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Advancing Free Trade
for Asia-Pacific Prosperity

Workshop on Technological Challenges and Opportunities to Supply Flexibility to Electric Systems

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Produced by
Carlos Rojas Zanol
Ministry of Energy, Chile

For
Asia Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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Executive Summary

The APEC Workshop on Technological Challenges and Opportunities to Supply Flexibility to Electric Systems was proposed by the Chilean Ministry of Energy in order to support the achievement of the APEC goal of doubling the share of renewables by 2030, as power system flexibility is a key aspect to achieve a sustainable, secure, reliable and efficient energy matrix.

The aforementioned project proposed a workshop and a seminar, where expert speakers and APEC representatives could discuss the latest technological trends aimed at providing flexibility, along with policy, regulatory, and market instruments, intended to improve the flexibility in power systems.

A workshop was held on the first day with the objective of sharing information on best practices within APEC economies, as well as to facilitate a dynamic discussion among APEC representatives, international expert speakers and representatives from the Chilean Ministry of Energy.

On the first-day workshop, Chilean, Thai and Malaysian representatives shared their experiences with the group. Afterwards, a panel discussion composed of these economies was held. The main conclusions of this panel were: the flexibility in power systems is a key enabler to more renewable energy participation; the flexibility can be provided by different segments in the market, like generation, transmission, demand, and storage; and it is important to adapt early and improve the market regulatory framework to promote flexibility in the power systems.

On the second day, a seminar focused on expert presentations with an invited audience from the Chilean energy sector. The seminar comprised of three sessions: the first focused on the relevance of power system flexibility to increase the share of renewables in the energy mix, the second focused on policies and regulations to enhance power system flexibility, and the third session focused on the opportunities to provide flexibility by the demand side. In this event, six experts gave presentations, and panels discussion with Chilean experts were held.

Based on the workshop and seminar discussions, some recommendations to guide regulators and policymakers were prepared. These recommendations are the following.

- The ability to easily integrate more variable renewable energy depends on the underlying flexibility of the power system. As a consequence, it is important to adapt early and improve the market regulatory framework to promote flexibility in power systems.
- Flexibility requirements in power systems are needed across different time scales, from sub-seconds to years. An appropriate electrical market design should have price signals which efficiently cover all flexibility requirements.

- The flexibility in power systems can be improved by better operation planning and practices. Therefore, an appropriate regulatory framework should contemplate a continuous improvement of the system operation planning, as the variable renewable energy forecasting, dispatch interval, and market settlement interval.
- It is important to note that flexibility can be provided by several assets in the power system, like generation, transmission, demand, and storage. An appropriate electrical market design should give market signals to all of them, not only to the generation segment. All power system assets can provide flexibility, including variable renewable energy.
- Particularly, in order to enable Demand Side Response participation on the provision of flexibility, reducing the regulatory uncertainty and clarifying possibilities within existing regulatory frameworks is needed. Additionally, it is important to increase customer awareness and knowledge of their role as an active participant.

Thirteen and forty-one attendees participated in the first and second day, respectively. The women's participation was 25% and about 30% in the first and second day, respectively. According to the survey results, in both events, the participants increased their level of knowledge of the topic discussed after participating in them.

The participants appreciated the opportunity to exchange views on technological challenges and opportunities to supply flexibility to electric systems, as well as international experiences and best practices on market regulation and policies to improve flexibility in power systems.

Introduction

This document has been prepared by the Chilean Ministry of Energy to present a summary of the results of the workshop “Technological challenges and opportunities to supply flexibility to electric systems”, held on October 21st and 22nd, 2019, in Santiago Chile.

The Chilean Ministry of Energy proposed to APEC a project to conduct a workshop and a seminar, where expert speakers and APEC representatives could discuss the latest technological trends aimed at providing flexibility, along with policy, regulatory, and market instruments, intended to improve the flexibility in power systems.

The above-mentioned project intends to support the achievement of the APEC goal of doubling the share of renewables by 2030, as power system flexibility is a key aspect to move forward and reach a sustainable, secure, reliable and efficient energy matrix.

A workshop was held on the first day with the objective of sharing information on best practices within APEC economies, as well as to facilitate a dynamic discussion among APEC representatives, international expert speakers and representatives from the Chilean Ministry of Energy.

On the second day, a seminar focused on expert presentations with an invited audience from the Chilean energy sector was held. In this seminar, six experts presented, and panels discussion with Chilean experts were held.

The following chapter presents the background of the project. The fourth chapter presents the workshop overview, including the project description and objectives, the summary of the first and second day, and an analysis of the results. The fifth chapter contains the main conclusions obtained in the workshop and some recommendations to policy and regulation makers. Finally, the last chapter is the appendix of this document.

Background

The Asia-Pacific Economic Cooperation (APEC) has set two energy-related regional aspirational goals. The first seeks to reduce APEC's aggregate energy intensity by 45% from 2005 levels by the year 2035 (established in the 2011 APEC Economic Leaders Declaration), and the second seeks to double the share of renewables in the APEC energy mix by 2030 (established in the 2014 APEC Economic Leaders Declaration).

In 2018, the APEC Publication "Filling the Gap to Double Renewable Energy in the APEC Region" noted that solar accounts for 41.2% of the total renewable energy potential of the APEC Region, while wind energy accounts for 36.7%. Given that the energy produced by Variable Renewable Energy (VRE) sources such as solar and wind is not constant, power systems must incorporate technologies, or other alternatives, that will enable them to compensate for the varying levels of energy production from some renewables. Since solar and wind energies represent a significant proportion of the APEC region's renewable energy potential, enabling power systems to incorporate these variable renewable energies is vital to achieving the aforementioned APEC goal.

Furthermore, according to the 6th APEC Energy Demand and Supply Outlook prepared by the Asia-Pacific Energy Research Centre, renewables are the fastest-growing energy source in the region and "all APEC economies have made commitments to promote the use of renewable power generation and have implemented a variety of policies to support wider adoption of renewable technologies". The Outlook also projects that variable renewable energies will increase significantly in upcoming years and could reach 30% of peak load in APEC by the year 2040, and therefore, "to integrate VREs while maintaining reliability of electricity supply, each economy needs to prepare sufficient measures to manage short-term variability (in general, less than 20 minutes) and longer-term variability (hourly, daily and seasonally), such as ramping up and down of flexible generation, charging and discharging of storage, demand-side management programs, and curtailments".

Although diverse strategies will be used by economies in order to support improved energy efficiency and increased renewable energies, common challenges related to power system flexibility will be faced. In this context, the decommissioning of thermal power plants, the decreased costs for renewable energy generation, the growing energy distributed systems development, as well as the energy resilience needs, are bringing new challenges for electric systems, such as the flexibility needed to manage them under variable resources and demand.

Even in presence of market and regulatory actions that may be made in individual economies, the need to understand the technological alternatives that can provide this flexibility, as well as their cost, benefits, scopes, and trends, are cross-cutting. The understanding of these alternatives directly affects the future development of the electric system in economies, opens possibilities for

the creation of new industries, and it is the grounding to formulate proper regulatory frameworks.

Increasing the flexibility of electricity systems is a challenge that will be faced throughout the world, as more variable renewable energy sources (such as solar and wind) are increasingly used. This challenge will be faced by both developed and developing economies. Some developed economies are at the forefront of efforts to meet this challenge, and it is beneficial when economies already have robust electricity grids.

Workshop Overview

Project objectives and brief description

The objectives of the project proposed by the Chilean Ministry of Energy were as the following:

- Create a space for sharing knowledge and experience about cross-cutting technological alternatives to provide flexibility to the electric systems, in order to accelerate the deployment of solutions.
- Present the experiences of economies and share the learnings about the deployment of solutions related to power systems flexibility.
- Develop recommendations based on international experiences related to the critical aspects of the market and regulatory challenges that may be of relevance to economies in order to encourage flexibility under specific conditions.

The project comprised of two events: a seminar focused on expert presentations with an invited audience from the Chilean energy sector and a workshop focused on a more dynamic discussion among APEC representatives, international expert speakers and representatives from the Chilean Ministry of Energy. These events were carried out on October 21st and 22nd, 2019, in Santiago Chile.

First-day summary: Workshop

The objective of the first-day workshop was sharing information on best practices within APEC economies, as well as to facilitate a dynamic discussion among APEC representatives, international expert speakers and representatives from the Chilean Ministry of Energy. In this event, Chilean, Thai, and Malaysian representatives shared their experiences with the group.

The general structure of this event was the following:

- ❖ Welcome remarks
- ❖ Presentations by APEC representatives
  - Chile
  - Thailand
  - Malaysia
- ❖ Panel discussion and questions

The workshop began with the welcome remarks by Mr Gabriel Prudencio, Head of Sustainable Energy Division at the Chilean Ministry of Energy, who highlighted the energy transition facing power systems around the world and also in Chile.

This transition includes decarbonization of the energy matrix, distributed energy generation development, demand response, storage, electromobility, more participation of variable renewable energy, and other elements. These changes in power systems involve new challenges to cope with variability and uncertainty in both generation and demand. In this context, power system flexibility will play an important role.

Additionally, Mr Prudencio mentioned the Chilean commitments: the goal of carbon neutrality by 2050; retirement of coal power plants by 2040; and the promoting of non-conventional renewable energies, distributed energy generation, electromobility, energy efficiency, electrification of several consumptions, and other policies.

Afterwards, representatives from Chile, Thailand, and Malaysia delivered presentations to the group.

The Chilean presentation was given by Mr Francisco Martínez, Head of the Regulatory Support Unit at the Chilean Ministry of Energy. Firstly, the presentation highlighted the Chilean commitments related to carbon neutrality by 2050 and the retirement of coal power plants by 2040, emphasizing that these commitments and other policy goals require flexibility in the Chilean power system.

Secondly, Mr Martínez noted the Chilean Ministry of Energy is currently working on a market-regulatory plan aimed at improving the flexibility in the Chilean power system, called the “Flexibility Strategy”. In this plan, a preliminary definition of flexibility has been established, corresponding to “the ability of an electric system to respond to the variability and uncertainty of supply and demand, securely and efficiently, in all time scales”.

Then, Mr Martínez highlighted that the flexibility of power systems can be improved, or provided, through changes in market design, operational practices, generation, demand, transmission, and storage.

According to results obtained in the Chilean Flexibility Strategy, two future flexibility-requirements in the Chilean power system have been identified: the capacity to cover the net load ramp and the system inertia; and a current lack of regulatory framework to improve power system flexibility, such as a market signal to promote flexibility in the generation segment, enable the participation of storage in the electrical market, the dispatch interval, the market settlement interval, the improvement of the system operation planning and the variable energy forecasting.

Finally, Mr Martínez presented the three main pillars are being considered in the Flexibility Strategy, (1) Stablish a long term market signal to recognize flexibility, (2) Enable the participation of storage energy systems and harness their diverse features, and (3) Improve elements of the operation planning and real-time operation.

The second presentation was performed by Mr Yaowateera Achawangkul, Senior Professional Mechanical Engineer of the Department of Alternative Energy Development and Efficiency at the Thailand Ministry of Energy. The presentation began by showing an overview of the overall Thailand energy system. Then, the Thailand energy strategic plan called “Thailand Integrated Energy Blueprint” (TIEB) was described.

Additionally, Mr Yaowateera presented renewable energy power generation under the latest Power Development Plan (PDP 2018). He described the structure of Thailand’s Electricity Supply Industry, the status of power generation and transmission system in Thailand, and the Renewable Energy Forecast Center, which is currently in a developing process (it began in 2018 and it is expected to be implemented in the National Control Center in 2021).

Finally, Mr Yaowateera presented some results of the IEA study called “Thailand Renewable Grid Integration Assessment” that undertakes a comprehensive analysis covering the technical, economic, and policy and regulatory frameworks. In this study, the economic impact of flexibility options was analyzed. According to this study, the key findings to unlock flexibility in Thailand are: (1) Modeling results suggest that wind and solar resources have highly complementary generation profiles to one another, allowing a contribution to both midday peak demand and evening peak demand; (2) Fuel supply contract flexibility is a key strategy for encouraging power system transformation; (3) Thermal plants will be required to cycle up and down more with higher shares of Variable Renewable Energy; and (4) Demand Side Management, Electromobility, storage, and plant flexibility leads to a more steady use of the system.

The following presentation was performed by Ms Rina Haiges, Principal Assistant Secretary at the Ministry of Energy, Science, Technology, Environment and Climate Change, Malaysia.

Ms Haiges presented a general overview of Malaysia's electricity sector, including the annual evolution of the energy demand and supply by type, the installed capacity by type, the coal power plants installed by region, and the balance fuel mix. Then, Ms Haiges described the regulatory framework in Malaysia and the policies related to the electricity supply industry. Finally, Malaysia’s representative described the Incentive-based Regulation (IBR) that was introduced in early 2014 for the electricity subsector, as part of the modernization of the electricity supply industry.

Afterward, a panel discussion was made up, composed of Mr Martínez, Mr Yaowateera, and Ms Haiges, from Chile, Thailand, and Malaysia, respectively. Furthermore, questions from the audience to the panel were received. The main aspects discussed on the panel were: challenges of power systems due to the energy transition, flexibility requirements in power systems, policies and regulations to improve flexibility in power systems, how to cover net load ramp requirements, who should pay for the renewable energy forecast deviations, and others aspects related to the topic.

In summary, the main conclusions of this panel were: the flexibility in power systems is a key enabler to more renewable energy participation; flexibility can be provided by different segments in the market, like generation, transmission, demand, and storage; and it is important to early adapt and improve the market regulatory framework to promote flexibility in the power systems.

Second-day summary: Seminar

A seminar focused on expert presentations was carried out on the second day. An invited audience from the Chilean energy sector attended this event.

The general structure of this event was the following:

- Welcome remarks
- First session: Flexibility for the energy transition
  - Two presentations
  - Panel discussion and questions
- Second session: Policies and regulations to enhance power system flexibility
  - Two presentations
  - Panel discussion and questions
- Third session: Boosting power system flexibility with distributed energy resources
  - Two presentations
  - Panel discussion and questions

The agenda for this event can be found in the Appendix of this document.

The seminar began with the welcome remarks by Mr Gabriel Prudencio, Head of Sustainable Energy Division at the Chilean Ministry of Energy, who highlighted the energy transition facing power systems around the world and also in Chile.

This transition includes decarbonization of the energy matrix, distributed energy generation development, demand response, storage, electromobility, more participation of variable renewable energy, and other elements. These changes in power systems involve new challenges to cope with variability and uncertainty in both generation and demand. In this context, power system flexibility will play an important role.

Additionally, Mr Prudencio mentioned the Chilean commitments: the goal of carbon neutrality by 2050; retirement of coal power plants by 2040; and the promoting of non-conventional renewable energies, distributed energy generation, electromobility, energy efficiency, electrification of several consumptions, and other policies.

The second welcome remarks were given by Mr Mathias Francke, SOM Chair APEC Chile, who highlighted the government efforts to accelerate the energy transition to a more sustainable economy, emphasizing the goal of carbon neutrality by 2050 and the retirement of coal power plants by 2040. Additionally, Mr Francke noted these seminars technically support moving forward to a sustainable energy matrix.

First session: Flexibility for the energy transition

The first presentation was performed by Mr Enrique Gutiérrez, Energy Analyst at the International Energy Agency (IEA). The presentation began by showing some IEA's projections that concluded solar photovoltaic drives strong growth in the renewable capacity expansion (renewables expand by 50% through 2024), and clean electricity sources have the potential to become the largest source of electricity generation by 2040.

Mr Gutiérrez described the Power System Flexibility Campaign Network that brings together public and private sector stakeholders, through a series of interviews, workshops and high-level events, in order to identify policy priorities for power system flexibility.

Then, Mr Gutiérrez noted IEA has defined six phases of Variable Renewable Energy integration in power systems. These phases have particular transitions challenges. In this context, power system flexibility is a relevant element to integrate more Variable Renewable Energy, and flexibility is needed across different time scales from sub-seconds to years. He also noted that requirements of flexibility can be grouped into short-term, medium-term, and long-term needs.

Five Variable Renewable Energy characteristics underpin three types of system effects, and the magnitude depends on Variable Renewable Energy share and system flexibility. Variability has a profile effect, uncertainty and non-synchronous have balancing effects, and modularity and location-constraint have grid effects.

Regarding the system cost due to flexibility requirements, flexible technologies as Demand-side response, Electricity storage, Interconnection, Flexible generation, can minimize the long-term system cost.

He highlighted that appropriate policy, market, and regulatory frameworks are key factors to unlock power system flexibility and can enable participation from a broad range of power system assets (all power system assets can provide flexibility, including Variable Renewable Energy).

Mr Gutiérrez also mentioned electricity networks remain a critical enabler of system flexibility (Inter-regional and international coordination can yield significant economic benefits), batteries are becoming a cost-competitive flexibility provider (Prequalification requirements and the design of flexibility

services are key to enable battery storage in flexibility services), and Demand Side Response is valuable with high Variable Renewable Energy.

Finally, Mr Gutiérrez presented some takeaways:

- Flexibility will continue becoming increasingly important in the coming years as Variable Renewable Energy becomes increasingly cost-competitive.
- The ability to easily integrate Variable Renewable Energy depends on the underlying flexibility of the power system.
- While small shares of Variable Renewable Energy may not represent a challenge for system operation, acting early-on is an area opportunity to maximize the value from various flexibility sources.
- In many cases, the policy and regulatory framework will need to adapt to catch-up with technology.
- System and market operations are key to enable a level-playing field.

The second presentation was performed by Mr Ernesto Huber, Operation Manager at Coordinador Eléctrico Nacional (Chilean Independent System Operator). The presentation began by showing a general overview of the Chilean power system.

Mr Huber presented the impressive potential in Chile of renewable resources: more than 1,865 GW of wind, solar and hydro energy; more than 2,000 MW of geothermal; and 2,000 MW of biomass. Additionally, he showed the current situation and the challenges of integrating variable renewable energy in Chile. These challenges mainly correspond to transmission constraints in the north of Chile, liquefied natural gas inflexible, and security constraints.

Also, some sources of flexibility were presented: interconnections, thermal power plants, transmission systems, demand-side response, and storage system. In this context, Mr Huber highlighted the lack of availability of reservoirs in the Chilean system to provide flexibility, given the drought conditions of the last years.

Finally, Mr Huber presented some perspectives of the challenges for the near future in the Chilean power system: the decarbonization plan, which includes coal power plant retirement; increasing the installed capacity of non-conventional renewable energy; how to cover the net load ramps given by duck curves; the growth of distributed Energy Resources, promoted by policies; the massive integration of power electronics; Dynamic Digital Mirror in the control room; electricity consumption increase; climate change adaption and mitigation; and transmission and distribution development (new HVDC lines, flexibility requirements, etc.).

Afterwards, a panel discussion was convened, composed of Mr Gutiérrez, Mr Huber, and Mr Rodrigo Palma, professor at Universidad de Chile. Furthermore, questions from the audience to the panel were received. The main aspects discussed on the panel were: the challenges of the Chilean power system, the

hurry of flexibility in the Chilean system, policies and regulations to improve the flexibility in power systems, the relevance of Distributed Energy Resources in the flexibility, if it is necessary to create a new market for flexibility or adapt the current markets, and others aspects related to this topic.

Second session: Policies and regulations to enhance power system flexibility

The third presentation was performed by Ms Marielle Lahti, Director of Smart Grids and Electricity markets at Swedish Smart Grid Forum. The presentation began by showing a general overview of the drivers for a transition in Sweden that includes the ONU's sustainable development goals number seven, eight and eleven, corresponding to affordable and clean energy; industry, innovation and infrastructure; and sustainable cities and communities; respectively. She highlighted that some Sweden targets are no net emissions of greenhouse gases after 2045, 100% renewable electricity production by 2040, and 50% more energy efficient energy usage 2030 compared to 2005.

Ms Lahti also presented an overview of the Swedish electricity market, describing: interconnections, electricity prices, the structure of the Swedish market, and the electricity production mix. Then, she described some relevant aspects of smart grids, smart cities and the elements that involve them: electrical vehicles, renewable energy, storage, smart traffic/transport, smart homes, smart meters, flexible demand, among others. In this context, information, communication, and coordination among these elements are fundamental for a well-functioning smart grid.

Afterward, the key elements in the market design to enabling the system flexibility were presented by Ms Lahti. These elements are:

- Price signals need to be correct and reach actors; metering is a key factor.
- Review and possibly adjust concession and license frameworks to avoid unnecessary barriers to new initiatives and local energy communities.
- Increase customer awareness and knowledge in their role as an active participant.
- Reduce or remove incentive distortions between OPEX and CAPEX as these may create entry barriers for new technology and service providers and technological lock-in.
- Role of the Distribution System Operator, network regulation, and network tariff design.

Additionally, Ms Lahti presented some recommendations aimed to enable power system flexibility:

- Seek a market design that provides reliable electricity at least cost to consumers while maximizing market efficiency.

- Work towards regulations that stimulate the right investments while managing customer interests.
- Need to manage tradeoffs between technical neutrality and the transformative acceleration of, for example, smart infrastructure.
- Need to reduce regulatory uncertainty and clarify possibilities within existing frameworks.

Then, the Swedish action plan to increase demand-side flexibility was described. This plan comprises four steps: first, increase the customer awareness of demand-side flexibility; second, map the potential for demand-side flexibility and identify aids to realizing the potential practically; third, promote demand-side flexibility by giving customers information on options; and fourth, promote demand-side flexibility by creating incentives for customers to offer their flexibility to actors.

Finally, Ms Lahti presented some conclusions:

- The Distribution System Operator should primarily have incentives to buy flexibility services.
- New and existing markets for flexibility need to be developed and coordinated.
- The network regulation needs to be adjusted so that there are correct incentives for buying flexibility services.
- Models for reimbursement to relevant actors when flexibility is activated needs to be developed, particular with regards to balancing responsible parties.

The fourth presentation was performed by Mr Francisco Martínez, Head of the Regulatory Support Unit at the Chilean Ministry of Energy. Firstly, the presentation highlighted the Chilean commitments related to carbon neutrality by 2050 and the retirement of coal power plants by 2040, emphasizing that these commitments and other policy goals require flexibility in the Chilean power system.

Secondly, Mr Martínez noted the Chilean Ministry of Energy is currently working on a market-regulatory plan aimed to improve the flexibility in the Chilean power system, called “Flexibility Strategy”. In this plan, a preliminary definition of flexibility has been established, corresponding to “the ability of an electric system to respond to the variability and uncertainty of supply and demand, securely and efficiently, in all time scales”.

Then, Mr Martínez highlighted that the flexibility of power systems can be improved or provided through changes in market design, operational practices, generation, demand, transmission, and storage.

According to results obtained in the Chilean Flexibility Strategy, two future flexibility-requirements in the Chilean power system have been identified: the capacity to cover the net load ramp and the system inertia; and a current lack of regulatory framework to improve power system flexibility, such as a market

signal to promote flexibility in the generation segment, enable the participation of storage in the electrical market, the dispatch interval, the market settlement interval, the improvement of the system operation planning and the variable energy forecasting.

Finally, Mr Martínez presented the three main pillars are being considered in the Flexibility Strategy, corresponding to (1) Stablish a long term market signal to recognize flexibility, (2) Enable the participation of storage energy systems and harness their diverse features, and (3) Improve elements of the operation planning and real-time operation.

Afterward, a panel discussion was made up, composed of Ms Lahti, Mr Martínez, and Ms Carolina Zelaya, lawyer and energy-expert consultant. Furthermore, questions from the audience to the panel were received. The main aspects discussed on the panel were: the flexibility sources in the Chilean and Swedish power systems, the role of Demand Side response on flexibility, the Chilean Flexibility Strategy that is currently in process, and policies and regulations to improve the flexibility in power systems.

Third session: Boosting power system flexibility with distributed energy resources

The fifth presentation was performed by Mr Thomas Gereke, Senior Management Consultant e-Mobility Infrastructure at Siemens. The presentation began by showing the three major factors that drive the transformation of energy systems: decarbonization, decentralization, and digitalization. In this transformation, e-Mobility is becoming an essential element.

The presentation showed the main drivers for e-Mobility adaption, which are: a clean air strategy, reducing emissions, and noise; sector coupling, renewable integration; integrated mobility concept; decreasing prices for battery packs; attractiveness, declining acquisition costs and total cost of ownership; driving range, continuous increase of electromobility driving range; and Infrastructure and applications.

Additionally, Mr Gereke presented some future perspectives of electromobility deployment, charging infrastructure, the challenges for the planning of e-Mobility infrastructure locations, and an overview of charging technologies (current and near future).

An overview of the e-Mobility roles in Europe and an overview of e-Mobility aspects for the installation of charging infrastructure were presented. Then, the possible impacts on the grid giving the charging of electro vehicles were described.

Finally, Mr Gereke highlighted the importance of preparing the future distribution networks, taking into account expansion, intelligent network

operation, manage the stress, and enable new actor's participation (electromobility, distributed energy resources, small storage, and others).

The sixth presentation was performed by Mr Max Luke, Consultant at NERA Economic Consulting. The presentation began by showing the US Demand Response programs, which were designed to reduce peak demand and costs. California and Wisconsin authorized the first Demand Response programs in 1975 and several states followed in the 1980s-1990s. Demand Response in the US began to participate in wholesale electricity markets in the 2000s. Nowadays, US utility companies have contracts with customers for more than 20 GW of demand response capacity.

Currently, Demand Response providers contribute more than 23 GW of capacity to wholesale power markets in the US. Most of the wholesale market revenue for Demand Response is earned through capacity markets. It is important to mention that Demand Response is the largest Distributed Energy Resource in the US (compared to rooftop solar photovoltaic, electromobility charging demand and grid-connected batteries).

Mr Luke highlighted that weekly, daily and hourly load shifting is valuable in systems with high penetrations of wind and solar generation, and he highlights growth in "behind-the-meter" (BTM) energy technologies could enable new types of load flexibility and localized grid investment deferral.

Finally, Mr Luke presented some actions at the federal and state government levels that have helped and hindered the promotion of flexibility services.

Afterward, a panel discussion was made up, composed of Mr Gereke, Mr Luke and Ms Daniela González, Director Partner at Domo Legal. Furthermore, questions from the audience to the panel were received. The main aspects discussed on the panel were: the opportunities of electric vehicles to provide services to the grid, such as flexibility services; how much the provision of services to the grid can affect the battery life of an electric vehicle; the importance of demand aggregators to provide services to the grid with demand response; and what are the key elements to promote Demand Response to provide flexibility.

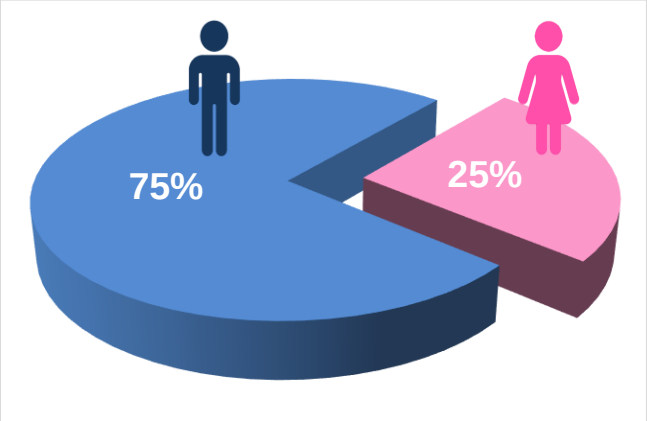
Results analysis

First-day workshop

Thirteen attendees participated in the first day, including four APEC representatives (Chile, Thailand, Malaysia, and Viet Nam), four international experts, and five representatives from the Chilean Ministry of Energy.

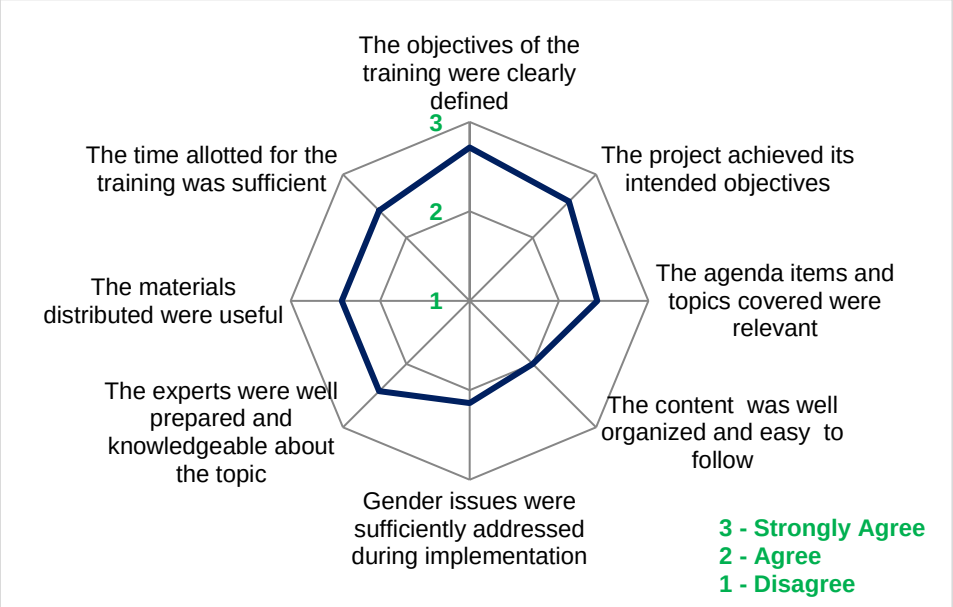
Regarding participation by gender of active participants in the discussion (APEC representatives and international experts), 25% were women and 75% men. The following figure shows this result.

Figure 1: Workshop – Participation by gender



During the event, an evaluation survey was circulated among the active participants in the discussion (APEC representatives and international experts). The following figure shows the average answers to some aspects asked on the survey.

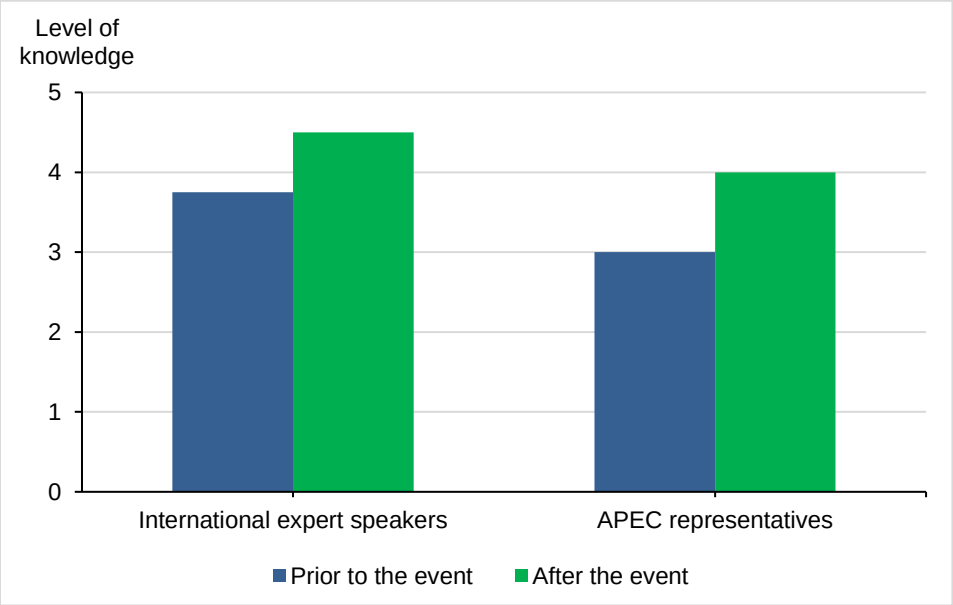
Figure 2: Workshop survey – Average answers to some aspects asked



The survey asked, “How relevant was this project to you and your economy”. The answer options to this question were: not much, a little, somewhat, mostly, and very. APEC representatives answered mostly and very, which indicates the topic is quite relevant to the APEC economies.

Additionally, the level of knowledge of the topic prior to and after participating in the event was asked to the participants. Both APEC representatives and international experts increased their level of knowledge on the topic after participating in the event, as can be seen in the following figure.

Figure 3: Workshop survey – Level of knowledge



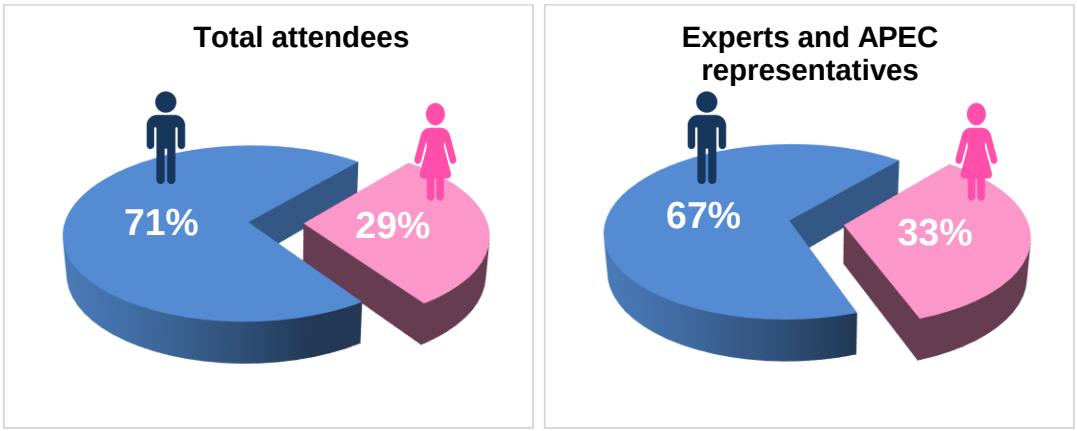
Links to the answered surveys can be found in the Appendix of this document.

Second-day seminar

Forty-one attendees participated in the second day, including three APEC representatives (Thailand, Malaysia, and Viet Nam), nine experts (internationals and Chileans), and an invited audience from the Chilean energy sector.

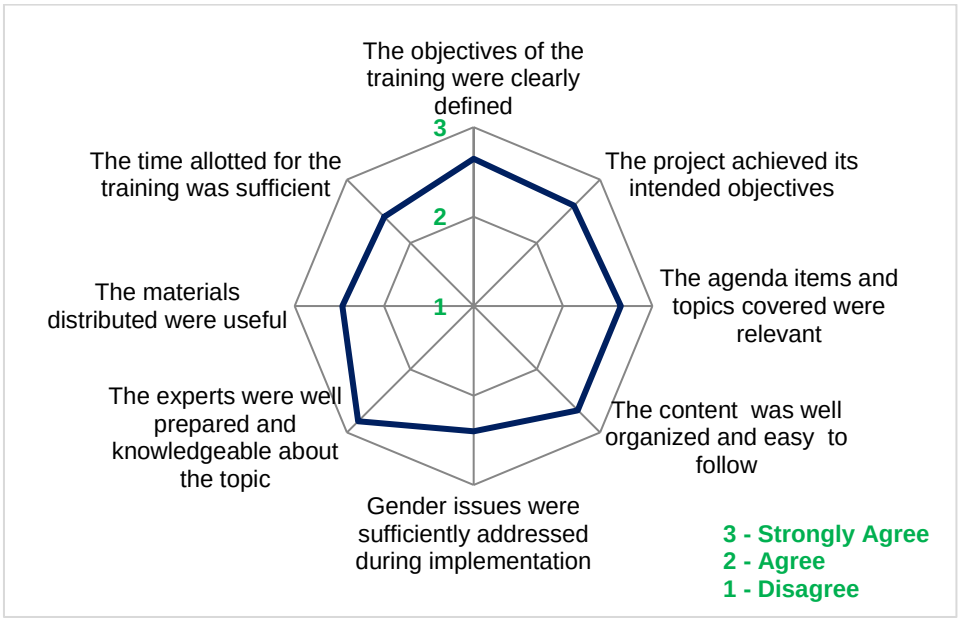
Regarding participation by gender, on one hand, considering APEC representatives and experts, 33% were women and 67% men. On the other hand, considering the whole attendees, 29% were women and 71% men. The following figure shows these results.

Figure 4: Seminar – Participation by gender



During the seminar, an evaluation survey was circulated among the attendees. The following figure shows the average answers to some aspects asked on the survey.

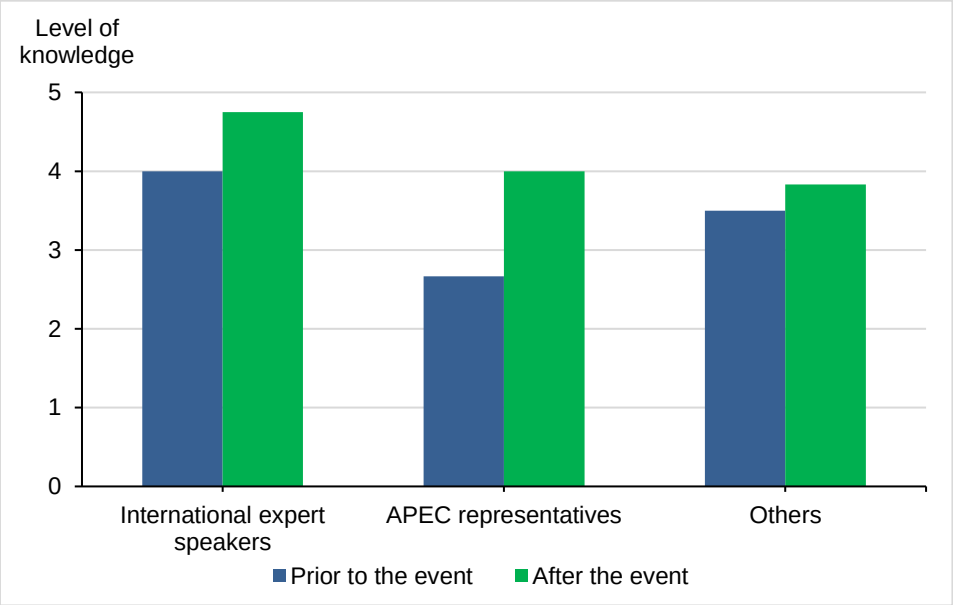
Figure 5: Seminar survey – Average answers to some aspects asked



The survey asked, “How relevant was this project to you and your economy”. The answer options to this question were: not much, a little, somewhat, mostly, and very. APEC representatives answered mostly and very, which indicates the topic is quite relevant to the APEC economies.

Additionally, the level of knowledge of the topic prior to and after participating in the event was asked to the participants. All attendees increased their level of knowledge on the topic after participating in the event, as can be seen in the following figure.

Figure 6: Seminar survey – Level of knowledge



Links to the answered surveys can be found in the Appendix of this document.

Conclusion and Recommendations

In summary, the workshop on technological challenges and opportunities to supply flexibility to electric systems was smoothly carried out, where expert speakers and APEC representatives could discuss the latest technological tendencies aimed at providing flexibility, along with policy, regulatory, and market instruments, intended to improve the flexibility in power systems.

The participants of the workshop and seminar shared knowledge and experience about cross-cutting technological alternatives to provide flexibility to the electric systems. They reviewed the best practices and experiences of economies and share the learnings about the deployment of solutions related to power systems flexibility.

According to the survey results, in both events, the participants increased their level of knowledge of the topic discussed after participating in them. Regarding participation by gender, woman participation was 25% and about 30%, on the first and second day, respectively.

Based on the workshop and seminar discussions, some recommendations to guide regulators and policymakers were prepared. These recommendations are the following.

- The ability to easily integrate more variable renewable energy depends on the underlying flexibility of the power system. As a consequence, it is important to adapt early and improve the market regulatory framework to promote flexibility in the power systems.
- The flexibility requirements in power systems are needed across different time scales, from sub-seconds to years. An appropriate electrical market design should have price signals which efficiently allow cover the whole flexibility requirements.
- The flexibility in power systems can be improved by better operation planning and practices. Therefore, an appropriate regulatory framework should contemplate a continuous improvement of the system operation planning, as the variable renewable energy forecasting, dispatch interval, market settlement interval, among others.
- It is important to note that flexibility can be provided by several assets in the power system, like generation, transmission, demand, and storage. An appropriate electrical market design should give market signals to all of them, not only to the generation segment. All power system assets can provide flexibility, including variable renewable energy.
- Particularly, in order to enable the Demand Side Response participation in the provision of flexibility, reducing the regulatory uncertainty and clarifying possibilities within existing regulatory frameworks is needed. Additionally, it is important to increase customer awareness and knowledge of their role as an active participant.

The participants appreciated the opportunity to exchange views on technological challenges and opportunities to supply flexibility to electric

systems, as well as international experiences and best practices on market regulation and policies to improve flexibility in power systems.

Also, the participants expressed a strong desire to maintain the contacts they had established during the workshop and seminar, and their deep appreciation to the organizers of the events for the efficient organization and the warm hospitality extended to them.

Appendix

The following appendix contains links to the presentations exposed during the workshop and seminar, links to the answered surveys for the workshop and seminar, and the seminar agenda.

Links to presentations

- Presentations exposed during the workshop (October 21st) can be found in the following link: https://www.dropbox.com/sh/hjyel861wiswm1b/AADMNfwQ0GM4Gfh0_ZechXQda?dl=0

- Presentations exposed during the seminar (October 22nd) can be found in the following link: https://www.dropbox.com/sh/16x654jy9hln6w9/AAAPrn3XFQGUo9vdWZxSmEyQa?dl=0

Links to surveys

- Answered surveys for the workshop (October 21st) can be found in the following link: https://www.dropbox.com/s/qrxsj71ugjeccsb/EWG%2015%202018%20-%20Survey%20-%20October%2021st.pdf?dl=0

- Answered surveys for the seminar (October 22nd) can be found in the following link: https://www.dropbox.com/s/yiwd4wdq1q2kzhd/EWG%2015%202018%20-%20Survey%20-%20October%2022nd.pdf?dl=0

Seminar agenda

Agenda - October 22nd	
09:40 – 10:00	Registration
10:00 – 10:20	Welcome remarks Gabriel Prudencio, Head of Sustainable Energy Division, Ministry of Energy Mathias Francke, APEC Chile SOM Chair
Flexibility for the energy transition	
10:20 – 11:20	**Expert speaker presentations and panel discussion** • ***Luis Enrique Gutiérrez Tavarez*** *Energy Analyst – System Integration of Renewables* *International Energy Agency* • ***Ernesto Huber*** *Operation Manager* *Coordinador Eléctrico Nacional* • ***Rodrigo Palma*** *Professor* *Universidad de Chile*
11:20 – 11:30	Coffee break
Policies and regulations to enhance power system flexibility	
11:30 – 12:30	**Expert speakers presentations and panel discussion** • ***Marielle Lahti*** *Director Smart Grids and Electricity markets* *Swedish Smart Grid Forum* • ***Francisco Martínez Conde del Campo*** *Head of Regulatory Support Unit* *Ministerio de Energía* • ***Carolina Zelaya Ríos*** *Lawyer, energy expert* *Independent consultant*
12:30 – 12:40	Coffee break
Boosting power sys lexibility with distributed energy resources	
12:40 – 13:40	**Expert s rs presentations and panel discussion** • ***Thomas Gereke*** *Senior Management Consultant e-Mobility Infrastructure* *Siemens* • ***Max Luke*** *Consultant* *NERA Economic Consulting* • ***Daniela González Durán*** *Director Partner* *Domo Legal*
13:40 – 13:45	Closure