Innovative solutions for achieving 100% renewable power systems by mid-century

Workshop minutes

17th July 2019, Montevideo, Uruguay

I. Context

To truly benefit from the unique setting of regional and international experts discussing disruptive innovations in the power sector, the workshop on '*Innovative solutions for 100% renewable power systems by mid-century*' has been held back-to-back with the regional IRENA Innovation day in Montevideo, Uruguay. The focus was on countries who have pledged very high (above 70-80%, and in some cases 100%) renewable power targets by mid-century.

This workshop was part of the **experience-sharing programme on innovative solutions for very high shares of renewable power by mid-century** that is taking place throughout 2019, supported by the government of Sweden and in collaboration with the government of Uruguay.

Based on the outcome of previous discussions among country representatives, this workshop explored the most relevant disruptive innovations which enable the rapid uptake of a high share of renewables in the power system. Open discussions like these and insights gained will greatly assist participating countries in driving their energy-system transformations towards very-high or 100% renewable power systems in the coming decades.

Experts from the industry, as well as innovators, including new actors with innovative business models, as well as representatives from academia have been invited to join the discussions. The workshop was attended by 58 participants, including public sector representatives from Costa Rica, Germany, Paraguay, Sweden, Uruguay, Argentina, Belize, Ecuador, Honduras, Mexico, Nicaragua and Poland and regional organizations, such as OLADE (Latin American Energy Organization), Comisión de Integración Energética Regional (CIER) and Fundación Bariloche.

The objective of the workshop on '*Innovative solutions for 100% renewable power systems*' was to connect and build a network for country representatives for the international exchange of perspectives, plans and good practice in working towards very high levels of renewable power. Informed by the Innovation Day discussions, the workshop further assessed challenges and opportunities faced by the region.

IRENA wants to prevail in its role as facilitator and platform for international discussions to enable and drive energy system transformation. Therefore, the agency is strongly supporting the Uruguayan initiative to promote dialogue amongst countries that have already achieved very high shares of renewables in their energy sector, on how to turn current challenges into opportunities. The first dialogue, demonstrating and encouraging this joint commitment to drive renewable energy growth in a context of international collaboration, will take place during the 18th IRENA council in Abu Dhabi, on the 5th of November 2019.

II. Highlights of the introductory remarks

Overall, participants highlighted that changes witnessed worldwide, such as cost reductions of renewable energy technologies, accelerated growth of installed renewable capacity and rising investments in renewables, provide an opportunity to decarbonize end-use sector through **electrification with renewable power**. Key drivers of renewable energy growth include: climate change mitigating and adaptation, pollution reduction, energy

security, independence with more resilient power systems, as well as growing electricity demand linked to population growth.

Institutional and regulatory structures of the energy sector in the Latin American and Caribbean region have been designed in the 1990s, based on fossil fuels, facing now challenges to adjust to a fundamentally different configuration of power systems, enabling the integration of larger shares of renewables. While current efforts and a growing number of examples in the region indicate a clear 'yes' that 100% renewable-powered systems can be operated, and while there is a great potential for renewable energy in the Latin American region, there is only a small percentage of this potential materialized now. For example, while Uruguay successfully addressed these challenges, and while a growing number of countries, including Argentina are gradually tackling these challenges, other nations in the region are still at the beginning of addressing these challenges. Overall, strategies, macro-economic and regulatory frameworks for the decarbonization of economies need to be tailored for each country in the region with a strong commitment to effective collaboration. Challenges throughout the region include the cost-effectiveness and continuity of state policies as key underlying factors to power sector transformation and the long-term success of policies. Last, but not least, as 97% of the region has access to electricity, the remaining 3% amount to 18 million people, which is a great challenge which could be tackled with renewable energy sources, for example through micro grids with wind, solar or hybrid systems.

III. Challenges and opportunities in the implementation of ambitious policy targets to achieve power systems with high shares of renewable power by mid-century

Key challenges identified refer to the variability of these resources, the integrating of high shares of variable renewable energy (VRE) shares and unlocking flexibility in the power system. As 43 IRENA member countries have policy aims for high shares of renewable energy, exploring similar challenges among these member countries becomes crucial.

The starting point and the strengths of participating countries vary greatly, for example:

- **Sweden** has currently almost 100% fossil free power production, it is a net exporter of power, it has already an extensive national transmission network, with strong interconnections with neighbouring countries, as well as a well-functioning liberalized energy-only market with interconnected countries in Europe. Moreover, 63% of the power is already generated by renewable energy sources.
- **Uruguay** holds no hydrocarbon reserves and reduced its dependence on both imported fuels and hydropower by completely transforming its energy mix in less than nine years. At the end of 2018, the share of renewables in the power mix accounted for over 98%, without subsidies, which could mainly be achieved thanks to the rapid implementation of the energy policy by the state-owned utility.
- **Ecuador** relies heavily on hydropower and has a strong abundance of natural resources. Through large investments between 2015-2018 Ecuador's power mix has changed and the share of hydropower rose from 48% to 83%, to the detriment of fossil fuels. However, solar PV, wind and biomass make up only 1.5% of the power mix.
- **Belize** developed recently its energy policy framework, part of which the Ministry of Energy has been created (2013). Subsequently, the National Sustainable Energy Action Plan, the Energy Planning Manual and the Consolidated Project Plan have been developed (2015-2017).
- **Nicaragua** is undergoing a challenging electrification process whereby 54% of the country is electrified and power generation is 75% fossil fuel based. The country's transmission network is deficient, and its power system is poorly interconnected within the region and there are no energy efficiency programs in place. 2009 marked the start of promoting renewable energy in Nicaragua. The introduction of new

generation projects based on renewable energies in the period 2019-2033, are expected to modify the generation matrix by increasing the generation of renewable energy from 58% in the year 2019 to 70% by 2033.

Some of the challenges discussed are country-specific, such as:

- **Sweden** has targets are in place, but challenges linked to their implementation remain key, which is why a dialogue with other countries is needed to identify best practices and work together to achieve similar policy goals. Other challenges mentioned are: competition of land, public acceptance, more time-efficient authorization processes for the construction of wind power plants, challenges related to the efficiency system operation to effectively ensure security of supply and engagement of societal stakeholders;
- **Uruguay** faces a challenge in providing access to electricity to the remaining 0.2% of the population, which call for solutions to remove the technical, legal and economic barriers by thinking "out of the box" and going "the extra mile".
- **Ecuador** faces a challenge in creating synergies and complementarity between various generation resources according to the seasonality, because seasons are difficult to define.
- **Belize's** electricity is generated predominantly via large shares of hydropower and biomass, but 40-45% of power is imported from Mexico, making energy security a significant topic, even though the country holds indigenous petroleum sources (which are exported as crude oil and refined abroad). Moreover, the regulatory body has only 20 years of existence and the country experienced increases in electricity prices due to underproduction of hydro power.

However, some common challenges and opportunities could be identified:

- **Expansion of transmission network** (e.g. in Uruguay from a radial transmission system to a more robust ring as well as in Paraguay, in Germany, or in Sweden from North to South due to uneven distribution of power production and consumption points)
- **Improving the existing institutional and regulatory frameworks** (e.g. in Ecuador there is a need to restructure the current regular framework to allow for VRE dispatch schemes; in Sweden, while the electricity market is an enabler for VRE integration, there is room for improvement, for example by incentivising system-friendly behaviour on the demand side through the electricity market-price; in Belize, the renewable energy target of 80% by 2020 will not be met due to current legislation imposing a competitive process of projects, which lead to unfeasible projects due to costs, etc.);
- **Increasing electricity demand** (e.g. in Ecuador, in Uruguay, or in Sweden where around 100 TWh of capacity needs to be replaced in the next 20 years, due to expected end of economic life time of nuclear power plants by 2040 and due to increased demand for electricity in the transport and steel industry);
- **Policies for the electrification of other end-use sectors**, while representing a challenge, can also be part of the solution, creating benefits from both environmental and economic point of view (e.g. Costa Rica, Sweden, Uruguay).
- **Decarbonizing the transport sector** (e.g. in Costa Rica; in Uruguay where oil and derivatives accounted for 37% of the energy supply in 2018, mainly because of the transport sector; or in Belize, where transport accounts for 50% of energy consumption);
- **Investments in renewable energy projects** (e.g. in Ecuador, investment from private actors in renewable energy projects and further cost reductions in storage technologies are needed; Belize faces in addition to institutional, regulatory, technical and environmental, also financial challenges).
- **Willingness to interconnect with neighboring countries** (e.g. Uruguay is strongly interconnected with neighbouring countries and investments in interconnections with Argentina and Brazil have been

undertaken to deepen the integration and power exchanges; overall it was highlighted that one of the key needs of the region is to achieve better power sector integration which could support renewable energy growth).

- **New ways to operate power systems** (e.g. cost-effective VRE operation, minimising curtailment via demand-side management, storage and wider regional interconnections; impacts and bottlenecks must be identified in the transformation of hydro-thermal systems into hydro-wind-solar-thermal systems; need to have better VRE forecasts);
- **Capacity building** (e.g. in Belize, there are limits in human resources and in the technical ability to support the expansion of renewable energy; in Uruguay, there is the need to train people and work with universities as high expertise is required; overall modelling and forecasting training is needed in the region to analyse predictions of technical and economic impact of solar and wind).
- **Digitalization of the power sector** (e.g. other challenges that need to be addressed include IT efforts, especially for the roll-out of smart meters in less digitally advanced countries like Paraguay).
- **Societal changes shifting the power system paradigm** (e.g. need to change mindsets of engineers, policy-makers and consumers).

Participating countries have various plans to tackle these challenges, such as:

- **Sweden** has ambitious targets in place since 2016, including 100% renewable power targets by 2040 and expects the share of VRE to grow from 13% to 50% thanks to increases in installed wind capacity. Sweden is currently working with IRENA on a study how systemic innovations can help integrate large shares of renewable.
- In **Uruguay**, almost 100% of electricity comes from RE (97% in 2018). The country is also implementing a pilot project to explore the use of clean hydrogen in long-distance and heavy-duty transportation to continue decarbonizing the transport sector.**Ecuador** seeks to continue the reduction of fossil fuel consumption in the power sector via its Energy Master Plan, aiming to incorporate 500 MW new wind, solar PV and small-capacity hydroelectric plants by facilitating the bidding processes, in addition to the incorporation of 30 GW new hydropower by 2027. Diversification of the energy mix, which should be based on renewables, with continued work on energy efficiency, self-sufficiency and promotion of research in new technologies are other priorities. Ecuador is also implementing a project in the Galapagos Islands aiming to preserve natural resources, reduce fossil fuels consumption and to promote the use of renewables. Another innovative project is the country's contribution towards rural electrification for communities in the Amazon Forest via microgrids with PV systems with remote monitoring.
- **Belize's** future plans include an energy policy organised around five pillars: energy efficiency, renewable energy, clean production, governance and infrastructure. Currently, different options are being explored, such as increasing hydro and biomass production whilst reducing imports from Mexico. There is a strong willingness to be able to sell electricity back Mexico and to connect to the wider region in Central America in the next decade. Other priorities include strengthened energy planning, mobilizing financial and technical resources for clean growth and redirecting saving towards climate resilience and sustainable development whilst maintaining strong sectorial engagement.

IV. Technical feasibility of a 100% renewable power system by 2050

The second session explored the technical feasibility of a 100% renewable power system by 2050 showcasing some of IRENA's work on this topic, including the Knowledge Framework and Power Sector flexibility assessment, which has been also performed for Uruguay. It was concluded that a 100% renewable-powered

system is an ambitious undertaken, but feasible, if the related challenges are addressed. This conclusion was made based on the examples presented, such as:

Uruguay considers that this objective is technically feasible given that almost 100% of electricity comes from RE (97% in 2018) and thanks to large hydropower capacity with strong interconnections with neighboring countries equivalent to 125% of its historical demand peak. Fossil fuels have been replaced by wind power and biomass is increasingly used for industrial processes. There are also plans to increase shares of solar PV. As shares of wind and solar are rapidly increasing, these turn from 'non-conventional' sources to rather 'conventional' ones. Uruguay also has the vision that in the future, when fossil sources become depleted or are scarce resources, in order to intelligently resolve their preservation for other uses, biomass will take their place in the system acting as a backup to the VRE. The country has enough resources for this and knows how to use it because biomass already is part of the generation system. Overall, Uruguay's energy transition enabled savings of circa 500 million dollars. Storage (including EV batteries used in distribution networks), electro-mobility, IT systems, such as creating automated mechanisms to improve performance, enabling the collection real-time information for micro generation as well as improving forecasts, and better incorporating cyber security in system operations are key enabling technologies. While the knowledge and resources are available to make 100% renewable-powered systems a reality, Uruguay's strengths lie in a centralized dispatch and planning framework and calls for international bodies such as OLADE, CIER and IRENA to help in making optimised regional exchanges and large integrated systems possible.

Paraguay's perspective shows that a 100% renewable-powered system is technically feasible. Hydropower plays already an important role but there is still room for improvement, which is why the country continues to build hydro dams as hydro is considered the backbone for the future power system. Installed capacity for renewable power is growing more rapidly than non-renewable capacity. Therefore, there is a need to simultaneously cater for the exponential expansion of renewable capacity whilst dealing with the replacement of non-renewable capacity, which is an enormous technical and capability challenge. Moreover, the global projections depend on the price for oil and gas, which has geopolitical implications and could affect the renewable energy deployment.

Moreover, 99% of electricity in Costa Rica has been generated with renewable energy sources in 2018.

V. Showcase of experiences from leading countries operating power system with very high shares of renewables

Sweden:

- Sweden's power system is interconnected with neighbouring countries and is part of the same electricity market (operated by Nord Pool) with both day-ahead and intraday markets. This type of market is perceived as a key enabler to increase the share of variable renewable energy, thanks to geographical smoothing effects (396 TWh have been traded on this market in 2018).
- The Swedish carbon tax is implemented since 1991 on fuels. This acted and still acts as an incentive to encourage RE use and to reduce energy consumption.
- Technology-neutral policies are perceived in general as fundamental.
- The electricity certificate mechanism is a market-based support scheme for renewable electricity, with retailers mandated by law to meet quota obligations. Although costs are passed to end-consumers, these only represent 2% of the final electricity bill.
- 2020 renewable power target has been already reached in beginning of 2019. Forecasts indicate that the forthcoming 2030 target will already be met in 2021 due to rapid expansion of wind power.

- Wind power is currently profitable without support schemes. The rapid expansion of wind power is also a challenge which need to be managed. But it is a challenge that can be met, especially thanks to interconnections.
- There is no such thing as an 'ultimate' solution. There is the need to work on challenges in the power and energy system for the next generations.

Uruguay:

- In Uruguay, a large amount of 'non-conventional' renewable was incorporated in a very short period, especially wind. Therefore, it was necessary to adapt practically all aspects of the operation of the electrical system.
- The Uruguayan power system is historically a hydraulic system with thermal backup and constitutes a single system with the Argentinian System and further interconnected with Brazil. There is a market, although with a predominant state company, namely UTE which owns 100% of distribution and transmission. Dispatch is done by optimizing production costs.
- The incorporation of wind power generation was promoted in 2010 by an agreement of all political parties to install at least 300 MW of wind power, which was followed by a rapid process of expansion thanks to bidding processes.
- The installed wind power ended up reaching 1500 MW, a very significant figure in relation to demand. In fact, the rate of building wind parks is more rapid than the pace of the grid to accommodate such high shares of wind. There is further surplus generation in the centre of the country.
- Wind generation is dispatched with zero variable cost. Installing wind capacity, although generation is frequently curtailed or exchanged, is more cost-effective than using fossil fuels.
- Many weather stations for improved forecasting and telecontrol technologies have been implemented in wind parks to assess real-time operation and manage a system with increasing variable generation.

Germany

- The '*Energiewende'* is Germany's long-term energy and climate strategy. Goals within this strategy are very ambitious and for some of these, Germany is lagging behind, including its target on gross final energy consumption.
- Wind generation concentrates in the North whilst demand centres are located in the South. Therefore, there is a strong need to improve transmission networks to prevent shortages. However, there are associated legal as well as social acceptance ('not in my backyard', NIMBY) problems, which are hampering the procedures. This is both time consuming and costly.
- There is a high share of renewables in the power sector but not in transport or cooling/heating. A great priority is therefore to increase renewable energy shares also in other end-use sectors and achieve sector-coupling. Currently however, the power sector remains ahead of other sectors.
- Storage as well as power-to-X solutions to balance demand and supply and make use of excess renewable electricity are also an important research area in Germany.
- Germany further tries to strengthen the position of consumers and turn them into prosumers, through incentivising programs such as the use of domestic PV, which is supported by financial institutions.
- Grid expansion, storage, flexibility and sector coupling remain the main priorities in Germany.

Cost Rica

- Costa Rica is small country in territory with 5 million inhabitants and an electricity system in which 1700 MW represents the peak demand. There is an abundance of natural resources and Costa Rica made

and still makes the most out of these. There is a legal mandate in place imposing the use of national resources, especially water. This policy remained constant and non-altered throughout various governments.

- In 1949, the national vertically integrated utility ICE (similarly as UTE in Uruguay) has been created. Since then, large shares of hydropower and geothermal resources have been added to the power mix. ICE has become an expert in developing geothermal technologies and provides support to other countries. Wind power is also becoming increasingly important, with the first wind park being built in 1996. There is complementarity between wind power and seasonal hydro power storage, which is particularly beneficial in dry seasons. Therefore, there is no great need of thermal power production. 99% of electricity in Costa Rica has been generated with renewable energy sources in 2018.
- The country's decarbonisation plan has been launched in February 2019, which sets a policy framework until 2050 and includes even more ambitious goals by building on 10 strategic pillars. Work in different sectors, such as the agro-industry, waste and transport sector, is especially encouraged in order to decarbonise the entire economy and achieve higher levels of competitiveness. Electrifying the transport sector to make use of excess generation and charge electric vehicles at night is especially considered as a win-win situation.
- Costa Rica is part of regional market to exchange and import power to avoid the generation of thermal power. Congestion in the transmission network, especially in Nicaragua, engender however challenges. Increasing the resilience of the transmission system is further deemed essential in light of effects from climate change and Costa Rica's vulnerability to hurricanes.
- Although Costa Rica experienced great progress with regards to renewables in the power sector, there is still, similarly as in Uruguay, a great reliance on fossil fuels, especially in the realm of transport. Therefore, the electrification of end-use sectors is becoming increasingly an important priority. Simultaneously, Costa Rica is carefully monitoring developments in marine energy and organises the Panamerican conference on Marine energy. Pilot project for storage are also put in place. The study of hydrogen, efficient demand management and virtual power plants are further becoming increasingly important.
- Only a small increase in power demand is expected through the current electrification policies. Expansions in hydro and geothermal capacity are planned in 2021 and 2026 respectively, followed by expansions uniquely in wind and solar.
- Costa Rica is conducting thorough analyses on how to integrate VRE in a safe manner and how much capacity is feasible for system stability and flexibility. 11 MW VRE generation (mostly solar) has been achieved through distributed generation, the experience of expanding distributed generation has been positive that it cannot be considered at pilot stage anymore. However, clearer 'rules of the game' and regulations are needed. By 2022, 2 million smart meters are expected to be in place. A 100% roll out is targeted.
- A step by step implementation, coupled with thorough analyses, instead of making drastic changes has been a key to the current success.

Honduras

- Before 1994, power demand was small but started growing. In light of this, Honduras expanded generation capacity through thermal generation units but soon realised that work on renewable energy is needed. Therefore, in 2007 a legislation has been passed supporting RE generation. As a consequence, the Honduras experienced a drastic change in its generation mix between 2005-2017. The country's current target is to produce 80% of its electricity from renewable sources by 2038. At present, hydro sources account for most of the renewable sources used in power generation.

- The state-owned Electric Power Company intends to increase hydropower capacity and has a portfolio of projects, that it hopes to develop in the mid-term. Also, according to private sector's expansion plans, growth in hydropower as well as small increases in biomass capacity and 32 MW in solar power are expected. Additionally, there are two possible geothermal plants to enter in the medium term that would add 35 MW.
- Through a Social Development Fund and with the support of the International Development Bank, work is undertaken on the installation of hybrid systems (isolated mini-networks) in the Caribbean islands Guanaja and in several municipalities in the jungle area of Gracias a Dios and Choluteca.
- Honduras has identified numerous benefits and opportunities regarding renewable power growth. These include, but are not limited, to its great abundance and in some cases inexhaustible natural resources, job creation, less dependence on fossil fuels and rural electrification through mini grids in isolated areas. However, although investment costs are decreasing, for some hydro plants, significant initial investments are required. Increases in hydro capacity further engender environmental and social impacts, such as displacements of local communities, which requires their inclusion in project development.

Paraguay

- In Paraguay, most electricity is produced from renewables, especially hydropower and biomass. However, there is virtually no solar and wind power generation in Paraguay's power system and the cheap cost of biomass and hydro discourage the expansion of VRE sources. There are small enterprises of PV generation plant in isolated areas at the initiative of the private sector but of little relevance.
- The largest power demand stems from the residential sector and is highest in summer with demand peaks at midday and night because of the use of AC. However, this demand can be met through renewable hydro power.
- In 2006, an act has been implemented to encourage wind and solar, but the experience was unsuccessful, and the act is currently in revision as costs still act as a significant barrier and there is reluctance to subsidize VRE generation. An adequate regulatory framework is missing. The national plan for energy efficiency further needs to be included the act, especially since renewable power and energy efficiency are seen as complementary.
- An electricity market for VRE and distributed generation is required that is suitable to the country's reality. At the moment, Paraguay has an excess in power generation from hydro power plants. However, there is the recognition to start the energy transition before entering in a state of crisis and learn from the experiences of countries with high shares of VRE.
- According to projections, by 2030, hydro power will not be able to satisfy demand anymore. Therefore, IRENA and OLADE have an important role in raising awareness of the importance of starting the transition now amongst decision-makers as currently there are no incentives in place for VRE generation. Due to currently significant surpluses in generation, citizens in Paraguay are often wasting electricity and therefore awareness raising is urgently required.
- In Paraguay, there is also state-owned utility, which, however, would needs to start thinking as a company. UTE from Uruguay could serve as a source of inspiration.

VI. Innovative solutions for 100% renewable power

Significant work is needed to achieve climate targets and meet Paris agreement, according to IRENA's REMap studies. As shown in IRENA's recent "*Innovation Landscape for a renewable-powered future*"[1] report, innovations do not emerge in isolation and synergies between innovations are needed to truly have an impact. Examples combining innovations across the four dimensions (enabling technologies, market design, business models and system operation) include demand-, supply- and grid-flexibility solutions, whereby the importance of digital technologies is highlighted. Some of the innovative solutions for 100% renewable-powered futures presented, include:

- **Power to Heat in Uruguay:** in 2012, a wool laundry factory, 50km from Montevideo, installed a 1.8MW wind turbine, for self-consumption (approx 1.1 MW), injecting generation surplus into the grid. Various options for the use of energy surplus were analysed, since it was a no longer economically viable option to transfer it to the network. Consequently, various projects to exploit the surplus of power produced by the turbine, and to use it for internal purposes rather than feeding it into the grid, were proposed. As the factory has a very significant consumption of hot water, which is heated via fuel oil and wood by two steam boilers, solutions have particularly targeted to increase the factory's energy efficiency by eliminating the use of fuel oil. An electric boiler to produce steam (1.5 MW)has been installed. This has both eliminated the use of fuel oil for steam generation (up to 14,500 liters per month) and optimised the power generation from the wind turbine as steam can be produced with surplus power and hence excess electricity does not need to be injected into the grid. A robust and reliable data network has been also created for continuous data collection to develop an adaptive control strategy that maximizes the generation of the wind turbine. AI models have been used for generation forecasts. The system has been running over the last 5 months and over 100 MWh can be tapped per month thanks to this project, with no power being injected to the grid, but locally consumed.
- **Distributed ledger technology as an enabler for VRE integration in the USA:** As we are moving towards power systems with high shares of VRE and with an increasing number of distributed resources, which are able to provide flexibility. Power systems are becoming more and more complex and services to manage this complexity are lacking. Large investment in renewable energy are being undertaken, coupled with more and more DERs in the system and an exponential growth of EVs. Many devices are becoming or are already internet-connected, which unlocks new opportunities to manage power systems.The Energy Web Foundation, a global non-profit organization, aiming to accelerate the energy transition with blockchain and decentralized technologies to scale consumer participation, showed what solutions for both large utilities and small start-ups are developed to create an energy blockchain ecosystem to facilitate the sustainable energy transition. Open source technologies and programming methods for applications with blockchain are developed for companies in the power sector to innovate and to become more competitive. Support is also provided for transparent renewable energy procurement and making it easier for large companies to specify their renewable energy needs in a transparent way. A current project is also the development of a trading system in Thailand. Another pilot project on carbon credit solutions for EVs has been designed in San Francisco for a Californian utility to meet needs of California's Low Carbon Fuel Standard (LCFS). This pilot highlights the value of digital solutions and blockchain applications to harness the potential of EVs and create business models. The pilot project looked at assessing the carbon intensity of the grid when EVs are charging, which allowed to issue more accurate and time-sensitive carbon credits. This can incentivize consumers to charge their EV at different times of the day. The utility can either aggregate the carbon credits from

[1] https://www.irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future

consumers and sell them or give it to their consumers as an incentive to use EVs. Simultaneously, transparent records of all EV charging are also created.

- **Predictive maintenance with the help of AI algorithms in Uruguay:** the Sectorial Research Fund based on data is aimed at financing research projects aimed at generating knowledge from available national data available. The National Agency for Research and Innovation and MIEM created this fund with the objective to develop advanced methodologies, which can be transferred to other domains. The objective of the presented project is to develop methodologies to analyse data series available in UTE's database and take advantage of extensive sets of data from wind farms to generate quality information on the performance and predict faults of the turbines. The focus is on principles of prevention, prediction and pro-action to develop tools for predictive maintenance. The challenge of managing complexity opens opportunities to progress in this direction and develop new knowledge. AI algorithms are developed to predict failures and improve generation forecasts, with artificial neural networks regarded as a new paradigm. Artificial neural networks together with SCADA monitoring data are powerful monitoring tools, allowing the early diagnosis of anomalous operations of critical components of a wind turbine, and therefore avoid high costs and downtime through predictive maintenance. Working with different variables – forecast of temperature of the box and comparison to actual temperature, if measured temperature starts increasing compared to RNN forecast, then a fault can be expected. Every reality implies a new challenge. Opportunities exist to create knowledge by linking academia with the reality companies are facing.

VII. Concluding remarks:

Local resources and local context matter. Guaranteeing electricity access to isolated communities remains a challenge in the region. Challenges are not always of technical or infrastructure nature but relate to a great extent to regulation, finance, policy, necessary skills and social acceptance. Success factors identified in leading countries include careful planning, foresight, consistency in policy-making, fostering consensus among stakeholders and knowledge of local resources and strengths. There is an appetite for experience-sharing in fora that should be organised by OLADE and IRENA. The political will to act and to build awareness are apparent, especially considering the fact that numerous presentations highlighted that no great deal of sharing experience in the region is happening at the moment. More is done on a supply side rather than on a demand side. However, EVs and demand-side response have been identified as opportunities to unlock greater flexibility from distributed energy resources. Electrification of end-use sectors has been also mentioned several times. Renewable power-to-X, including renewable power-to-hydrogen have been mentioned less than during the discussions on the previous day (i.e. Innovation Day) and incertitude remains with regards to the potential. Overall, there is a need to identify the untapped flexibility sources in the region.