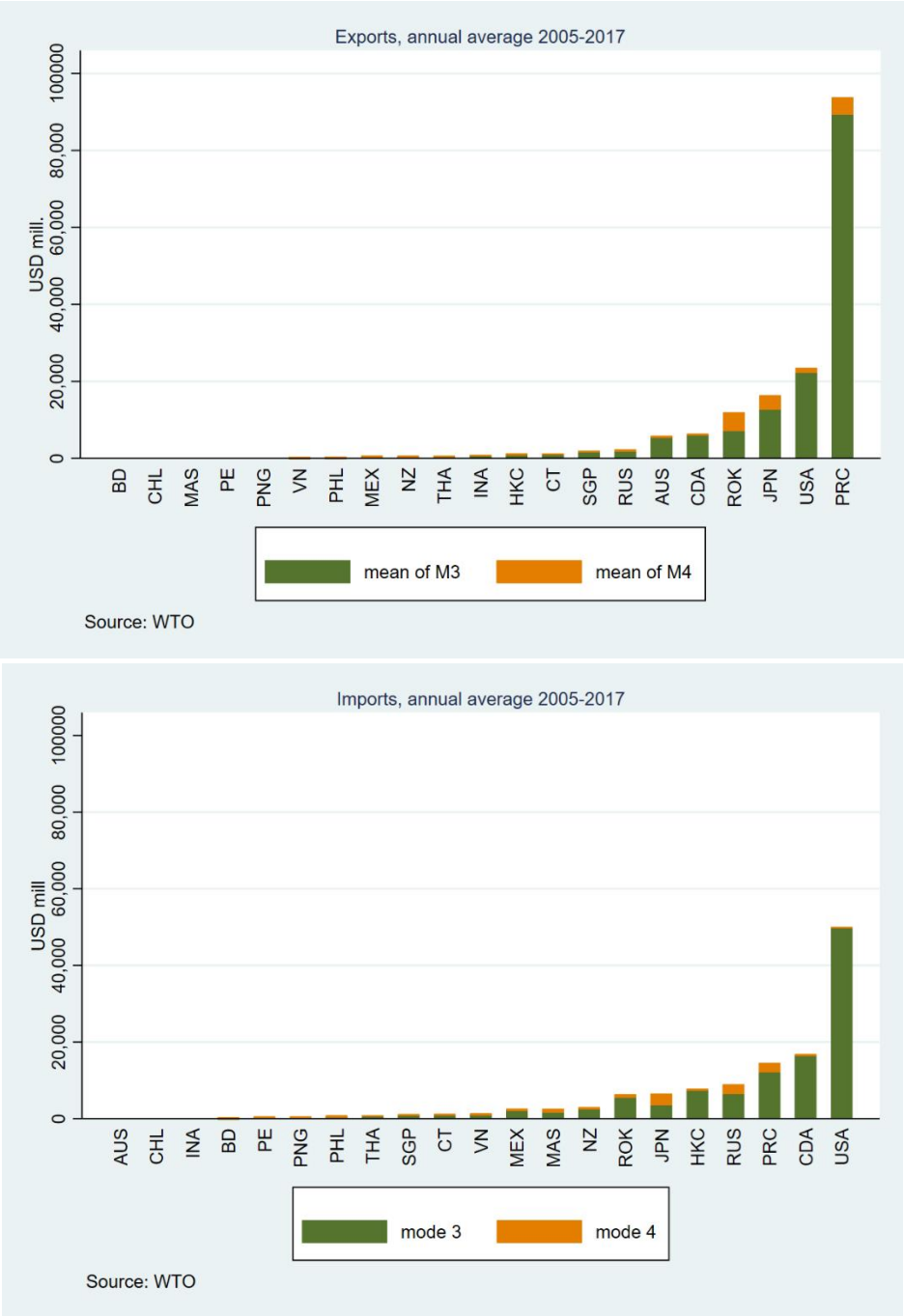
The OECD input-output database has a broader coverage of economies, but a more aggregated sector coverage than the WIOD. It includes 19 APEC economies, but lumps repair and installation of machinery and equipment together with other manufacturing. Sewerage and waste collection are grouped together with electricity, gas, and water, while business services are aggregated into one category. The data confirms that the core environmental services are not much traded, but repair and maintenance as well as business services are traded more extensively.

Most statistical offices do not produce services trade data by mode of supply. However, the WTO has constructed an experimental database which covers trade in services by mode of supply during the period 2005-2017. All APEC economies are included. The data are more aggregated than desirable for a rigorous analysis of environmental services. Categories that include environmental services are Maintenance and repair; Construction; and Other business services. For construction services the data cover only commercial presence (mode 3) and movement of people (mode 4). For the other sectors, trade data are broken down on modes 1, 2 and 4, while mode 3 is covered in a separate, more aggregated database.

Figures 7 and 8 depict annual average exports and imports by mode and economy over the period 2005 to 2017 for construction (EBOBS code SE), and Other business services (excluding trade related) (EBOPS SJXS34) respectively. Appendix 4 depicts Waste management and de-pollution, agricultural and mining services (EBOPS SJ32), where trade is very limited according to this database. Furthermore, modes 2 and 4 dominate trade in these services, suggesting that trade takes place through shipment of waste for treatment in foreign economies.

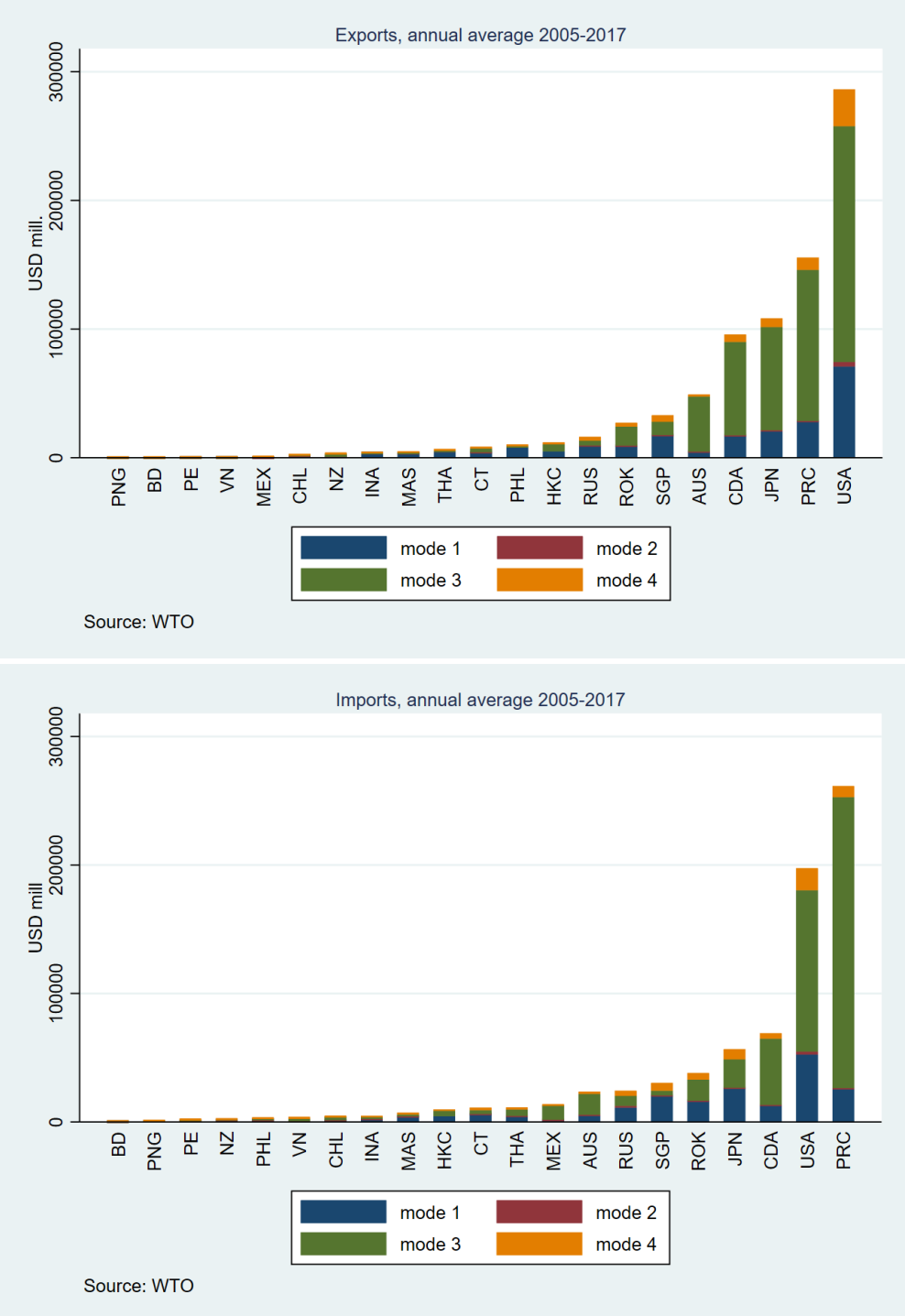
China dominates exports of construction services, while the US is the largest importer. Construction is mainly traded through commercial presence (mode 3), supported by movement of natural persons (mode 4). Mode 4 is relatively more important in Korea and Japan's export of construction services, indicating that construction firms from these economies tend to bring their own construction workers to projects in foreign markets.

Figure 7: Trade in construction services by mode



Additionally, for Other business services (Figure 8) commercial presence dominates, but cross-border supply (mode 1) is also important, particularly for the United States. The largest exporter is the United States, followed by China, while China is the largest importer followed by the United States.

Figure 8: Trade in other business services (excluding trade related) by mode

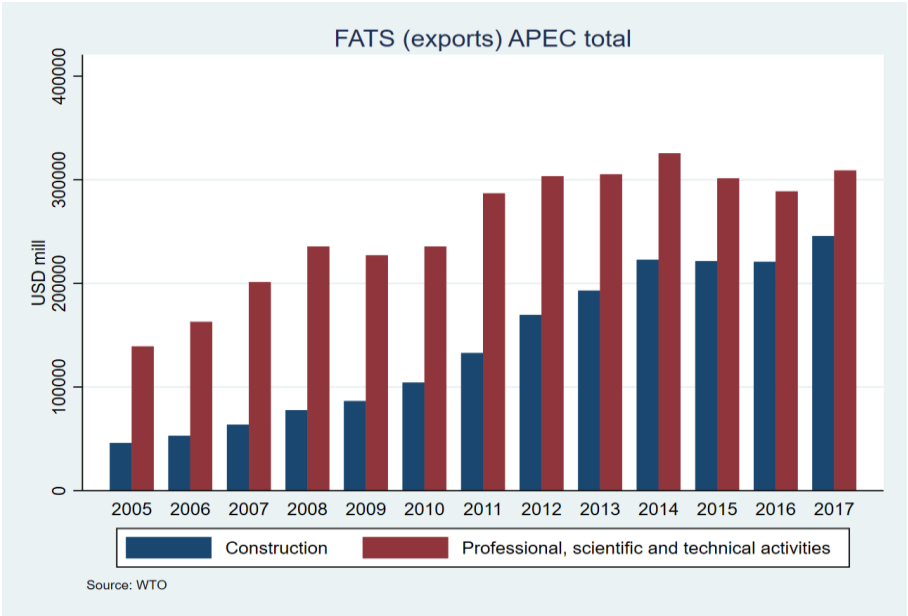


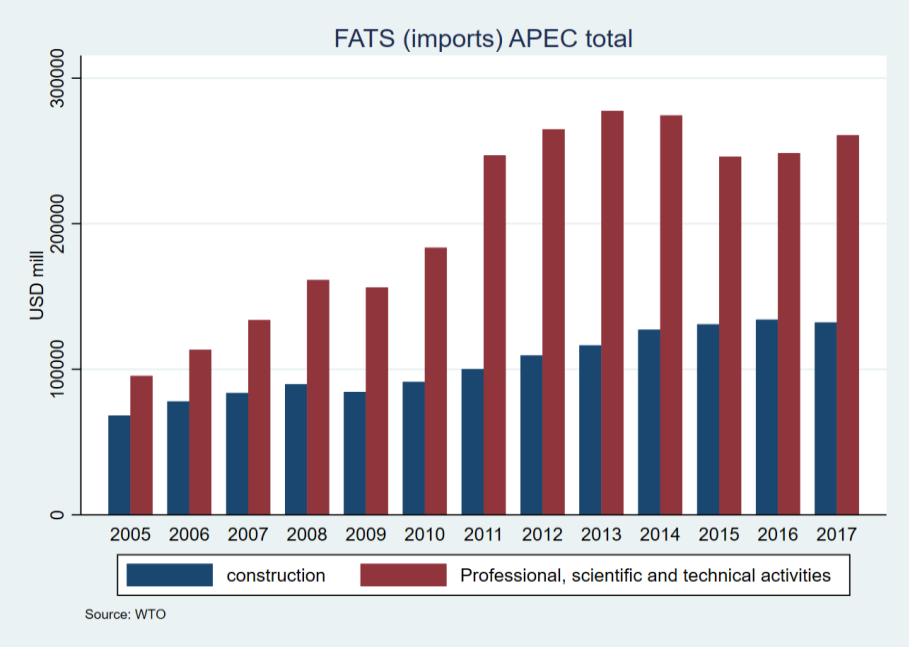
As part of the project to develop an experimental database on services trade by mode, the WTO has created a database on sales of foreign affiliates (FATS), which corresponds to mode 3. It covers the period 2005-2017 and all APEC member economies. Figure 9 depicts total FATS by APEC economies in Construction and Professional, scientific, and technical activities by year.

We note that APEC as a whole is a net exporter of both Construction and Professional, scientific and technical activities through mode 3. While FATS in construction services has increased steadily over the period covered, FATS in professional, scientific, and technical activities fluctuates over time,

although the trend is also rising for this category. FATS in construction account for about four percent of total FATS in APEC economies, while professional, scientific, and technical activities account for about six percent of the total.

Figure 9: Foreign affiliate sales by year and sector, APEC





No international organization offers meaningful information on stocks and the flow of foreign direct investment in environmental services. Except for a handful of economies, the data are aggregated with other sectors and each database covers a different set of economies and sectors.

The OECD database on FDI by sector, reporting and partner economy covers eight APEC economies as reporters (Australia; Canada; Chile; Japan; Korea; Mexico; New Zealand; and the USA), and in principle it covers environmental services in some detail. However, most entries are missing at the detailed level. Meaningful coverage is only available for construction services, where the share of the sector in total inward and outward FDI stocks is on average less than one percent of total foreign investment stocks. Only Korea and the United States report data on FDI in water collection, treatment

and supply. Korea had the largest outward stock, amounting to USD 0.5 billion in 2018, or 0.1% of total outward investment stock. The two same economies also report FDI in sewerage, waste management and remediation, where the US had the highest outward FDI stock in 2018, amounting to slightly less than USD 1 billion, or 0.02% of total outward stock.

UNCTAD's database on FDI includes time series data on FDI stocks and flow by economy, covering most economies in the world, but it only provides information on total FDI stocks and flows. The IMF publishes a similar database based on its Coordinated Direct Investment Survey (CDIS), covering the majority of the world's economies since 2009.

This section has demonstrated that environmental services are mainly produced and consumed locally. Further, it reveals substantial gaps in the data on trade in environmental services, which makes rigorous analysis of the impact of trade policy on trade in such services a challenge. Proprietary firm-level data may fill some of this gap, but such analysis would be limited to studying the impact of policy changes in individual economies. Furthermore, since all firms within an economy face the same policy changes, the impact can be hard to identify unless one has comprehensive information from both before and after the policy change.[25] APEC may therefore usefully consider developing a method for the systematic collection of data, for instance through a harmonized survey in all member economies to get a better sense of the volume, value and nature of trade in environmental services.

[25] Modern econometric techniques would allow meta-analysis of economy-specific analyses. Furthermore, it is possible to construct synthetic databases that can be used for analysis of several economies, exploiting variation across economies.

6 Future opportunities for trade in environmental services

Opportunities for environmental services provision in the future will be driven by the strength of demand for environmental improvement worldwide — largely but not solely in response to government policies — but especially within the APEC region itself. The upper end of the scale of that demand is defined by estimates that have been made of the amount of investment needed to meet the United Nations' Sustainable Development Goals (SDGs). Even if the world's economies fall short of that investment, the demand growth could still be substantial. Other forces that will affect trade in environmental services include economic growth more generally, which itself is often associated with increased environmental awareness and demand for a cleaner environment by the population at large (Sauvage and Timiliotis, 2017: 9).

SDG 6, for example, calls for universal access to safe and affordable drinking water and significant improvements in sanitation by 2030. Within this goal are several targets. Target 6.1 aims "to achieve universal and equitable access to safe and affordable drinking water for all", while Target 6.2 aims to "achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, *paying special attention to the needs of women and girls* and those in vulnerable situations" (emphasis added) (Hutton and Varughese, 2016: 1). Hutton and Varughese (2016: 15) have estimated that for the developing economies of Eastern Asia and South-Eastern Asia to achieve these two targets alone, capital investments in water-supply and sanitation infrastructure would need to average over USD 26 billion annually between 2015 and 2029 (Table 6).[26] Moreover, to make such infrastructure climate-resilient would add roughly 20% to this cost (Alisjahbana et al., 2019: 64). Annual expenditure on operations and maintenance of the new facilities by the end of the period would be of the same order of magnitude (Hutton and Varughese, 2016: 16). Additional investments would be needed to achieve SDG Targets 6.4 through 6.6, which envisage improving water use efficiency and water resource management to help conserve water-related ecosystems at large.

Table 6: Estimated annual capital investment required between 2015 and 2029 to meet SDG Targets 6.1 and 6.2 by 2030 in the developing economies of Eastern and South-Eastern Asia (billions of U.S. dollars of 2016)[1]

World Bank region	Urban areas	Rural areas
Eastern Asia[2]	13.4	2.5
South-east Asia[3]	7.2	3.2
Total	20.6	5.7

1. Numbers refer to the baseline estimates.
2. Region includes the Democratic People's Republic of Korea and Mongolia, as well as the APEC economies of China; Hong Kong, China; and Korea.
3. Includes Cambodia, the Lao People's Democratic Republic, Myanmar, and Timor-Leste, as well as the APEC economies of Brunei Darussalam; Indonesia; Malaysia; the Philippines; Singapore; Thailand; and Viet Nam.

Source: Hutton and Varughese (2016: 15).

The markets for cleaner energy and associated infrastructure, including battery storage, as well as for energy-efficiency improvements, are also expected to grow strongly over the next decade. The International Energy Agency's latest *World Energy Outlook 2020* included for the first time a

[26] Additional investments would be required by other APEC economies, but would be smaller in total.

"Sustainable Development Scenario" (SDS 2020) that starts with the targeted outcomes for the SDGs most closely related to energy (part of SDG 3, plus SDGs 7 and 13) and then works backwards to set out what would be needed to deliver these goals in a realistic and cost-effective way.[27] SDS 2020 is also aligned with the 2015 Paris Agreement on Climate Change and integrates assumptions about the stimulus packages required for a global sustainable recovery from COVID-19 (IEA, 2020).[28]

SDS 2020 sets out an ambitious investment schedule, and the levels of investments suggested in Table 7 may never come to pass. Nonetheless, they do show the market implications of policies aimed at achieving the SDG goals related to energy, and of the Paris Agreement — notably, a doubling of the annual rate of investment in clean energy in the current decade, compared with the previous half-decade, and a 70% increase during the decade after that.[29] The scenario envisages that, over the whole of the projected period out to 2040, investments would be roughly of the same magnitude in each of the investment areas, apart from battery storage. Improvements in the technology of battery storage could, of course, alter these trajectories.

Table 7 relates to global investments. Given that APEC accounts for around 60% of the world economy, and half of world trade (APEC Policy Support Unit, 2019), it seems reasonable to expect that at least half of such investments will take place within the APEC region. A large component of the investments represents goods, rather than services, but the services component could still reach hundreds of billions of U.S. dollars each year.

Table 7: Estimated average annual global investment on renewable energy, associated infrastructure, and improvements in energy efficiency under the IEA's Sustainable Development Scenario (billions of U.S. dollars of 2020)

Investments	**Actual**	**Projected**	
	2015-19	**2020-30**	**2031-40**
Grid-connected renewable-energy electric power generating plants	310	569	666
Electricity networks	294	437	829
Battery storage	3	21	57
Improvements in energy efficiency	251	521	809
End-user renewable-energy installations and other	30	311	805
Total	888	1859	3166

Data source: IEA (2020: 413).

Yet another trend in policy stems from the pressure on governments to reduce material waste streams – i.e., to make their economies more "circular" (Hew, 2020). Recognition of the value of making the transition to a circular economy has been gaining momentum within APEC since 2014 and elsewhere, including among the global business community (Singh, 2020; WBCSD, 2020). The idea of a circular

[27] Part of SDG 3 aims to reduce the severe health impacts of air pollution; SDG 7 aims to achieve universal access to energy; and SDG 13 is consistent with the Paris Agreement's goals for climate change.

[28] See also https://www.iea.org/reports/world-energy-model/sustainable-development-scenario.

[29] Not shown in Table 7 are investments in nuclear power, the use of which is not pursued across all APEC economies. During the 2020-40 period, the IEA projects would average around USD 56 billion a year under the Sustainable Development Scenario.

economy is also intrinsic to SDG 12, which calls on all economies of the world to "Ensure sustainable consumption and production patterns".

The assumption behind the circular-economy policies under consideration is that not only will they cut waste but also reduce costs for businesses and households and spur the development of new sectors. A recent study by the Ellen MacArthur Foundation (2018: 21) found that adopting a circular economy trajectory in China could save businesses and households up to USD 11.2 trillion annually by 2040. Some evidence has also emerged suggesting that firms applying circular business models were more resilient to supply chain disruptions during the early phase of the COVID-19 pandemic (VITO, 2020). The encouragement of circular-economy practices can be expected to increase demand in particular for services related to solid and hazardous waste treatment, especially material recovery, recycling, and waste-to-energy production.

Increases in annual expenditure of tens of billions of U.S. dollars have emerged also out of financial-needs assessments for meeting pledges made by signatories to the Convention on Biological Diversity (CBD) (see, for example, UNTT Working Group on Sustainable Development Financing, 2014). Of the CBD's Aichi commitments, Alisjahbana et al. (2019: 68) list protected areas (both terrestrial and marine), tackling invasive alien species, and restoring ecosystems as among the leading targets with annual average "investment gaps" exceeding USD 10 billion annually, of which the authors reckon the Asia-Pacific region would need to account for around half of the global estimate.[30] Steps taken to achieve these targets would clearly have a bearing on demand for services related to environmental monitoring, analysis or assessment and the protection of biodiversity or landscape.

Finally, to provide a narrower perspective, research by commercial market-research firms has also predicted strong growth in various environmental services, as suggested by a brief selection of some of the more recent research reports listed in Table 8.

Table 8: Indicative sample of projected global sales, and sales growth in various environmental goods and services markets

Market	**Global sales, USD billion (year)**	**Compound annual growth rate (forecast period)**	**Leading growth regions** (overlap with APEC in **bold**)	**Source**
Water filters	18.5 (2018)	6.9% (2019-26)	**Asia-Pacific; North America**	www.reportsanddata.com/report-detail/global-water-filters-market-by-manufacturers-countries-type-and-application-forecast-to-2022
Ultraviolet disinfection equipment	2.6 (2019)	11.3% (2020-27)	**North America**; Europe; **Asia-Pacific**	www.reportsanddata.com/report-detail/ultraviolet-disinfection-equipment-market
Biomethane	1.8 (2019)	6.4% (2020-27)	Europe; **Asia-Pacific; North America**	www.reportsanddata.com/report-detail/biomethane-market
Biogas power plants	12.2 (2018)	5.6% (2019-26)	Europe; **Asia-Pacific; North America**	www.reportsanddata.com/report-detail/biogas-power-plant-market
Continuous emissions	2 (2019)	8.8% (2020-27)	**Asia-Pacific; North America**	www.reportsanddata.com/report-detail/continuous-emissions-monitoring-

[30] The Asia-Pacific region in this context, which is a report by ESCAP, includes many more economies in Asia than those that are members of APEC, but not Canada, Chile, Mexico, or Peru.

monitoring systems				systems-cems-market
Market	**Global sales, USD billion (year)**	**Compound annual growth rate (forecast period)**	**Leading growth regions** (overlap with APEC in **bold**)	**Source**
Outdoor air quality sensors	Not yet available	Not yet available	**North America; Asia-Pacific**	www.reportsanddata.com/report-detail/outdoor-air-quality-sensor-market
Rooftop solar photo- voltaic (PV) installations	7.4 (2018)	17.1% (2019-26)	**Asia-Pacific; North America**	www.reportsanddata.com/press-release/global-rooftop-solar-photovoltaic-pv-installation-market
Geothermal power generation	9 (2019)	> 4% (2019-26)	**Asia-Pacific;** Africa	www.reportsanddata.com/report-detail/global-geothermal-power-generation-market-by-manufacturers-countries-type-and-application-forecast-to-2022
Off-shore wind turbines	29.4 (2017)	7.7% (2018-25)	Europe; **Asia-Pacific; North America**	www.reportsanddata.com/report-detail/off-shore-wind-turbine-market
Oil spill management	150 (2019)	3.1% (2020-27)	**Asia-Pacific**; **Latin America**	www.reportsanddata.com/report-detail/oil-spill-management-market

Source: Authors' compilation.

All of the aforementioned estimates relate to aggregate investment, or sales, involving both goods and services, and mainly at the global level. The corresponding share of these values that will be supplied through international trade, and the services component of that trade, have not been estimated. Nevertheless, it is reasonable to expect that growth in demand for environmental services will roughly track growth in investment and other expenditure, and that trade will play an important part in their provision.

7 Barriers to environmental services provision and availability

Information on barriers to trade in environmental services have not been collected in a systematic manner for the APEC economies. Information can be pieced together from the following sources: the OECD Services Trade Restrictiveness Index (STRI), the WTO and World Bank Services Trade Policy Database, commitments, reservations in free trade agreements (FTAs), and domestic laws and regulations.

The OECD STRI, which covers 14 of the 21 APEC economies, is the most comprehensive and timely. It has information on trade restrictions in 22 sectors and 49 economies for the period 2014-2020. Environmental services are not among the sectors covered as such, but construction and engineering, which we propose to include in an expanded list of environmental services, are covered. The database for these sectors includes detailed measures on public procurement, movement of people and restrictions on data flows, which in most cases apply horizontally to all sectors, including core environmental services. What is missing in the STRI database are trade barriers and trade restricting regulations that are specific to core environmental services. Conversely, some restrictions specific to engineering and construction may not apply to core environmental services.

The WTO and World Bank STRI follow a similar methodology as the OECD STRI and is available for 76 economies in 2016. Five APEC economies not available in the OECD STRI (Chinese Taipei; Hong Kong, China; the Philippines; Singapore; and Viet Nam) are included in the WTO database. However, the database does not cover engineering and construction for these five economies, and only horizontal measures, mainly related to dataflows, are available in this database.

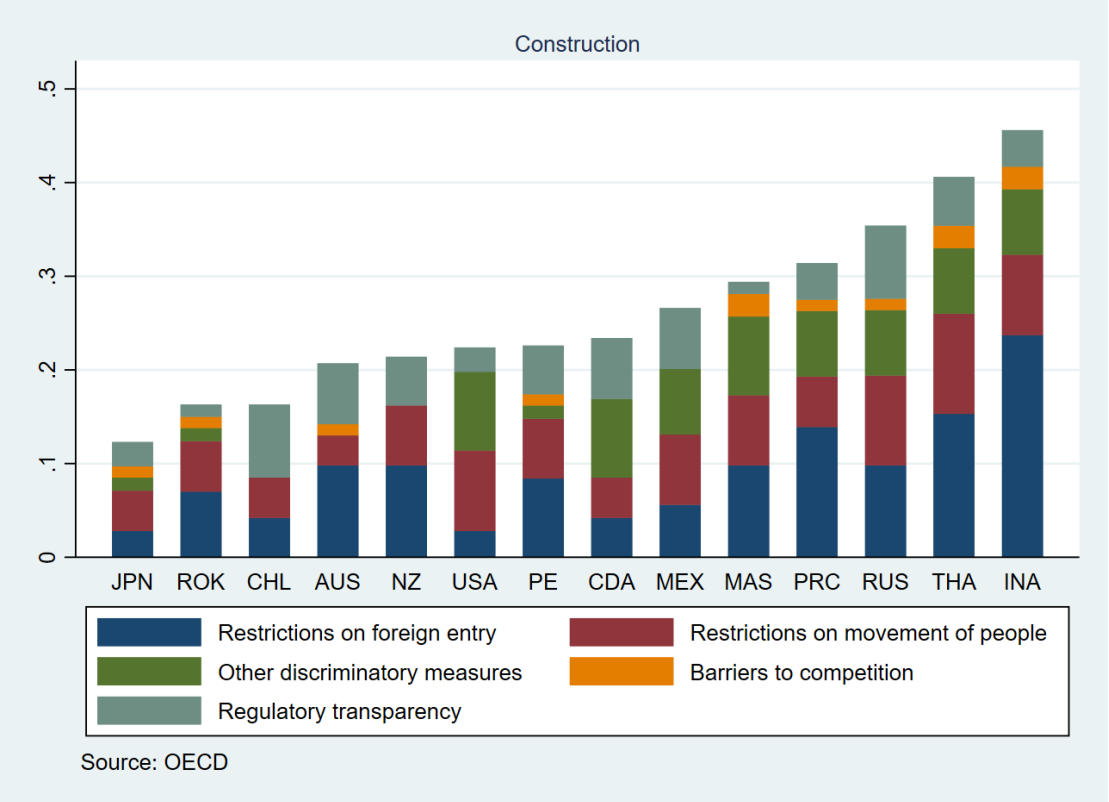
The OECD STRI is constructed from primary sources, i.e. the laws and regulations in force in each economy and sector covered. The raw data for constructing a regulatory database and indices are publicly available for the APEC economies that are not covered by the STRI as well as the sectors not yet covered, but it is beyond the scope of this study to construct the STRI for environmental services for the APEC economies. More readily available information can be found in reservation lists and lists of non-conforming measures in recent FTAs. This information may be upward biased since economies often have more liberal applied policies than their commitments in trade agreements.

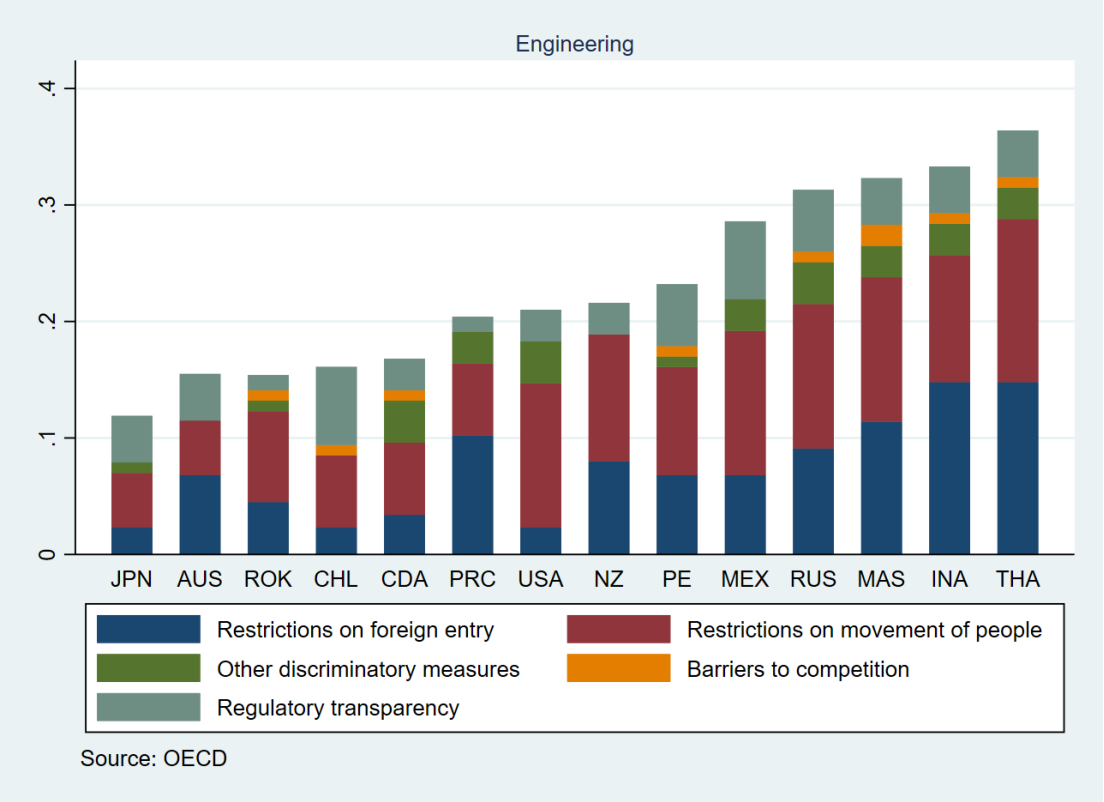
Figure 10 depicts the OECD STRI for construction and engineering services for 2020 for the 14 APEC economies covered by the OECD database. Details on the measures that contribute to the score are presented in Appendix Table A5.1 and information on reservations relevant to environmental services in the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) is also covered in Appendix 5.

The category of "Other discriminatory measures", which feature prominently in the construction sector, represent market access and national treatment issues in public procurement where several APEC economies have preferences for local suppliers and explicit or implicit discriminatory procedures related to public procurement.[31] Restrictions on the movement of people dominate the engineering sector and relate to professional licensing in combination with reserving parts of the market for locally licensed engineers. Labour market tests and, in some cases, quotas are also important barriers facing environmental goods suppliers that need to install and maintain equipment. A recent study found that trade restrictions on mode 4 is not only negatively related to trade through mode 4, but also substantially restricts overall trade in services. Thus, a 10% increase in a trade restrictiveness index for mode 4 reduces overall bilateral services exports by 3% (Shingal, 2020).

[31] Local content requirements have also been imposed in connection with subsidies for renewable-energy projects in some APEC economies; see Bahar et al., 2014.

Figure 10: Services trade restrictiveness, 2020





Some government policies adversely affect trade in services related to energy in particular. For example, policies that artificially depress prices for fossil fuels, or electricity generated by fossil fuels still exist

in several APEC economies.[32] This under-pricing makes it more difficult for renewable energy to compete for the provision of heat or electric power, which in turn depresses demand for services such as those connected with the installation and operation of renewable-energy plants, the installation of solar water heaters, and the improvement of energy efficiency. Other policies, such as ones that reserve coastal freight-transport services to domestically registered vessels, can increase the costs of renewable-energy plants installed in the ocean.

The impact of policy on trade flows in environmental services can be assessed by using gravity regressions. A crude and broad-brushed measure would be whether economies are members of the same free trade agreement. One can also explore to what extent APEC economies systematically trade more with each other, all else equal. Finally, one could explore more specific trade policy measures such as those captured by the STRI.

As noted before, the STRI does not fully correspond to environmental services, although many of the measures apply to broad services categories. In addition, not all APEC economies are covered by the STRI. A technical point is that the gravity model has a bilateral dimension, so any economy-specific variable cannot be estimated precisely unless information on domestic trade is available. The best we can do is therefore to study the impact of free trade areas, APEC and regulatory heterogeneity.[33] In addition, we can explore the relations between trade in environmental goods and services. The results of these estimations are reported in Table 9.

As one would expect, business services are the least sensitive to trading over long distances, while water, sewerage and waste management are substantially biased towards economies that share a common border. The parameter suggests that neighbouring economies trade more than twice as much with each other in this sector, all else equal. For this sector, FTAs do not make a positive difference, while APEC economies do trade this service more intensively with each other than one would otherwise expect. Maintenance and repair services are largely driven by exports of machinery. The result indicates that a 10% increase in exports of machinery increases trade in maintenance and repair by about 4%.

Intra-APEC trade in construction services as well as maintenance and repair services under performs compared with what could be expected. A possible explanation is that mode 3, not captured in the trade data, is relatively more important within APEC. This should be further investigated to establish whether the statistically significant negative coefficients reflect a higher propensity to trade through mode 3, or alternatively, intra-APEC trade barriers. If the latter is the explanation, an in-depth analysis could identify what these barriers are and how they could be lowered.

[32] Among the top 25 economies identified by the International Energy Agency as charging below international-price parity for fossil fuels or electricity are the following APEC members, ranked by a percentage of GDP in 2019: Indonesia (1.7), Russia (1.5), Malaysia (0.5), Mexico (0.3), and China (0.2). See https://www.iea.org/data-and-statistics/charts/value-of-fossil-fuel-subsidies-by-fuel-in-the-top-25-countries-2019.

[33] The STRI database includes regulatory heterogeneity indicators by sector and economy pair. These indicators show the weighted average share of measures where two economies have different answers to the questions in the STRI.

Table 9: Gravity regression results exploring the relationships between bilateral trade in environmental services and geography, institutions and policy

	Water, sewerage, waste management	Maintenance and repair services		Construction	Other business services
Ln distance	-0.656***	-0.758***	-0.459***	-0.504***	-0.250***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)
Common border	1.101***	0.180***	0.210***	0.809***	0.363***
	(0.00)	(0.03)	(0.03)	(0.02)	(0.01)
Common language	0.116***	-0.202***	-0.321***	0.280***	0.400***
	(0.00)	(0.02)	(0.02)	(0.02)	(0.00)
FTA	-0.027***	0.468***	0.148***	0.525***	0.387***
	(0.00)	(0.02)	(0.02)	(0.02)	(0.00)
Both APEC	0.780***	-0.609***	-0.781***	-0.170***	0.189***
	(0.00)	(0.03)	(0.03)	(0.03)	(0.01)
Ln exports of machinery			0.447***		
			(0.01)		
N	33952	36948	9311	36948	36942
Pseudo R^2	0.827	0.878	0.87	0.826	0.927

Note: Pseudo maximum likelihood regressions with economy and time fixed effects. Standard errors in parentheses. ***, ** and * signify statistical significance at a 0.1%, 1% and 5 % level, respectively.

Table 10 introduces regulatory heterogeneity as measured by the STRI into the regressions for water, sewerage and waste management. The most relevant index for this sector is engineering and construction.

Table 10: Gravity regression results exploring the relationships between bilateral trade in environmental services and geography, institutions and regulatory heterogeneity

	Water, sewerage, waste management	
ln distance	-0.498***	-0.510***
	(0.00)	(0.00)
Common border	1.201***	1.204***
	(0.00)	(0.00)
Common language	0.343***	0.357***
	(0.00)	(0.00)
FTA	-0.320***	-0.328***
	(0.00)	(0.00)
both APEC	1.090***	1.062***
	(0.00)	(0.00)
Heterogeneity, engineering	-2.064***	
	(0.00)	
Heterogeneity, construction		-1.985***
		(0.00)
N	7665	7665
Pseudo R2	0.829	0.828

Note: Pseudo maximum likelihood regressions with economy and time fixed effects. Standard errors on parentheses. ***, ** and * signify statistical significance at a 0.1%, 1% and 5 % level, respectively.

We observe that regulatory differences substantially restrict trade in this sector. The coefficient suggests that economies with exactly the same regulation in engineering trade seven times as much with each other in this sector than economies that have completely different regulation. Likewise, economies that have exactly the same regulation in construction trade about six times as much with each other as economies with a completely different regulatory regime. The actual regulatory differences are in between the two extremes and exact results are uncertain and must be interpreted with caution. Nevertheless, the results suggest that regulatory cooperation and, where possible, harmonization would be the most important factor for realizing the opportunities for trade in environmental services.

8 Policy recommendations

This study follows on a long list of other studies previously carried out for APEC, most recently under the Environmental Services Action Plan (ESAP), and concurs with the recommendations of those studies, which focused on ways to build capacity for good regulatory practice, and on the capacity-building needs for technicians and workers (APEC Group on Services, 2020; APEC Policy Support Unit, 2016). Below, we complement those earlier recommendations with several suggestions relating to defining the scope of environmental services, improving data on trade in environmental services, addressing gender issues, and making trade in environmental services within the APEC region more open.

8.1 Definition and scope of environmental services

This study is in agreement with the findings of the Study for Final Review of Environmental Services Action Plan, which observed that "the environmental services sector is systematically defined too narrowly, and that there is a need for classification systems to consider a broader set of services that contribute to environmental protection" (APEC Group on Services, 2020: 5). Indicating where in CPC Version 2.1 specific services could be identified within broader categories is an approach suggested here. That said, classification systems for services (and goods, for that matter) become obsolete almost from the day they are published, so they can at best serve as guides for the development of commitments. Some systems for monitoring and responding to new developments, particularly in environmental regulations and in technologies, would be helpful in this regard.

Raising awareness about environmental services was also an action item under the ESAP, and progress was made on that front, for example through the organization of workshops targeted at audiences of stakeholders. But there are additional ways that policy-makers could be made aware of the wide scope of environmental services (and complementary goods). A good example is the Sustainable Technology Promotion Platform (STePP) maintained by the Investment and Technology Promotion Office of the United Nations Industrial Development Organization, based in Tokyo.[34] Such an on-line platform, translated into several APEC languages, could serve both as an educational tool and a way for environmental service (and goods) providers based in the APEC region to make known their availability.

> Recommendation: We recommend using CPC Ver. 2.1 division 94 as a basis for defining environmental services, and extending the coverage to environment-related services classified under divisions outside of division 94, including those that would fall under the 2007 list of categories prepared by the Friends of the Chair of the EGS Group. We offer Appendix 3 as an example of (or a starting point for discussions on) an expanded list of environmental services.

8.2 Data and statistics on trade in environmental services

Good regulatory practices involve impact assessment, which in turn requires timely, detailed and relevant information. The same goes for trade-policy analysis. This report has identified several information gaps that need to be filled in order to facilitate robust policy-impact assessment. Comparable data on output, expenditure, imports, and exports of environmental services are needed.

> Recommendation: We recommend that statistical agencies in APEC economies make a joint effort to collect data on output, expenditure, imports, and exports of environmental services.

[34] See http://www.unido.or.jp/en/activities/technology_transfer/technology_db/.

Comparable information on trade policy across the APEC economies is not readily available. The OECD STRI database and indices cover 14 APEC economies for construction, engineering services and horizontal measures on movement of people, public procurement, cross-border data flows and transparency in public administration.

> Recommendation: We recommend that APEC explores developing STRIs for environmental services for its membership, in collaboration with the OECD.

For in-depth analyses of individual economies, firm register data, systematic time use surveys and household budget surveys could be used to facilitate rigorous impact assessment of policy on trade and welfare in a gender perspective. Most APEC economies have undertaken one or more time use surveys since the year 2000.

> Recommendation: To facilitate future APEC-wide and individual economy analysis, we recommend using firm register data, systematic time use surveys and household budget surveys to facilitate rigorous impact assessment of policy on trade and welfare in a gender perspective. The surveys should as much as possible be harmonized to the International Classification of Activities for Time-Use Statistics developed by UN Statistics and ILO.

8.3 Gender

Access to high-quality cost-effective environmental services has a large impact on health and well-being for women and girls. Transparent, open, and well-regulated markets for environmental services improves such access, particularly in the developing APEC economies where universal access to high-quality environmental services is not yet guaranteed. Unsafe basic environmental services, such as the provision of clean water and sanitation, are often due to lack of maintenance rather than lack of investment. One reason is that investment is easier to fund than maintenance where the latter competes for scarce resources on the municipality budget.

> Recommendations: We recommend that APEC economies:

- Explore how green public procurement could contribute to sustainable, cost-effective environmental services using technology suitable for local conditions and needs to guarantee universal access.
- Make adequate resources available for maintenance of existing environmental infrastructure and explicitly include future maintenance costs in new investment projects, for example, in a resource budget.

Labour demand in environmental services is largely directed towards technical occupations, and women account for a small share of that employment. Jobs in the sector are relatively well-paid and employment in the sector is forecasted to grow in the near future. A more balanced gender composition of employment would create new job and career opportunities for women.

> Recommendations: To address the above, we recommend that APEC economies should:

- Encourage girls at an early age to choose vocational technical or STEM occupations through female role models and technical-oriented activities as part of the school curriculum.
- Improve facilities at building sites and other relevant work places to accommodate all genders.
- Strengthen the enforcement of work safety and workplace legislation with increased focus on discrimination and sexual harassment.

8.4 Trade policy

Openness to international trade offers opportunities for economies to access state-of-the-art technology and cost-effective environmental services. Environmental services are diverse and subject to rapid digitization and regulation at all levels of government. Barriers to trade in the sector are largely found behind the border in the form of regulatory diversity and regulatory measures that lag behind technological development.

Recommendations: We recommend that APEC economies:

- Liberalise market access with particular focus on cross-border dataflows, temporary movement of people and public procurement in environmental services, based on an expanded definition and scope of environmental services, per the preceding recommendation in Section 8.1
- Strengthen regulatory cooperation, aiming for mutual recognition of standards, regulatory equivalence, and where possible regulatory harmonization.
- Ensure that data from sensors monitoring the performance of environmental goods and infrastructure in real time can flow freely across borders subject to protection of privacy and security.
- Reform with a view to eliminating fossil fuel subsidies, which artificially reduce incentives to conserve energy and improve energy efficiency and undermine markets for non-fossil alternatives for providing heat or electricity.

Repair and installation of environmental goods are an important component of trade in environmental goods. Typically, a contract for delivery of such goods includes installation and subsequent monitoring and maintenance. Even if the volume of mode 4 trade is small, it is an essential part of the environmental management system. To avoid disruptions and downtime it is imperative that suppliers of environmental goods can deploy their staff to the premises of clients as needed without delay. The APEC Business Travel Card greatly facilitates business travel within APEC.

Recommendations: We recommend that:

- The APEC Business Travel Card is maintained and improved over time to keep up with technological advances, and is available to workers travelling to provide maintenance in another member economy who are paid in their home economy.
- APEC economies consider developing schemes similar to the APEC engineer scheme for other relevant regulated occupations and, in particular, for occupations relevant to environmental services for which certification is required.

Public procurement accounts for a large share of the market for environmental services. International tenders can be complex and require administrative capacity and technical competencies. In addition, transparency, non-discrimination, and market access in public procurement improve cost efficiency. As documented in the OECD STRI database, there is scope for further improvement in openness and transparency in public procurement in several APEC economies. The APEC Government Procurement Transparency Standards are a useful tool in this regard.

Recommendation: We recommend that APEC economies further strengthen capacity building in in the area of public procurement for environmental services.

9 Concluding remarks

Considerable progress has been made in better understanding environmental services provided within the APEC region over the last two decades, thanks in no small part to the APEC Environmental Services Action Plan (ESAP), endorsed by Ministers in 2015. This report is part of an attempt to continue the momentum created under that effort.

The COVID-19 crisis has accelerated the digital transformation of the economy and blurred the distinction between goods and services and between modes of services supply. There is no going back. Future policy for enhancing trade in environmental services for the benefit of consumers needs to consider the complementarity between goods and services, the role of data flows for a cost-effective environmental goods and services performance management, and the importance of rapid deployment of staff to attend to problems. In short, policy should be modernized to support the integration of goods and services into systems and solutions using new technology such as the Internet of things and artificial intelligence. Such technology helps reduce waste, monitor air and water quality among other things, supporting green and smart cities as well as greener production of goods and services.

This argument rests on the development of an updated definition and scope of environmental services, and it is imperative that policy development in environmental services – besides its inherent interrelatedness to sustainability – also be considered through the lens of gender and the impact of policy decisions on women and girls. We hope that the present report has contributed to this discussion and look forward to observing the future steps that APEC economies take in this area.

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Appendix 1: Environmental services classification in CPC Ver. 2.1 (Division 94)

The text contained in this Appendix has been copied verbatim from pages 556-560 of the Explanatory Notes to the *Central Product Classification (CPC) -- Version 2.1* (United Nations, 2015). Slight changes in formatting or punctuation (e.g., adding periods or semicolons at the ends of entries) have been introduced in some cases in order to save space. Five-digit codes cross-referenced in the notes (e.g., "cf. 54241") refer to subclasses outside of group 94.

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94 Sewage and waste collection, treatment and disposal and other environmental protection services

941 Sewerage, sewage treatment and septic tank cleaning services

9411 Sewerage and sewage treatment services

94110 Sewerage and sewage treatment services

This subclass includes:

- sewage removal services usually provided using equipment such as waste pipes, sewers or drains;
- sewage treatment services using dilution, screening and filtering, sedimentation, chemical precipitation, etc.

This subclass does not include:

- collection or purification of water, cf. 18000;
- construction, repair and alteration services of sewers and sewer pipelines, cf. 54241, 54251;
- distribution of water through mains on own account, cf. 69210;
- distribution of water through mains on a fee or contract basis, cf. 86330.

9412 Septic tank emptying and cleaning services

94120 Septic tank emptying and cleaning services

This subclass includes:

- emptying and cleaning of cesspools and septic tanks;
- servicing of chemical toilets.

942 Waste collection services

9421 Collection services of hazardous waste

94211 Collection services of hazardous medical and other biohazardous waste

This subclass includes waste collection specifically designed for the collection of:

- pathological wastes such as anatomical wastes, non-anatomical wastes, sharp wastes, such as syringes and scalpels;
- other biological-infectious wastes from hospitals, medical practices, dental practices, medical laboratories;
- other biohazardous wastes from non-residential locations.

94212 Collection services of industrial hazardous waste (except medical and other biohazardous waste)

This subclass includes waste collection from industrial locations specifically designed for the collection of hazardous wastes (except medical and biological) including materials that may be hazardous to human health or the environment and that require special handling techniques specified by legislation or regulation.

94219 Collection services of other hazardous waste

This subclass includes waste collection from non-industrial locations specifically designed for the collection of hazardous waste including materials that may be hazardous to human health or the environment that require special handling techniques specified by legislation or regulation.

9422 Collection services of non-hazardous recyclable materials

94221 Collection services of non-hazardous recyclable materials, residential

This subclass includes waste collection specifically designed for the collection of non-hazardous recyclable materials, whether presorted or commingled waste, such as cardboard, paper, plastic, glass, aluminium, steel and organic yard waste from residential locations, including curbside collection, back door collection or automated collection on a flexible or regular schedule.

94229 Collection services of non-hazardous recyclable materials, other

This subclass includes waste collection specifically designed for the collection of non-hazardous recyclable materials, whether presorted or commingled, such as cardboard, paper, plastic, glass, aluminium, steel, and other recyclable materials from non-residential locations, on a regular or flexible schedule.

9423 General waste collection services

94231 General waste collection services, residential

This subclass includes general collection of waste, garbage, rubbish, refuse, trash, and commingled materials from residential locations, including curbside collection, back door collection, or automated collection on a flexible or regular schedule.

94239 General waste collection services, other

This subclass includes general collection of waste, garbage, rubbish, refuse, trash, and commingled materials from nonresidential locations, on a regular or flexible schedule.

943 Waste treatment and disposal services

9431 Waste preparation, consolidation and storage services

94311 Hazardous waste preparation, consolidation and storage services

This subclass includes:

- consolidation, temporary storage, and preparation of hazardous waste;
- consolidation and preparation of hazardous waste for transportation to an appropriate facility that processes waste;
- services of drop-off centres, transfer stations and container stations.

94312 Ship-breaking and other dismantling of wrecks services

This subclass includes:

- ship-breaking;
- dismantling of wrecks, such as cars, computers etc., in order to obtain and separate recoverable materials.

This subclass does not include dismantling of wrecks, such as cars, etc., to obtain items for sale, cf. corresponding subclass in division 61 or 62.

94313 Non-hazardous recyclable materials preparation, consolidation and storage services

This subclass includes:

- consolidation, temporary storage and preparation of non-hazardous recyclable materials;
- transfer facility services of non-hazardous recyclable materials;
- recovery and preparation of non-hazardous recyclable materials, such as bailing, cleaning, sorting, volume reduction and similar preparation and consolidation of recyclable materials, for transportation to an appropriate facility that processes recyclable materials.

94319 Other non-hazardous waste preparation, consolidation and storage services

This subclass includes:

- consolidation, temporary storage and preparation of non-hazardous waste;
- transfer facility services for non-hazardous waste;
- consolidation and preparation of non-hazardous waste for transportation to an appropriate facility that processes waste.

9432 Hazardous waste treatment and disposal services

94321 Hazardous waste treatment services

This subclass includes treatment to reduce, eliminate, or transform hazardous waste.

Note: Processes include biological, chemical, and/or physical procedures or incineration. These procedures may lead to a disposable residual or result in the recovery of a recyclable material.

94322 Hazardous waste disposal services

This subclass includes disposal services for hazardous waste at a facility that meets legal standards for the disposal of hazardous waste, such as at approved controlled containment facilities or landfills.

9433 Non-hazardous waste treatment and disposal services

94331 Sanitary landfill services, non-hazardous waste

This subclass includes disposal of non-hazardous waste on or in a sanitary landfill which meets the sanitary landfill criteria specified by legislation or regulation, i.e. designed to prevent leaking etc.

94332 Other landfill services, non-hazardous waste

This subclass includes disposal of non-hazardous waste on or in landfills other than a sanitary one.

94333 Incineration of non-hazardous waste

This subclass includes incineration of non-hazardous waste in a facility that meets legal standards and requirements for incineration of non-hazardous waste.

94339 Other non-hazardous waste treatment and disposal services

This subclass includes other non-hazardous waste disposal services, such as services of chemical or biological reduction of agricultural waste and similar treatment services.

944 Remediation services

This group includes remediation services, i.e. services dealing with the effects of contamination caused by operation of facilities or by accidents. These services aim to eliminate or contain any existing contamination of the soil, water or air and have to be performed on site.

9441 Site remediation and clean-up services

94411 Site remediation and clean-up services, air

This subclass includes services involved in implementing approved plans for the remediation of air on a contaminated site, that meet requirements specified by legislation or regulation.

94412 Site remediation and clean-up services, surface water

This subclass includes services involved in implementing approved plans for the remediation of surface water on a contaminated site, that meet requirements specified by legislation or regulation.

94413 Site remediation and clean-up services, soil and groundwater

This subclass includes: services involved in implementing approved plans for the remediation of soil and groundwater on a contaminated site, that meet requirements specified by legislation or regulation.

9442 Containment, control and monitoring services and other site remediation services n.e.c.

94420 Containment, control and monitoring services and other site remediation services n.e.c.

This subclass includes:

- services involved in preventing additional or wider contamination on the site;
- preventing the movement of uncontrolled contaminates from the site;
- monitoring the site to determine the effectiveness of remediation activities;
- controlling access to the contaminated site;
- other site remediation services, n.e.c.

9443 Building remediation services

94430 Building remediation services

This subclass includes development and implementation of a remediation plan that removes, destroys, contains or otherwise reduces contaminants in buildings, such as asbestos, lead, radon, etc.

9449 Other remediation services n.e.c.

94490 Other remediation services n.e.c.

This subclass includes environmental emergency response services; other remediation services, n.e.c.

945 Sanitation and similar services

9451 Sweeping and snow removal services

94510 Sweeping and snow removal services

This subclass includes:

- street sweeping and cleaning services;
- gritting and salting of roads;
- snow ploughing and removal;
- runway sweeping and snow removal services;
- runway vacuuming services.

9459 Other sanitation services

94590 Other sanitation services

This subclass includes:

- beach cleaning services;
- drain unblocking services.

This subclass does not include:

- disinfection and extermination services for buildings and other non-agricultural structures, cf. 85310;
- pest control services in connection with agriculture, cf. 86119.

949 Other environmental protection services n.e.c.

9490 Other environmental protection services n.e.c.

94900 Other environmental protection services n.e.c.

This subclass includes:

- acidifying deposition (i.e., acid rain) monitoring, controlling and damage assessment services;
- other environmental protection services not elsewhere classified.

Appendix 2: Environmental services classification in CPC Ver. 2.1 (Other Divisions)

The titles of the groups, classes and subclasses contained in this Appendix have been copied verbatim from pages the Explanatory Notes to the *Central Product Classification (CPC) -- Version 2.1* (United Nations, 2015). However, the accompanying text has been condensed in order to highlight those services included within the subclasses that could be considered environmental.

General construction services of civil engineering works (542)

General construction services of dams (54233)

This subclass includes construction, repair, alteration and restoration services for dams and similar water-retaining structures, as well as embankments for coastal and other waterside areas.

General construction services of irrigation and flood control waterworks (54234)
This subclass includes the construction, repair, alteration and restoration services for irrigation and flood control waterworks, but not construction services for waterways for the purpose of water supply.

General construction services of long-distance pipelines (54241)
This subclass includes the construction, repair, alteration and restoration services for long-distance overland, underground and submarine pipelines for the conveyance of petroleum products, gas, water or other products, and pumping stations and similar related structures.

General construction services of long-distance communication and power lines (54242)
This subclass includes construction, repair and alteration services relating to long-distance high tension electric power transmission lines (cables), long-distance electricity power lines for railways, and transformer stations, pylons.

General construction services of local pipelines (54251)
This subclass includes construction, repair and alteration services for local gas pipelines and water and sewer mains, and local hot-water and steam pipelines such as those that form part of district heating systems.

General construction services of local cables and related works (54252)
This subclass includes the construction, repair and alteration services for local electricity transmission cables, as well as ancillary works associated with transformer stations and substations for distribution within local boundaries.

General construction services of sewage and water treatment plants (54253)
This subclass includes construction, repair, alteration and restoration services for sewage disposal plants and water treatment and purification plants.

General construction services of power plants (54262)
This subclass includes construction, repair and alteration services for heavy electrical generating plants and equipment, including plants and equipment for nuclear-powered generating stations.

General construction services of other civil engineering works (54290)
This subclass includes construction, repair, alteration and restoration services for waste dumps and waste incinerators, and plants for treating and processing of nuclear material.

Site preparation services (543)

Site formation and clearance services (54320)
Among the services included in this subclass are services related to soil stabilization, and test drilling and boring and core extraction services for construction, geophysical, geological or similar purposes.

Excavating and earthmoving services (54330)
Among the services included in this subclass are work services connected with land-based recreation, and the stripping of contaminated topsoil.

Water well drilling services (54341)
This subclass covers special trade construction services involving drilling or digging water wells, and installation services of water well pumps and well piping systems.

Septic system installation services (54342)
This subclass covers construction services of leach fields or drainfields, as well as installation services of septic systems, including:

- aerobic septic systems;
- evaporation-transpiration (ET) septic systems;
- greywater systems;
- holding tank septic systems;
- pressure dosing septic systems;
- septic disinfection systems;
- chemical, composting, incinerating and waterless toilets.

Assembly and erection of prefabricated constructions (544)
Among the services included in the sole subclass of this group (54400) are installation, assembly and erection services of other prefabricated structures and constructions, including public toilets.

Special trade construction services (545)
Among the services included in one of the subclasses of this group (54550: Structural steel erection services) are erection services of prefabricated (but not self-manufactured), structural steel components for overhead cranes or electricity transmission towers.

Installation services (546)

Heating equipment installation services (54631)
Among the services included in this subclass are services used in the installation and maintenance of central heating control systems, the connection of buildings to district heating systems, and the maintenance and repair of domestic boilers and burners.

Insulation services (54650)
Among the services included in this subclass are services used in installing weather-proofing thermal insulation in exterior wall cavities, hot and chilled water pipes, boilers and duct runs; and sound-insulation services.

Building completion and finishing services (547)
One of the subclasses in this group (54760: Joinery and carpentry services) covers installation services of door and window frames and of doors, windows, shutters, slatted shutters, garage doors, etc., made of any kind of material, which would include the installation of prefabricated double- and triple-paned windows and insulated doors.

Water transport services of freight (652)

Other coastal and transoceanic water transport services of other freight (65219)
This subclass includes towing services for floating cranes, and freight not elsewhere classified, which would include components of offshore wind turbines.

Leasing or rental services concerning machinery and equipment without operator (731)

Leasing or rental services concerning cars and light vans without operator (73111)
This subclass would include services that lease or rent battery-electric cars, light vans, or similar vehicles, to be driven by the person renting the vehicle.

Leasing or rental services concerning other goods (732)

Leasing or rental services concerning pleasure and leisure equipment (73240)
This subclass includes leasing, renting or hiring services concerning bicycles.

Research and experimental development services in natural sciences and engineering (811)
One subclass in this group (81139) covers experimental development research services related to the environment and other natural sciences, not elsewhere classified. Experimental development services refer to "systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products, and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed."

Architectural services, urban and land planning and landscape architectural services (832)

Urban planning services (83221)
This subclass includes undertaking studies of environmental impact and economic assessments of urban development plans.

Landscape architectural advisory services (83231)
This subclass includes the provision of advice, studies and reports on landscape architecture matters.

Landscape architectural services (83232)
This subclass includes landscape architecture services for recreational and open-space projects including parks and natural areas, as well as landscape architecture services related to:

- Preparing and modifying terrain such as land clearing and grading plans, drainage designs, erosion and sediment control designs, retaining wall designs, outdoor sprinkler system plans.
- Facilitating access to a site such as lighting plans, signage plans, trail and path plans, accessibility designs.

Engineering services (833)
Engineering services, as defined in the explanatory notes to CPC Ver. 2.1, include "the application of physical laws and principles of engineering in the design, development and utilization of machines, materials, instruments, structures, processes and systems for" various facilities. Three subclasses are directly relevant to the environment.

Engineering services for power projects (83324)
This subclass pertains to engineering services related to all manner of facilities that generate electrical power (including cogeneration facilities), including those that generate electricity from the energy in falling water (i.e., hydroelectric power), the sun, the wind, and geothermal energy. Presumably power plants that generate electricity from the energy contained in tides or waves would also be covered by this subclass. Notably, the subclass also includes engineering services related to overhead or underground electrical power transmission and distribution lines.

Engineering services for waste management projects (hazardous and non-hazardous) (83326)
This subclass includes:

- engineering services related to household garbage collection and disposal systems, such as:
  - recycling facilities;
  - composting facilities;
  - transfer stations;
  - resource recovery facilities;
  - landfill sites.

- engineering services related to programmes for the collection, treatment, recycling, and disposal of industrial air, water and solid wastes, generally to a level such that the remaining waste stream can be safely released to the natural environment or ordinary municipal systems.

- engineering services related to programmes for hazardous waste remediation, such as:
  - management of nuclear waste;

- chemical agent destruction;
- brownfield redevelopment;
- groundwater modelling;
- contaminated site remediation.

Engineering services for water, sewerage and drainage projects (83327)
This subclass includes engineering services related to systems for the collection, distribution, treatment, and disposal of water such as:

- Drinking water distribution systems, pumping stations, reservoirs, water storage facilities, water transmission and distribution mains including dams used primarily for local drinking water distribution and desalination plants.
- Systems for stormwater management, drainage and detention systems including dams used primarily for flood control.
- Systems for the collection, treatment, and disposal of waste water, except industrial waste water.
- Irrigation systems and water pipelines including dams primarily used for irrigation.

Scientific and other technical services (834)

Geological and geophysical consulting services (83411)
Among the services included within this subclass are: the provision of advice, guidance and operational assistance concerning the location of mineral deposits or groundwater by studying the properties of the earth and rock formations and structures; the provision of advice with regard to exploration and development of minerals or groundwater, including pre-feasibility and feasibility studies, project evaluation services; the evaluation of geological, geophysical and geochemical anomalies; and surface geological mapping or surveying.

Geophysical services (83412)
This subclass covers the provision of information on subsurface earth formations by seismographic, gravimetric, magnetometric, or other subsurface surveying methods.

Composition and purity testing and analysis services (83441)
This subclass includes testing and analysis of the chemical or biological properties of materials such as air, water, municipal or industrial waste, fuels, metals, soil, minerals, food and chemicals, as well as testing and analysis in related scientific fields such as microbiology, biochemistry, or bacteriology.

Testing and analysis services of physical properties (83442)
This subclass covers testing and analysis of physical properties such as strength, ductility, electrical conductivity or radioactivity of materials such as metals, plastics, textiles, woods, glass, concrete or other materials, as well as tests for tension, hardness, impact resistance, fatigue resistance or high-temperature effects.

Other professional, technical and business services (839)

Environmental consulting services are classified under subclass 83931.
The Explanatory Notes specify a long list of services covered by this subheading, most of which are advisory and pertain to the planning, or review phase of specific sites or projects, though "environmental assessment services" appear also to include activities that could involve the physical, chemical or biological evaluation of environmentally significant sites:

- Environmental assessments, i.e. objective studies undertaken for any one or more of the following purposes:
    - identify whether or not environmental contamination exists at a particular site, and if so determined, the source, nature, and extent of the contamination; assess the risk to public safety and health from environmental contamination associated with a project that is proposed or in place;
    - evaluate the impact on the ecology or economy of environmental changes resulting from human or natural activities.

- Environmental audits, i.e. independent assessment of the current status of a party's compliance with applicable environmental requirements or of a party's environmental compliance policies, practices and controls.
- Site remediation planning services, i.e. preparation of plans for the abatement of environmental contamination, usually at a specific site, that incorporate such technical or other requirements as may be prescribed by law or regulation.
- Evaluation of environmental studies, i.e. provision of analysis that explains the strengths or weaknesses of an environmental study and provides the basis for alternative judgments. The evaluation of environmental studies may also include an analysis of future responses to environmental regulators.
- Natural resource management consulting, i.e. provision of objective information, advice, or guidance concerning the best practices for ecologically sustainable development and use of: land; forests; bodies of water; gas, oil, and mineral deposits; wildlife populations and other natural resources.
- Waste management consulting, i.e. provision of objective information, advice, or guidance concerning the best practices for the minimization, transport, handling, disposal and/or recycling of waste.
- Environmental policy development consulting, i.e. advising public or private institutions on the design, development and implementation of environmental statutes, regulations, standards, or practices
- Other environmental consulting services n.e.c.

Cleaning services (853)

One of the subclasses in this group, 85340 covers "Specialized cleaning services", which among other services includes specialized cleaning services for reservoirs and tanks, these being parts of either industrial sites or transport equipment; furnace and chimney cleaning services; and cleaning of fireplaces, stoves, furnaces, incinerators, boilers, ventilation ducts and exhaust units.

Other support services (859)

One subclass in this group, 85970, pertains to "Landscape care and maintenance services". Among the services covered by this subclass are planting, care and maintenance services of: stationary and flowing water (including plant sewage systems); and plants for protection against noise, wind, erosion, visibility and dazzling.

Maintenance and repair services of fabricated metal products, machinery and equipment (871)

Maintenance and repair services of electrical machinery and apparatus n.e.c. (87152)

Among the services that this subclass includes are those involving the "repair, maintenance and rewinding services of electric motors, generators and transformers" and the "maintenance and repair services of electricity distribution and control apparatus". The former could pertain to generators powered by renewable-energy (for example, the wind or geothermal steam), and the latter could pertain to smart grids.

Maintenance and repair services of medical, precision and optical instruments (87154).

Among the services that this subclass includes are maintenance and repair services of instruments and apparatus for measuring, checking, testing and navigating and other purposes, including automotive emissions testing equipment, meteorological instruments, physical, electrical and chemical properties testing and inspection equipment, surveying instruments, and radiation detection and monitoring instruments.

Materials recovery (recycling) services, on a fee or contract basis (894)

Metal waste and scrap recovery (recycling) services, on a fee or contract basis (89410)

This subclass includes processing services of metal waste and scrap and of metal articles, whether or not used, into secondary raw material. Typical input consists of waste and scrap being sorted or unsorted but always unfit for further direct use in an industrial process, whereas the output is made fit for further processing and is to be considered then as an intermediate good. A process is required, either mechanical or chemical. Besides recovering metal from items such as used cars, washing machines, bicycles, and large iron pieces such as railway wagons, it includes the stripping of used goods such as cars or refrigerators to strip them of harmful waste (oil, cooling liquid, fuel, etc.).

Non-metal waste and scrap recovery (recycling) services, on a fee or contract basis (89420)

This subclass includes processing services of non-metal waste and scrap and of non-metal articles, whether or not used, into secondary raw material. Typical input consists of waste and scrap being sorted or unsorted but always

unfit for further direct use in an industrial process, whereas the output is made fit for further processing and is to be considered then as an intermediate good. A process is required, either mechanical or chemical. Examples of items processed are used tires, used plastics, chemical waste, used or broken glass, and demolition waste.

Services furnished by other membership organizations (959)

One subclass in this group, 95992, pertains to "Services furnished by environmental advocacy groups". It includes services provided by membership organizations for the purpose of furthering environmental protection, by means of information dissemination, political influence, fund-raising etc., such as by environmental, conservation or wildlife organizations.

Museum and preservation services (964)

One subclass in this group, 96422, pertains to "Nature reserve services including wildlife preservation services". It includes the operation of national parks, nature parks and reserves, including supervision, access and visiting services, as well as service associated with the conservation and maintenance of national parks, nature parks and reserves.

Appendix 3: Environmentally relevant services, per CPC Ver. 2.1

Key:

- APC: air pollution control or avoidance
- CRE: the production of cleaner or renewable energy
- EE: the improvement of energy efficiency
- EMAA: environmental monitoring, analysis or assessment
- ERC: environmental remediation or clean-up
- NRM: natural risk management
- NVA: noise or vibration abatement
- PBL: protection of biodiversity or landscape (incl. natural resources protection)
- SHWM: solid or hazardous waste management
- WWM: wastewater management
- WST: water supply or treatment

Services that do not fall under one of the above categories are identified as "Other" (OTH).

CPC 2.1 Subclass	Description	Environ. Services Categories
54233 ex	General construction services of dams [Hydro-electric dams]	CRE
54234	General construction services of irrigation and flood control waterworks	NRM
54241 ex	General construction services of long-distance pipelines [Pipelines for carrying water or hydrogen gas]	CRE
54242	General construction services of long-distance communication and power lines	CRE
54251 ex	General construction services of local pipelines [Pipelines for carrying water, sewage, or hydrogen gas]	CRE; WWM; WST
54252	General construction services of local cables and related works	CRE
54253	General construction services of sewage and water treatment plants	WWM; WST
54262 ex	General construction services of power plants [Plants powered by renewable energy]	CRE
54290 ex	General construction services of other civil engineering works [of waste dumps or waste incinerators]	SHWM; WWM; WST
54320 ex	Site formation and clearance services [related to soil stabilization; related to test drilling and boring and core extraction services for construction, geophysical, geological or similar purposes]	EMAA
54330 ex	Excavating and earthmoving services [for the purposes of land-based recreation or the stripping of contaminated topsoil]	ERC;
54341	Water well drilling services	WST

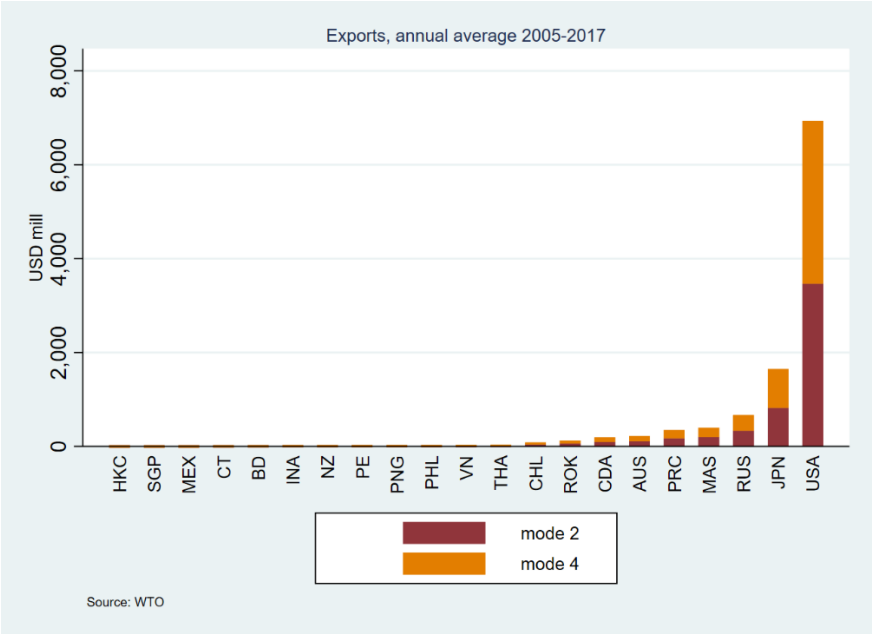
54342	Septic system installation services	WWM
54400 ex	Assembly and erection of prefabricated constructions [Public toilets]	WWM
54550 ex	Structural steel erection services [of prefabricated structural steel components for overhead cranes or electricity transmission towers]	CRE
54631	Heating equipment installation services	CRE; EE
54650	Insulation services	EE
54760 ex	Joinery and carpentry services [for prefabricated, insulated doors and double- or triple-paned windows]	EE
65219 ex	Other coastal and transoceanic water transport services of other freight [coastal and transoceanic water transportation of components of off-shore renewable energy plants and equipment for installing, repairing, or maintaining them]	CRE
73111 ex	Leasing or rental services concerning cars and light vans without operator [for electric vehicles]	ACT
73240 ex	Leasing or rental services concerning pleasure and leisure equipment [for bicycles]	ACT
81139 ex	Experimental development services in other natural sciences [environmental sciences not elsewhere classified]	EMAA
83221 ex	Urban planning services [studies of environmental impact and economic assessments of urban development plans]	OTH
83231 ex	Landscape architectural advisory services [related to natural landscapes]	PBL
83232 ex	Landscape architectural services [related to natural landscapes]	PBL
83324 ex	Engineering services for power projects [Power projects based on renewable energy]	CRE
83326	Engineering services for waste-management projects (hazardous and non-hazardous)	SHWM; WWM
83327	Engineering services for water, sewerage and drainage projects	
83327 ex	Engineering services [related to systems for the collection, distribution, or treatment, of water, including desalinization]	WST
83327 ex	Engineering services [related to systems for the collection, distribution, treatment and disposal of wastewater]	WWM
83327 ex	Engineering services [related to systems for systems for stormwater management]	NRM
83411	Geological and geophysical consulting services	
83411 ex	Geological and geophysical consulting services [related to groundwater]	WST

83411 ex	Geological and geophysical consulting services [related to the evaluation of geological, geophysical and geochemical anomalies]	NRM; SHWM
83412	Geophysical services	
83412 ex	Geophysical services [related to carbon, capture and storage]	EMAA; APC
83412 ex	Geophysical services [related to natural risk management]	EMAA; NRM
83441 ex	Composition and purity testing and analysis services	EMAA; APC; ERC; SHWM; WWM
83442	Testing and analysis services of physical properties	EE; EMAA
83931	Environmental consulting services	EMAA
85340 ex	Specialized cleaning services [Cleaning services for reservoirs and tanks, these being parts of either industrial sites; furnace and chimney cleaning services; cleaning of furnaces, incinerators, boilers, ventilation ducts and exhaust units]	APC; ERC
85970 ex	Landscape care and maintenance services [Planting, care and maintenance services of stationary and flowing water (basins, alternating wet areas, ponds, ditches, watercourses, sewage-treatment systems) and of plants for protection against noise, wind, erosion, visibility and dazzling]	NVA; PBL; WWM
87152 ex	Maintenance and repair services of electrical machinery and apparatus n.e.c. [Maintenance and repair of generators powered by renewable energy and smart grids]	CRE
87154 ex	Maintenance and repair services of medical, precision and optical instruments [Precision and optical instruments used for environmental monitoring or analysis]	EMAA
89410	Metal waste and scrap recovery (recycling) services, on a fee or contract basis	SHWM
89420	Non-metal waste and scrap recovery (recycling) services, on a fee or contract basis	SHWM
94110	Sewerage and sewage treatment services	WWM
94120	Septic tank emptying and cleaning services	WWM
94211	Collection services of hazardous medical and other biohazardous waste	SHWM
94212	Collection services of industrial hazardous waste (except medical and other biohazardous waste)	SHWM
94219	Collection services of other hazardous waste	SHWM
94221	Collection services of non-hazardous recyclable materials, residential	SHWM
94229	Collection services of non-hazardous recyclable materials, other	SHWM
94231	General waste collection services, residential	SHWM

94239	General waste collection services, other	SHWM
94311	Hazardous waste preparation, consolidation and storage services	SHWM
94312	Ship-breaking and other dismantling of wrecks services	SHWM
94313	Non-hazardous recyclable materials preparation, consolidation and storage services	SHWM
94319	Other non-hazardous waste preparation, consolidation and storage services	SHWM
94321	Hazardous waste treatment services	SHWM
94322	Hazardous waste disposal services	SHWM
94331	Sanitary landfill services, non-hazardous waste	SHWM
94332	Other landfill services, non-hazardous waste	SHWM
94333	Incineration of non-hazardous waste	SHWM
94339	Other non-hazardous waste treatment and disposal services	SHWM
94411	Site remediation and clean-up services, air	ERC
94412	Site remediation and clean-up services, surface water	ERC
94413	Site remediation and clean-up services, soil and groundwater	ERC
94420	Containment, control and monitoring services and other site remediation services n.e.c.	ERC
94430	Building remediation services	ERC
94490	Other remediation services n.e.c.	ERC
94510	Sweeping and snow removal services	ERC
94590	Other sanitation services	ERC
94900	Other environmental protection services n.e.c.	NVA; OTH
95992	Services furnished by environmental advocacy groups	OTH
96422	Nature reserve services including wildlife preservation services	PBL

Appendix 4: International trade in environmental services

Figure A4.1: Trade in Waste treatment and de-pollution, agricultural and mining services, annual average 2005-2017



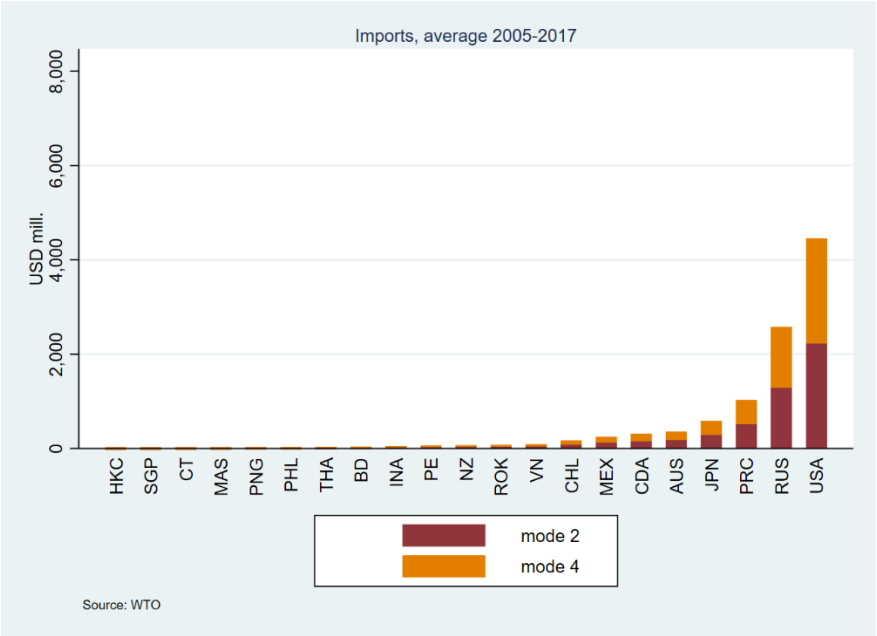


Table A4.1. Trade in environmental services, shares of gross output

	Construction		El, gas, water, sewerage, waste		Other business services		Repair, installation, other manuf.	
Economy	exports	imports	exports	imports	exports	imports	exports	imports
AUS	0.4%	0.0%	0.2%	0.3%	3.0%	4.2%	15.9%	149.2%
BD	0.1%	0.8%	0.2%	5.4%	17.6%	27.6%	0.3%	173.3%
CDA	0.2%	0.1%	5.9%	1.0%	15.4%	20.3%	26.0%	65.4%
CHL	0.0%	0.1%	0.4%	0.4%	2.1%	5.4%	4.8%	35.9%
PRC	0.0%	0.0%	0.7%	0.2%	0.8%	3.0%	29.4%	5.8%
HKC	0.0%	0.3%	2.5%	1.1%	46.2%	22.8%	21.4%	29.8%
INA	0.0%	0.1%	0.0%	0.8%	38.8%	45.6%	66.1%	24.4%
JPN	0.0%	0.1%	0.0%	0.2%	9.7%	11.7%	26.6%	82.5%
ROK	0.1%	0.1%	0.1%	0.5%	9.9%	22.6%	16.8%	29.8%
MAS	0.3%	0.4%	0.1%	1.3%	52.1%	56.6%	44.7%	23.3%
NZ	0.3%	0.3%	0.6%	0.3%	4.6%	4.5%	25.1%	98.4%
PE	0.0%	0.1%	0.1%	1.0%	1.9%	6.8%	3.2%	10.8%
PHL	0.0%	0.2%	0.0%	0.3%	84.1%	31.2%	51.7%	18.6%
RUS	0.3%	0.2%	0.7%	0.4%	7.6%	11.7%	15.2%	33.5%
SGP	0.5%	0.3%	0.6%	1.1%	26.7%	81.6%	51.7%	46.6%
CT	0.0%	0.3%	0.0%	0.7%	43.4%	30.9%	40.2%	23.5%
THA	0.0%	0.4%	0.7%	1.4%	54.6%	51.5%	41.6%	14.1%
USA	0.0%	0.1%	0.1%	1.0%	7.6%	4.0%	8.7%	40.4%
VN	0.0%	0.1%	1.1%	3.0%	4.5%	7.2%	48.3%	9.3%

Source: OECD input-output tables.

Appendix 5: Trade barriers relevant for environmental services, 2020

Table A5.1: STRI measures, horizontal

	AUS	CDA	CHL	PRC	INA	JPN	ROK	MEX	MAS	NZ	PE	RUS	THA	USA
Horizontal, data flows														
Free cross-border transfer of personal data or application of the accountability principle	no	no	no	no	no	no	no	no	no	no	no	no	no	yes
Cross-border transfer of personal data is possible to countries with substantially similar privacy protection laws	yes	no	no	no	yes	yes	no	no	yes	yes	yes	yes	yes	yes*
Cross-border transfer of personal data is possible when certain private sector safeguards are in place	yes	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes*
Cross-border transfer of data is prohibited	no	no	no	yes	no	no	no	no	no	no	no	no	no	no
Certain data must be stored locally	no	no	no	yes	yes	no	yes	no	no	yes	no	yes	no	no
Horizontal movement of people														
Quotas: intra-corporate transferees	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Quotas: contractual and independent services suppliers	no	no	no	no	no	no	no	no	no	no	no	yes	no	yes
Labour market tests: intra-corporate transferees	yes	no	no	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	no
Labour market tests: contractual and independent services suppliers	yes	yes	no	yes	yes	no	no	no	no	yes	no	yes	yes	yes
Horizontal public procurement														
Explicit preferences for local suppliers	no	yes	no	yes	yes	no	no	yes	yes	no	no	yes	yes	yes
Technical specifications affect the conditions of competition in favour of local providers	no	no	no	no	yes	no	no	no	no	no	no	yes	no	no
Contract award on the basis of non-objective/discriminatory criteria	no	yes	no	no	no	no	no	yes	no	no	no	yes	no	no
Horizontal, other														
Acquisition and use of land and real estate by foreigners is restricted	yes	no	yes	no	yes	no	yes	yes	yes	yes	yes	yes	yes	no
Cost to obtain a business visa (USD)	105	77.6	76	81	46	7.43	40	40	14.7	128	30	80	150	160
Number of documents needed to obtain a business visa	13	10	5	6	6	7	5	9	7	6	13	4	19	4

Source: OECD

Table A5.2: STRI measures, construction

	AUS	CDA	CHL	PRC	INA	JPN	ROK	MEX	MAS	NZ	PE	RUS	THA	USA
Foreign equity restrictions: maximum foreign equity share allowed (%)	100	100	100	100	67	100	100	100	100	100	100	100	100	100
Restrictions on cross-border mergers and acquisitions (M&A)	no	no	no	yes	yes	no	no	no	no	no	no	no	yes	no
Performance requirements	no	no	yes	no	yes	no	no	yes	yes	no	yes	no	yes	no
Local presence is required for cross-border supply	yes	no	yes	no	no	yes	yes	no	yes	no	no	yes	yes	no
Foreign branches are prohibited	no	no	no	yes	yes	no	no	no	no	no	no	no	no	no
Board of directors: majority must be residents	no	no	no	no	no	no	no	no	no	no	yes	no	yes	no
Board of directors: at least one must be national	no	no	no	no	yes	no	no	no	no	no	no	no	no	no
Board of directors: at least one must be resident	yes	yes	no	no	no	no	no	no	yes	yes	yes	no	yes	no
Managers must be national	no	no	no	no	yes	no	no	no	no	no	no	no	no	no
Managers must be resident	no	no	no	no	no	no	no	no	no	no	yes	no	yes	no
Minimum capital requirements	no	no	no	no	no	yes	no	no	yes	no	no	yes	yes	no
Screening explicitly considers economic interests	yes	yes	no	no	no	no	no	yes	no	yes	no	no	yes	no
Screening exists without exclusion of economic interests	yes	no	no	yes	yes	no	no	yes	no	yes	no	yes	yes	yes
Foreign suppliers are treated less favourably regarding taxes and eligibility to subsidies	no	yes	no	no	no	no	no	no	no	no	no	no	no	yes
National, state or provincial government control at least one major firm in the sector	yes	no	no	yes	yes	no	yes	no	yes	no	no	no	yes	no
Publicly-controlled firms are exempted from the application of the general competition law	no	no	no	no	yes	no	no	no	no	no	no	no	no	no
Time required to obtain a construction permit (in calendar days)	120.5	249	195	125.5	200	108	27.5	76	41	93	137	160	113	89

Source: OECD

Table A5.3: STRI measures, engineering

	AUS	CDA	CHL	PRC	INA	JPN	ROK	MEX	MAS	NZ	PE	RUS	THA	USA
Foreign equity restrictions: maximum foreign equity share allowed (%)	100	100	100	100	67	100	100	100	100	100	100	100	100	100
Equity restrictions applying to not licensed individuals or firms	100	100	100	100	100	100	100	100	0	100	100	100	49	100
Restrictions on cross-border mergers and acquisitions (M&A)	no	no	no	yes	yes	no	no	no	no	no	no	no	yes	no
Performance requirements	no	no	yes	no	yes	no	no	yes	no	no	yes	no	yes	no
Commercial presence is required in order to provide cross-border services	no	no	no	no	yes	no	yes	no	yes	no	no	no	yes	no
Local presence is required for cross-border supply	yes	no	no	no	no	yes	yes	yes	yes	no	no	yes	no	no
Localisation requirements for professional liability insurance	no	no	no	no	no	no	no	yes	no	no	no	yes	no	no
Board of directors: majority must be residents	no	no	no	no	no	no	no	no	no	no	yes	no	yes	no
Board of directors: at least one must be national	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Board of directors: at least one must be resident	yes	yes	no	no	no	no	no	no	yes	yes	yes	no	yes	no
Board of directors: majority must be licensed professionals	no	no	no	no	no	no	no	no	yes	no	no	no	yes	no
Managers must be national	no	no	no	no	yes	no	no	no	no	no	no	no	no	no
Managers must be resident	no	no	no	no	no	no	no	no	no	no	yes	no	yes	no
Manager must be a licensed professional	no	yes	no	yes	no	no	no	no	yes	no	no	no	yes	yes
Screening explicitly considers economic interests	yes	yes	no	no	no	no	no	yes	no	yes	no	no	yes	no
Screening exists without exclusion of economic interests	yes	no	no	yes	yes	no	no	yes	no	yes	no	yes	yes	yes
Prior or permanent residency is required for Licence to practice	no	no	no	no	no	no	no	no	yes	no	no	no	no	yes
Domicile required for Licence to practice	no	no	no	no	no	no	no	yes	yes	no	no	no	no	yes
Foreign professionals are required to take a local examination	no	yes	yes	yes	no	no	yes	no	yes	yes	no	no	yes	yes

Source: OECD

Reservations and non-conforming measures in the CPTPP

Three APEC economies that are not captured in the preceding STRI measured are signatories to the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP): Brunei Darussalam; Singapore; and Viet Nam. Their reservations and non-conforming measures in the CPTPP allow a consideration of some barriers to trade.

Brunei Darussalam

- Any measure that applies to land transactions.
- Any measure with respect to supply of a service by the presence of natural persons.
- Any measure with respect to the supply of potable water.
- Local presence requirements for a number of environmental services.
- Technology transfer requirements for a number of environmental services.
- Foreign equity limits for certificate A services.

Singapore

- Any measure with respect to supply of a service by the presence of natural persons.
- Any measure affecting real estate.
- Any measure relating to or affecting collection and administration of proprietary information by national electronic systems.
- Any measure affecting four engineering services:
    - Geological, geophysical and other scientific prospecting services;
    - Subsurface surveying services;
    - Surface surveying services;
    - Map making services.
- Any measure affecting the supply of waste water management.
- Any measure affecting the supply of potable water.
- Waste management, including collection, disposal, and treatment of hazardous waste: Foreign service suppliers must be locally incorporated in Singapore.
- Distribution and Sale of Hazardous Substances: Local presence is required.

Viet Nam

- Any measure that applies to land ownership.
- Reservations on national treatment in real estate.
- Any measures related to technical testing and analysis during a transition period of five years.
- Any measure related to assistance to SMEs.
- Foreign investment to establish a commercial presence in the form of a branch may not be permitted. Branches are, however, permitted in construction and related engineering services.
- Foreign services suppliers are not allowed to supply services incidental to energy distribution.

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