IRENA
International Renewable Energy Agency

Sharing experiences in applying innovative solutions to achieve 100% renewable power systems

Online workshop

10th October 2019, 16:00 (GMT+2)

Agenda

Elena Ocenic, Programme Officer,
Innovation Networks (IRENA)

Agenda

Time		Session	Speaker/participant
16:00	**16:05**	**Welcome address (IRENA)**	**Paul Durrant**, Programme Officer, Renewable Energy Innovation (IRENA)
16:05	**16:10**	**Introductory remarks**	**Elena Ocenic**, Programme Officer, Innovation Networks (IRENA) **Arina Anisie**, Associate Programme Officer, Renewable Energy Innovation (IRENA)
16:10	**17:00**	**Presentation of examples from each country participating with interactive Q&A (question 1-5)**	**Kenneth Hansen,** Danish Energy Agency (Denmark) **Alfonso Herrera,** Ministry of Environment and Energy (Costa Rica) **Manuel Barboza,** Costa Rican Electricity Institute (Costa Rica) **Hanna Ek-Fälth**, Renewable Energy Analyst, Swedish Energy Agency (Sweden) **Sara Grettve,** Project Manager, Swedish Energy Agency (Sweden) **Wilson Sierra**, Renewable energy, National Energy Directorate, Ministry of Industry, Energy and Mining (Uruguay) **Martin Scarone**, Renewable energy, National Energy Directorate, Ministry of Industry, Energy and Mining (Uruguay)
17:00	**17:30**	**Interactive discussion about innovations which are not included in IRENA's "Innovation Landscape Report" (question 6)**	All participants
17:30	**17:50**	**Interactive discussion about regulation and market design (question 7)**	**Emanuele Bianco**, Associate Programme Officer, Knowledge and Policy (IRENA)
17:50	**18:00**	**Next steps**	**Elena Ocenic**, Programme Officer, Innovation Networks (IRENA)

Welcome address

Paul Durrant, Programme Officer,
Renewable Energy Innovation (IRENA)

Introductory remarks

Elena Ocenic, Programme Officer,
Innovation Networks (IRENA)

Introductory remarks

Participating countries

*43 IRENA member countries have pledged to achieve some form of 100% renewable energy target in the coming decades. First IRENA member countries invited to join these activities based on policy targets to achieve **100% renewable power** (rather than 100% renewable energy) by 2030, 2040 or 2050 respectively. Uruguay and Paraguay are frontrunners in the operation of a power system with 98% and 100% of the power generated in 2017 from renewable energy sources. The activities are open to countries that have less specific targets and would like to explore a high ambition for renewable power.*

Denmark	Costa Rica	Germany	Norway	Spain	Sweden	Uruguay	Paraguay
							
100% renewable power by 2050	100% renewable power by 2030	At least 80% renewable power by 2050	100% renewable power by 2050	100% renewable power by 2050	100% renewable power by 2040	98% renewable power generated in 2017	100% renewable power generated in 2017

Introductory remarks

Planned activities

Type of workshop	Tentative date	Description	Location
Online	6th June 2019	Focus on sharing national objectives for renewable power and expected/experienced **challenges**	Remote
In-person	17th July 2019	Focus on **innovative solutions for 100% renewable power systems by mid-century** by exchanging perspectives, plans and good practice in working towards very high levels of renewable power. Workshop takes place back-to-back with the **IRENA Innovation Day** (15-16th July).	Montevideo, Uruguay
Online	10th October 2019	Focus on sharing national **experiences** with the application of innovative solutions	Remote
Online	**28th November 2019**	Focus on **disruptive innovative solutions** enabling 100% renewable power systems	Remote

Examples of innovative solutions

Guiding questions

1. Based on IRENA's mapping of 30 key innovations, please provide **3 examples** of the most innovative solutions that combine at least two of these innovations in a pilot project that has been implemented/trialed, or is currently being implemented/trialed in your power system(s) with the aim to integrate larger shares of (variable) renewables, if possible demand-side, supply-side, grid or system-wide solutions.

2. How was the project initiated (private, public, public-private partnership, etc.)?

3. Which **enabling technologies** or other innovative enabling measures have been particularly effective in implementing/trialing the solution?

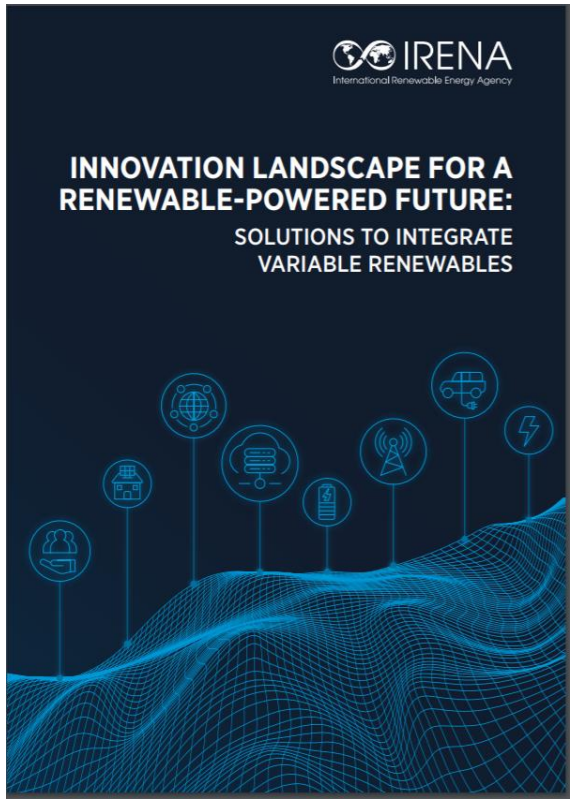
4. What are the **key lessons** learned from this experience and what are considered to be the '**success factors**'?

5. What are the **next steps** (i.e. abandoning the project, starting a follow-up project, scaling-up the solution, investing further in R&DD, conducting public consultations, etc.)?

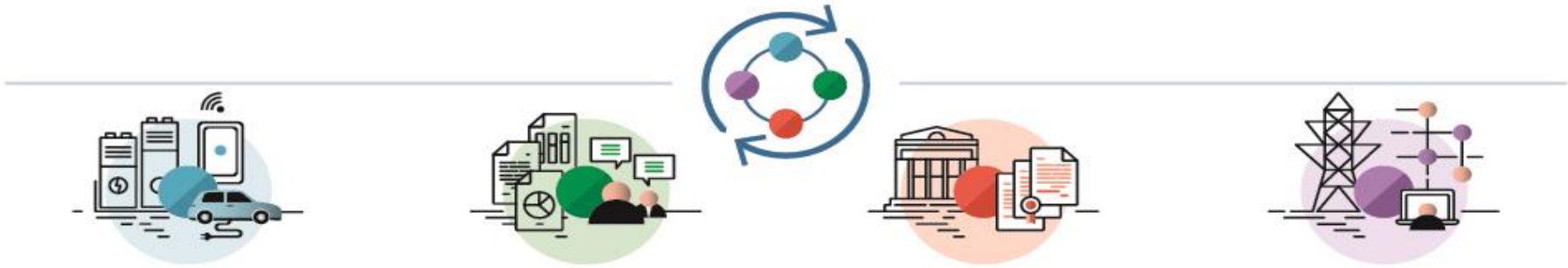
Innovation Landscape

Arina Anisie, Associate Programme Officer
Renewable Energy Innovation (IRENA)

Systemic innovation for VRE integration



Innovation Landscape Report



ENABLING TECHNOLOGIES	BUSINESS MODELS	MARKET DESIGN	SYSTEM OPERATION
1 Utility-scale batteries 2 Behind-the-meter batteries	12 Aggregators 13 Peer-to-peer electricity trading 14 Energy-as-a-service	17 Increasing time granularity in electricity markets 18 Increasing space granularity in electricity markets 19 Innovative ancillary services 20 Re-designing capacity markets 21 Regional markets	25 Future role of distribution system operators 26 Co-operation between transmission and distribution system operators
3 Electric-vehicle smart charging 4 Renewable power-to-heat 5 Renewable power-to-hydrogen	15 Community-ownership models 16 Pay-as-you-go models	22 Time-of-use tariffs 23 Market integration of distributed energy resources 24 Net billing schemes	27 Advanced forecasting of variable renewable power generation 28 Innovative operation of pumped hydropower storage
6 Internet of things 7 Artificial intelligence and big data 8 Blockchain			29 Virtual power lines 30 Dynamic line rating
9 Renewable mini-grids 10 Supergrids			
11 Flexibility in conventional power plants			

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

11 predefined flexibility solutions

SUPPLY-SIDE FLEXIBILITY SOLUTIONS		GRID FLEXIBILITY SOLUTIONS		DEMAND-SIDE FLEXIBILITY SOLUTIONS		SYSTEM-WIDE STORAGE FLEXIBILITY SOLUTIONS	
I	Decreasing VRE generation uncertainty with advanced generation forecasting	III	Interconnections and regional markets as flexibility providers	VI	Aggregating distributed energy resources for grid services	X	Utility-scale battery solutions
II	Flexible generation to accommodate variability	IV	Matching RE generation and demand over large distances with Supergrids	VII	Demand-side management	XI	Power-to-X solutions
		V	Large-scale storage and new grid operation to defer grid reinforcements investments	VIII	RE mini-grids providing services to the main grid		
				IX	Optimising distribution system operation with with distributed energy resources		

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

1st example - grid flexibility solution

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

2nd example - demand-side flexibility solution

Enabling technologies

- Behind-the-meter batteries
- Electric-vehicle smart charging
- Renewable power-to-heat (residential)
- Internet of things
- Artificial intelligence and big data
- Blockchain

Business models

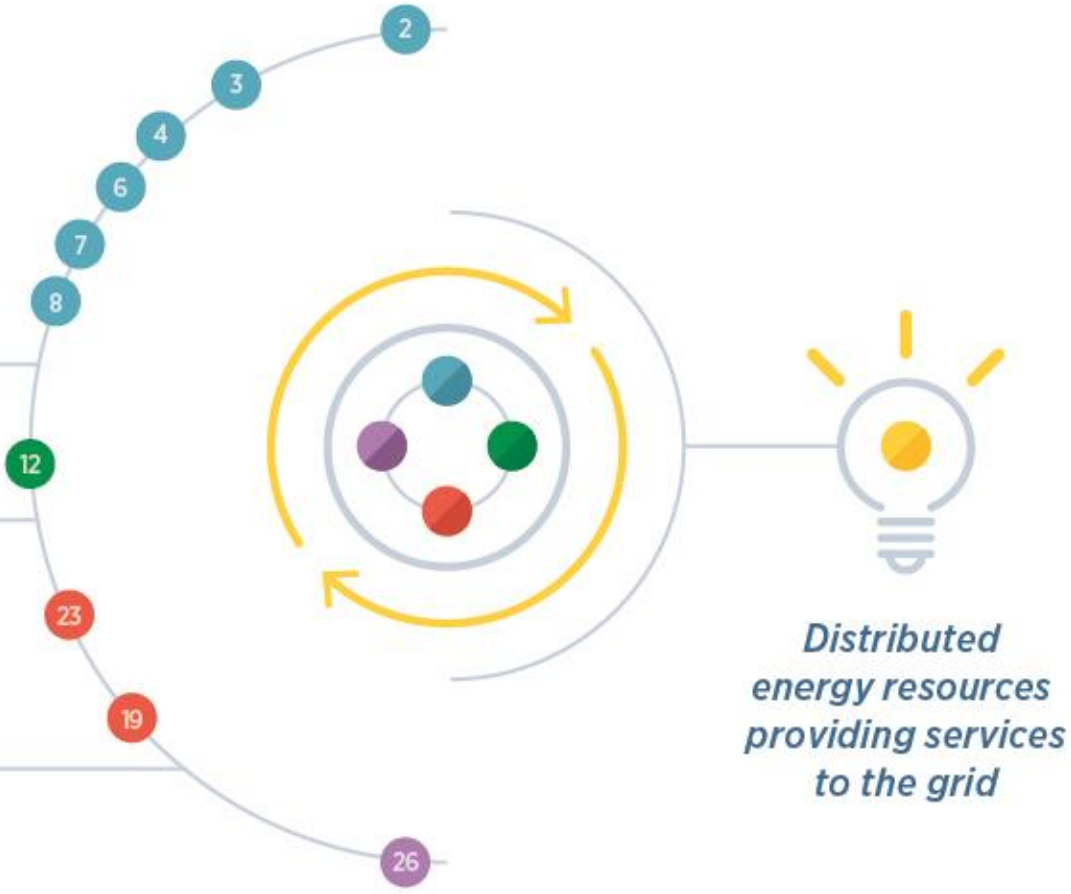
- Aggregators

Market design

- Market integration of distributed energy resources
- Innovative ancillary services

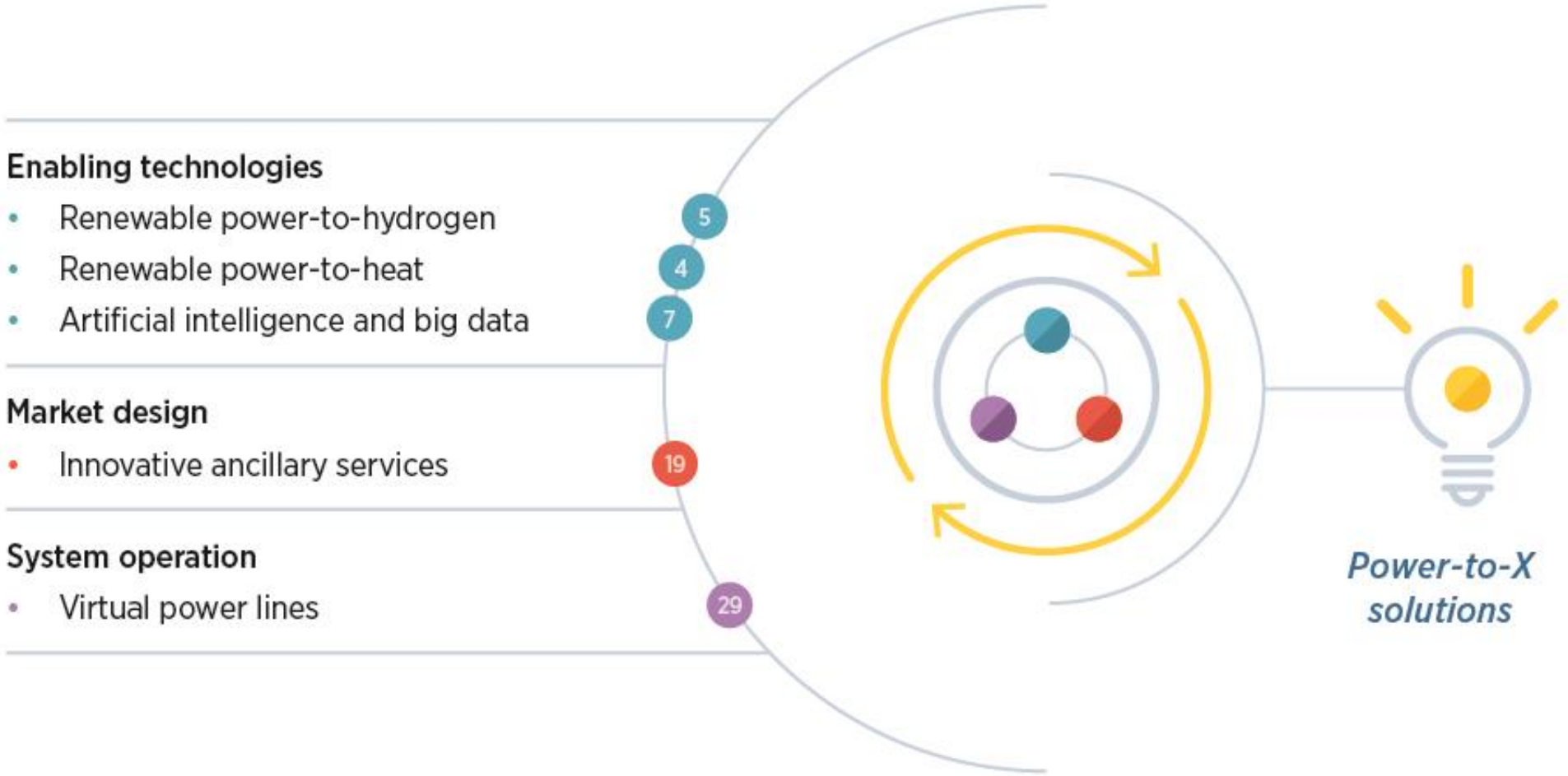
System operation

- Co-operation between transmission and distribution system operators



Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

3rd example - system-wide flexibility solution



Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

Denmark

Kenneth Hansen, Danish Energy Agency

Costa Rica

Alfonso Herrera, Ministry of Environment and Energy
Manuel Barboza, Costa Rican Electricity Institute

Sweden

Hanna Ek-Fälth, Renewable Energy Analyst
Swedish Energy Agency

Towards a 100% Renewable Power System

Sharing experiences in applying innovative solutions

Examples of innovative solutions

Swedish Energy Agency

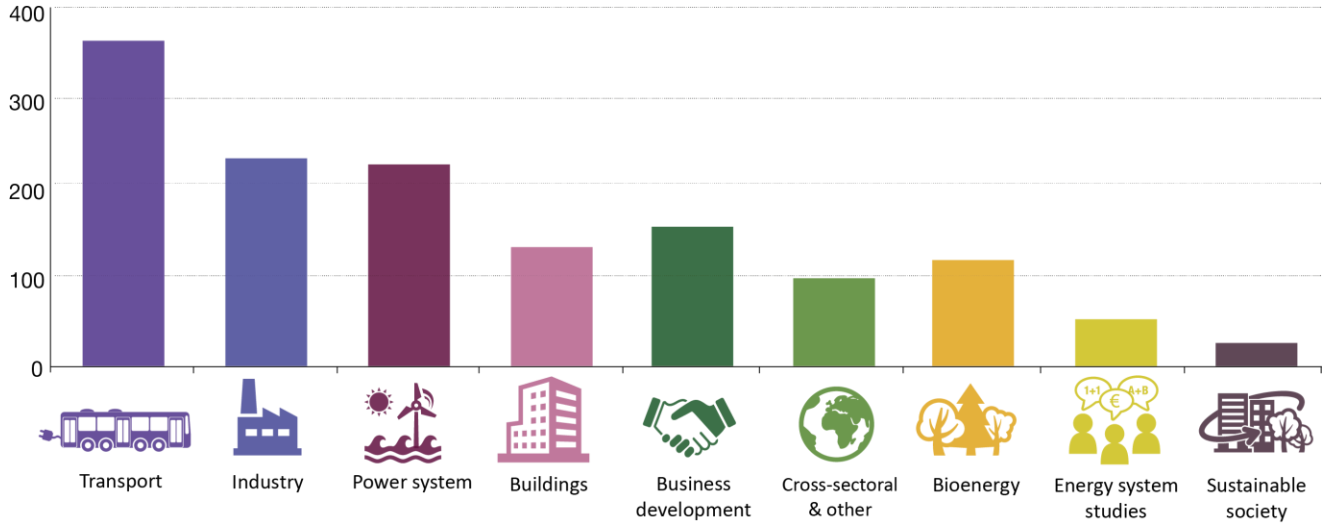
The role of the Swedish Energy Agency

- National authority for energy policy issues
- Sorts under Ministry of the Infrastructure
- Government funded
- Mission to promote a sustainable energy system
- Enforces governmental and parliamentary decisions
- Disseminates information within the energy and climate area and grants financial support to research and innovation
- Provides the public, the Government and the research domain with data (statistics, analyses, scenarios and forecasts)

Swedish Energy Agency

Research and innovation funding

- From basic research to demonstration and implementation
- Annual budget approximately 160 million €
- Doubled through industrial co-funding
- Some 90 programmes and 1200 projects running



Initiative:
Private: SSAB, LKAB and Vattenfall
Public: Swedish Energy Agency

Enabling technologies:
- Renewable power-to-hydrogen

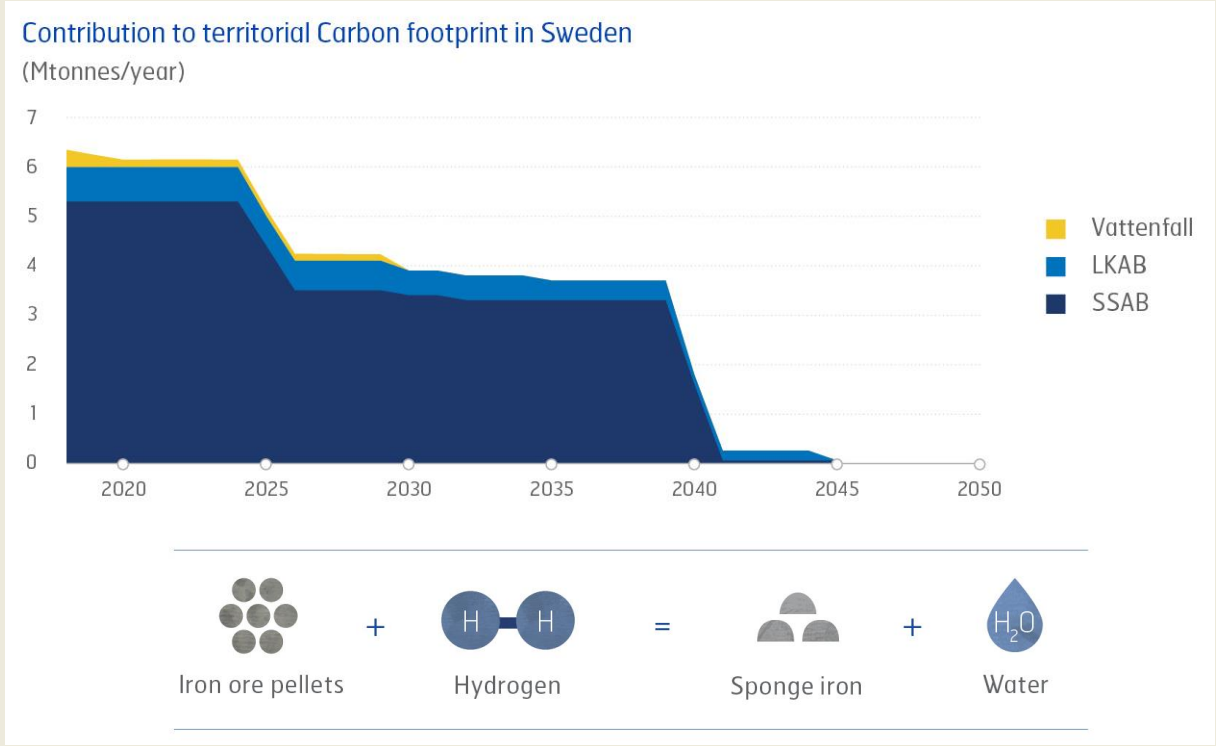
Market Design:
- Time-of-use tariffs

HYBRIT - Electrification of the steel industry

Hydrogen Breakthrough Ironmaking Technology – aiming to replace coal with hydrogen in the steelmaking process

- Initiated in 2016
- Pilot plant in operation planned to 2020
- Planned full scale implementation 2045

- Reducing Swedish total emissions with 10%
- Increasing electricity need with 15 TWh



Swedish Energy Agency

Initiative:
Private: Fortum

Enabling technologies:
- Utility-scale batteries
- Flexibility in conventional power plants

Hydropower + Batteries

Utilize and enhance the hydropower plant's role as a regulator and take better advantage of capacity regulation

- Pilot project started at a CHP plant in 2017
- Implemented at Forshuvud in may 2019

- Support grid stability
- Decreased wear and tear on the turbines

Swedish Energy Agency

Initiative:
Private: DSO:s Vattenfall and E.ON, TSO SvK
Public: EU Horizon 2020

System operation:
- Co-operation between TSO and DSO

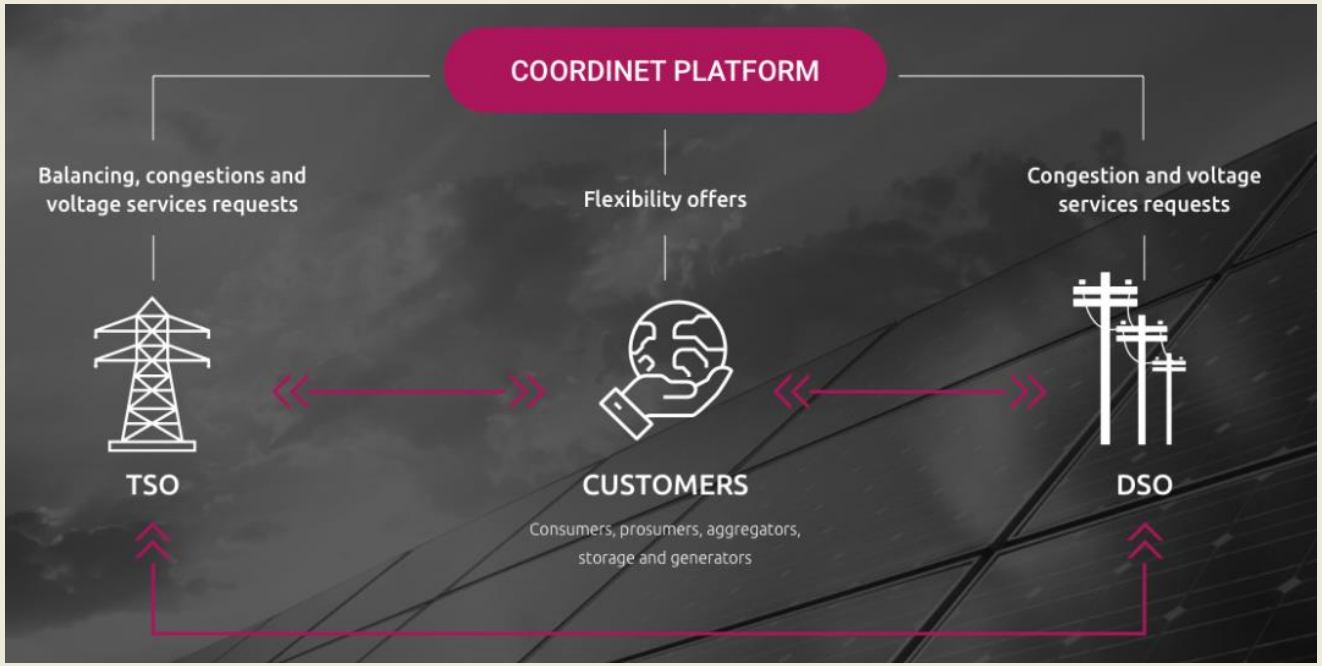
Market design:
- Regional markets
- Innovative ancillary services

Pilots in CoordiNet

Optimised TSO-DSO coordination to integrate VRE in flexibility markets

- Project started in January 2019
- Planned to end in 2022

- Support grid stability
- Development of a smart, secure and more resilient energy system



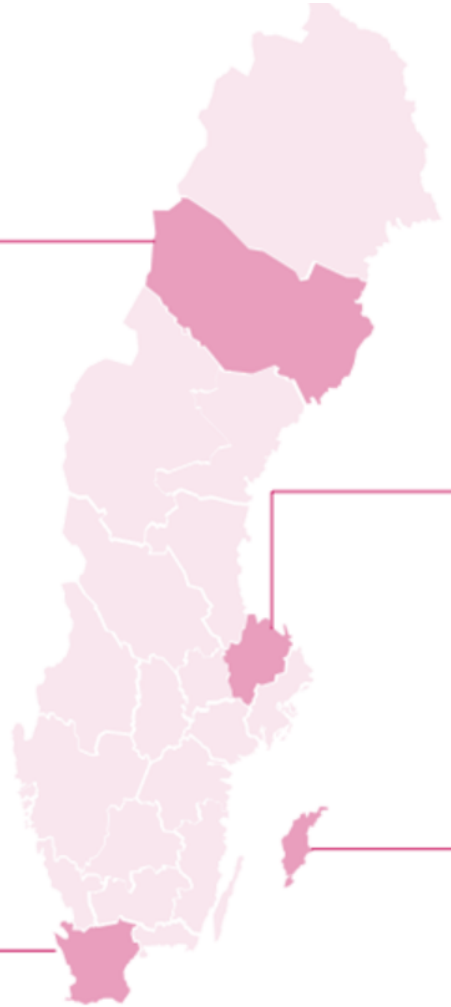
Swedish Energy Agency

coordiNET

MENU

VästerNorrland/Jämtland

Temporary constraints which results in limitation of wind and hydro power generation



Uppland

Congestion in the national grid and increased capacity requests from the society leads to limitations of the city growth.

Gotland

Grid constrains between Gotland and the mainland which slows down the expansion of the wind power.

Skåne

Increased capacity requests due to city growth leads to congestion

Uruguay

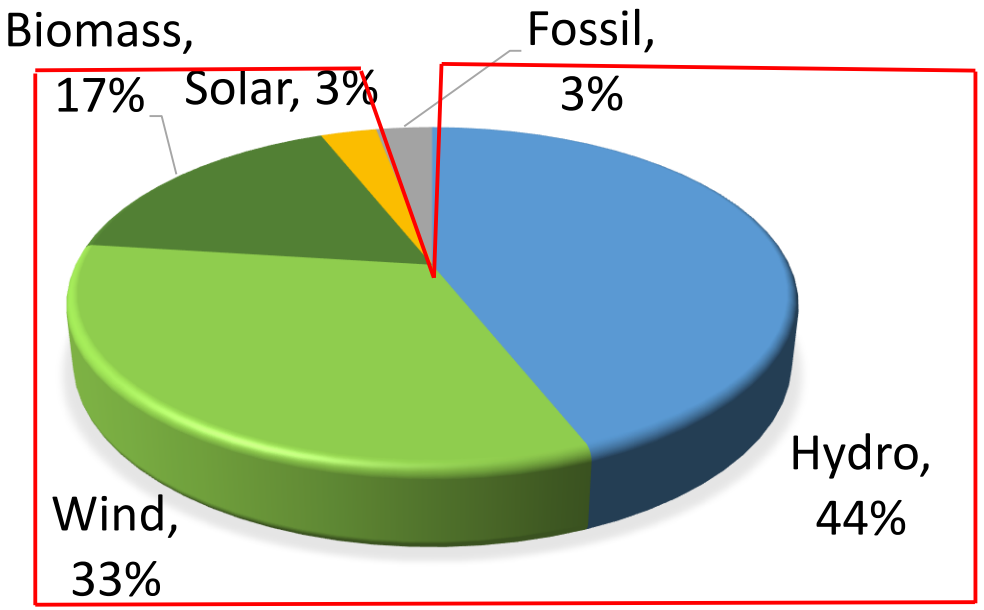
Wilson Sierra, Renewable energy, National Energy Directorate, Ministry of Industry, Energy and Mining

MIEM
MINISTERIO DE INDUSTRIA, ENERGÍA Y MINERÍA

SHARING EXPERIENCES – INNOVATIVE SOLUTIONS URUGUAY

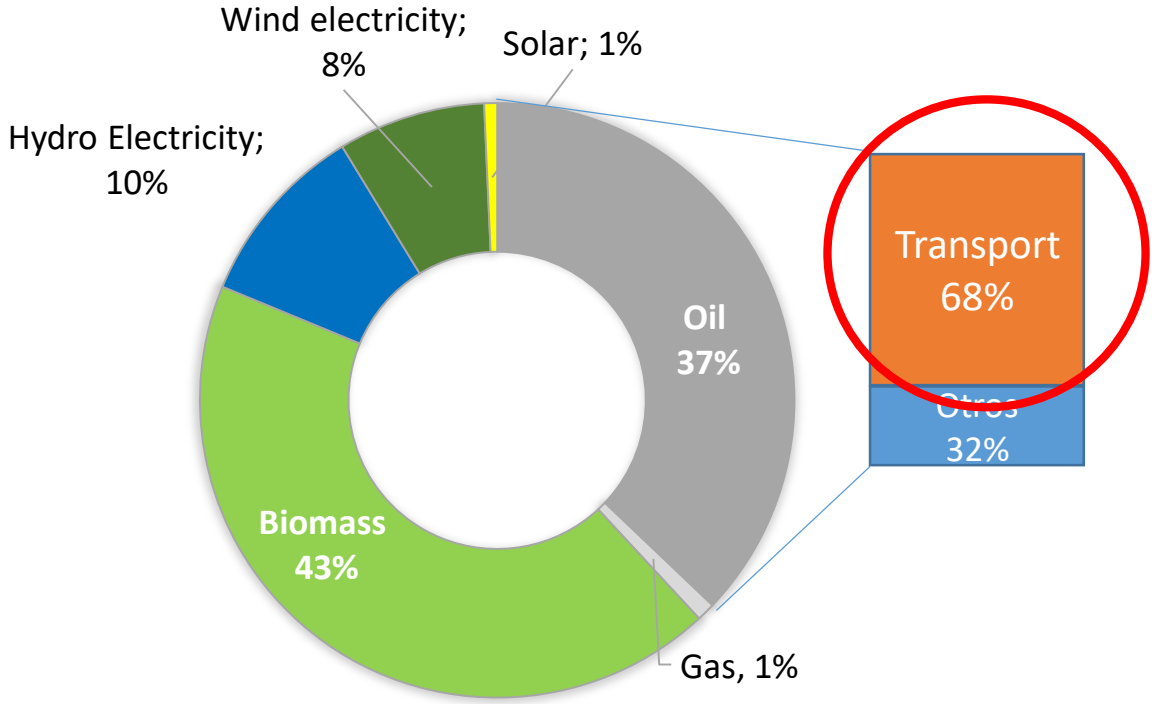
IRENA, OCTOBER - 2019

Power energy mix 2018 Uruguay



97 % Renewable

Global supply mix 2018 Uruguay

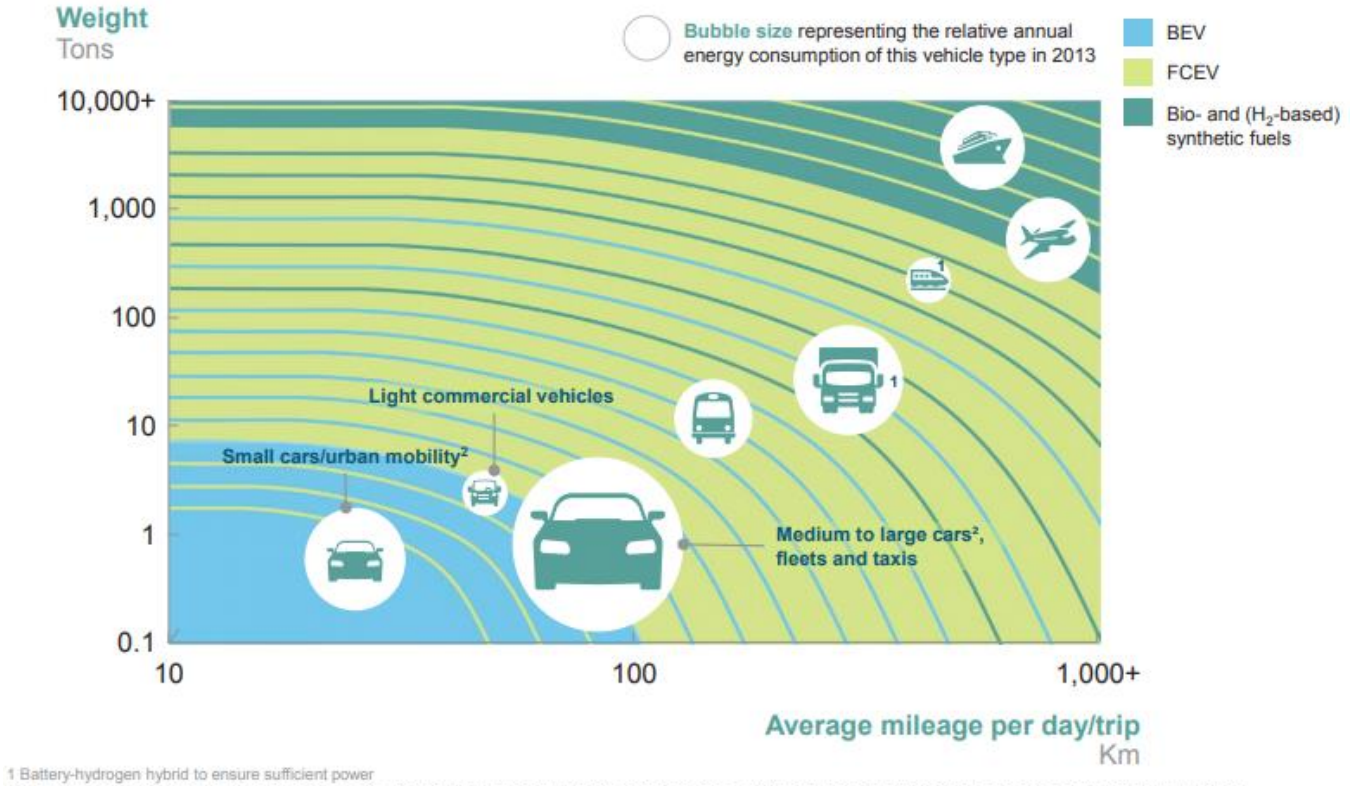


62% - RENEWABLES

New goal: transport decarbonization

- **Battery electric Vehicle (BEV)**

- **Fuel Cell Electric Vehicle (FCEV)**
  for heavy duty and Coach buses



1 Battery-hydrogen hybrid to ensure sufficient power
2 Split in A- and B-segment LDVs (small cars) and C+-segment LDVs (medium to large cars) based on a 30% market share of A/B-segment cars and a 50% less energy demand

Source: Toyota, Hyundai, Daimler

System-wide:

Power to hydrogen for transport (heavy duty and Coach buses). Pilot project

- Production of green hydrogen based of electricity from the grid (98 % renewable). Demand management (19 hours per day)
- one hydrogen fueling station in Montevideo
- 10 heavy vehicles (intercity buses range 500 km / road trucks range 900 km)
- 10 vehicles @ 1000 km / day => 600 ~ 900 kg H2 / day

- Renewable Power to Hydrogen
- Internet of Things
- Artificial Intelligence and Big Data
- Pay as you go models
- Time of use tariffs
- Advanced forecasting of variable renewable power generation

System-wide:

Power to heat (decarbonisation of heat)

- demands that use only energy surpluses
- energy surplus tariff: 30 USD/MWh (supplement fuel oil or natural gas 50 USD/MWh)
- institution hires a certain power
- utility ensure a number of hours of energy surplus for 7 years
- utility turns the general key on and off remotely
- take or pay

- Renewable Power to Heat
- Internet of Things
- Artificial Intelligence and Big Data
- Advanced forecasting of variable renewable power generation

Supply side:

- Wind, Solar and Hydro operating Forecast in the dispatch center (agreement with engineering school)
- Curtailment of Wind & Solar – dispatch remote control
- Flexible generation to accommodate variability (Biomass, Wind & Solar special contracts. Hydro)

Demand side:

- 100% smart metering for 2022 (today 100.000 users)
- Residential Electric boilers to hot water – utility remote controller
- thermometers installed in a sample of customers to design a product of air conditioner (hot/cold) – utility remote controller

Grid:

- Strong interconnections with Argentina (100 % of our historical peak demand) and Brazil (25% of our historical peak demand)

Thank you….

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SHARING EXPERIENCES – INNOVATIVE SOLUTIONS URUGUAY

IRENA, OCTOBER - 2019

Interactive discussion

Guiding questions

6. Are there other innovations or innovative solutions trialed/implemented in your country/region which are not captured in this figure?

ENABLING TECHNOLOGIES

1	Utility-scale batteries
2	Behind-the-meter batteries
3	Electric-vehicle smart charging
4	Renewable power-to-heat
5	Renewable power-to-hydrogen
6	Internet of things
7	Artificial intelligence and big data
8	Blockchain
9	Renewable mini-grids
10	Supergrids
11	Flexibility in conventional power plants

BUSINESS MODELS

12	Aggregators
13	Peer-to-peer electricity trading
14	Energy-as-a-service
15	Community-ownership models
16	Pay-as-you-go models

MARKET DESIGN

17	Increasing time granularity in electricity markets
18	Increasing space granularity in electricity markets
19	Innovative ancillary services
20	Re-designing capacity markets
21	Regional markets
22	Time-of-use tariffs
23	Market integration of distributed energy resources
24	Net billing schemes

SYSTEM OPERATION

25	Future role of distribution system operators
26	Co-operation between transmission and distribution system operators
27	Advanced forecasting of variable renewable power generation
28	Innovative operation of pumped hydropower storage
29	Virtual power lines
30	Dynamic line rating

Regulation and market design

Emanuele Bianco, Associate Programme Officer, Knowledge and Policy (IRENA)

Guiding questions

7. In general, a renewable energy-based power system has significantly different characteristics than the power systems for which the current organizational structures (i.e. power markets and regulation) were developed. Two of the main elements that organizational structures need to address are: a) the efficient long-term procurement of electricity and b) the procurement and dispatch of the needed flexibility for VRE integration. Failure to adapt the organizational structures to make them 'fit' for the renewable energy-based power system can produce barriers to the energy transition. In this context, please discuss:

a) Do you think the current organizational structure is 'fit' to enable the transition and sustainably support a renewable energy-based power system in your country/region?
b) What challenges related to the organizational structure of the power sector, if any, were faced in the past (or are faced today) in the energy transition? How were these challenges addressed or are planned to be addressed?
c) What challenges related to the organizational structure of the power sector, if any, do you anticipate in the future as your country and neighbors progress towards a renewable-based power system? How would you address these challenges?

Next steps

Next steps

➔ **October 2019**: IRENA shares the minutes of the workshop in Uruguay

➔ **October 2019:** IRENA shares the minutes of the present online workshop

➔ **5-6 November 2019**: IRENA Council with side-event:

Enhancing Dialogue among Countries with High Shares of Renewables in their Energy Systems

➔ **28 November 2019** (4 PM, GMT+2): Next online workshop

Thank you very much for your participation!

Further reading

- **IRENA (2019), Innovation Landscape for a renewable-powered future:** *Solutions to integrate variable renewables:* **Link**

- **IRENA (2019), Innovation Landscape Briefs:**
  - ✓ Market design briefs: **Link**
  - ✓ Enabling technologies**: Link**
  - ✓ Business models: **upcoming**
  - ✓ System operation: **upcoming**

- **IRENA (2020), Innovative solutions for 100% renewable power** - *Swedish case study:* **upcoming**
- **IRENA (2019), Innovation Outlook** smart charging for Electric Vehicles: **Link**
- **IRENA (2018), Hydrogen from renewable power:** *Technology outlook for the energy transition:* **Link**
- **IRENA (2019): Hydrogen**: *A renewable energy perspective:* **Link**