IRENA
International Renewable Energy Agency

Disruptive innovative solutions enabling 100% renewable power systems

Workshop

28 November 2019

Agenda

Welcome address

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

Round-table introduction

All participants

Project Overview

Ms 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.*

Costa Rica	Denmark	Germany	Norway	Spain	Sweden	Uruguay	Paraguay
							
100% renewable power by 2030	100% renewable power by 2050	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

Additional innovation work (funded by Sweden)

Workstream 1: Experience sharing programme on innovative solutions for very high shares of renewable power by mid-century

Activity
- Engagement with member countries having similar policy targets
- Engagement with experts, academia and private sector

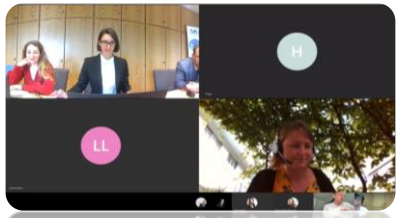
Input
- IRENA's 160 member countries
- IRENA's analytical tools and knowledge base (IITC, KPFC)

Output
- Online & offline engagement (regional workshops, online workshops)

Outcome
- Innovation network of countries with high renewable power targets
- Outlook for future international collaboration on this topic

100% Renewable Power

Online workshops



Workshop in Uruguay

January 2019 ⟵ ⟶ *January 2020*

Workstream 2: Country-level innovation study

Activity
- Internal IRENA (IITC, KPFC) engagement
- Engagement with member countries
- Engagement with key stakeholders in Sweden

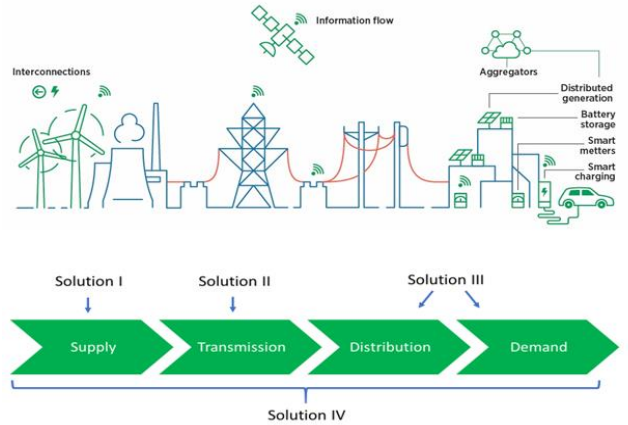
Input
- National and regional circumstances, approaches to innovation, as well as challenges & opportunities for a decarbonised power system by 2040
- Qualitative analysis of disruptive innovations
- Power-sector insights

Output
- Knowledge creation (published in a report)
- Outreach & dissimination of knowledge in Sweden, as well as other interested member countries

Outcome
- Informed decision-makers in Sweden
- Informed decision-makers in other member countries participating in the project

Innovative solutions for 100% renewable power

Swedish case study



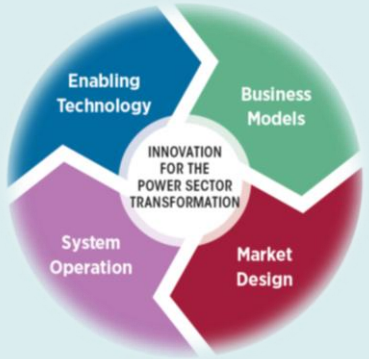
Workstream 1

Past activities

Type of workshop	Tentative date	Description	Location	Link
Online	6th June 2019	Focus on sharing national objectives for renewable power and expected/experienced **challenges**	Remote	Link
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	Link
Online	10th October 2019	Focus on sharing national **experiences** with the application of innovative solutions	Remote	Link
Online	**28th November 2019**	Focus on **disruptive innovative solutions** enabling 100% renewable power systems	Remote	Link

Workstream 2

Innovation Landscape Report for VRE integration + 30 Innovation Landscape Briefs + Swedish case study

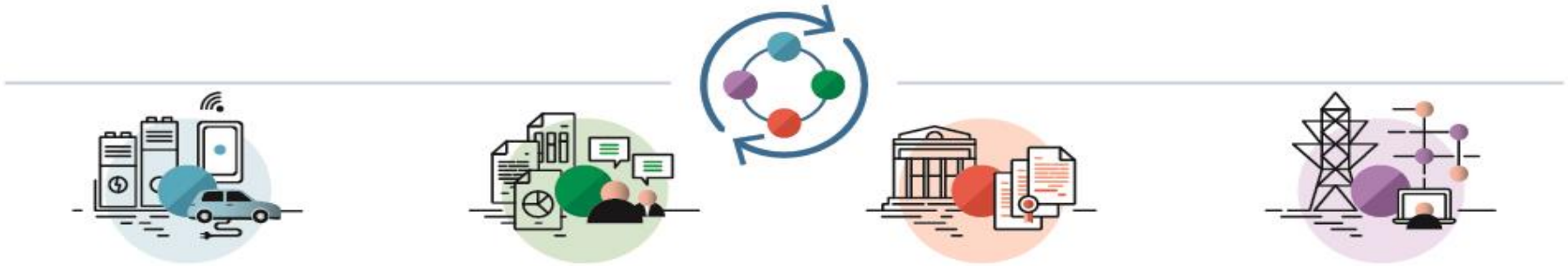


Swedish VC
(ongoing)

Workstream 1: network
Workstream 2: case study

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

30 innovations for VRE integration



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

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

Innovative solutions for 100% renewable power: Swedish case study

Solution I

Enabling technologies

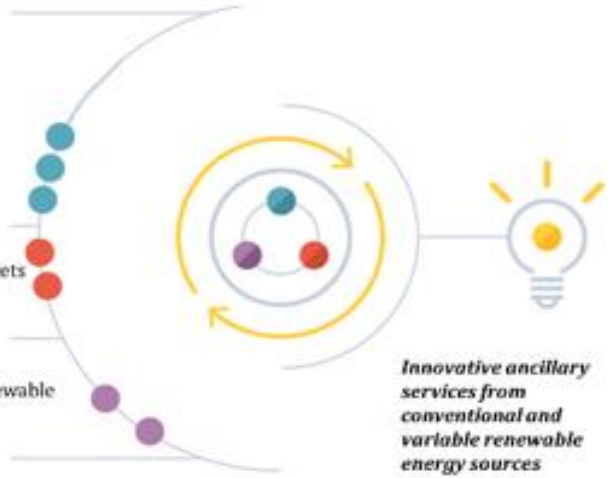
-Utility-scale batteries
-Internet of Things
-Artificial intelligence and big data

Market design

-Increasing time granularity in electricity markets
-Innovative ancillary services

System operation

-Advanced weather forecasting of variable renewable power generation



Innovative ancillary services from conventional and variable renewable energy sources

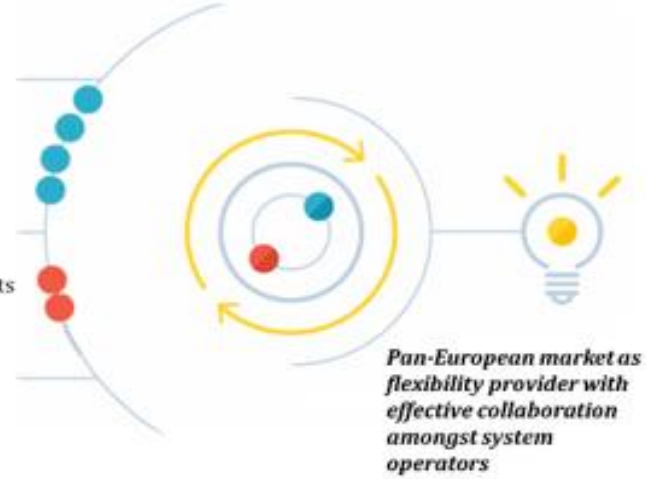
Solution II

Enabling technologies

-Internet of Things
-Artificial intelligence and big data
-Blockchain
-Supergrids

Market design

-Increasing time granularity in electricity markets
-Regional Markets



Pan-European market as flexibility provider with effective collaboration amongst system operators

Solution III

Enabling technologies

-Behind-the-meter batteries
-EV Smart charging
-Renewable power-to-heat
-Internet of Things
-Artificial intelligence and big data
-Blockchain

Business models

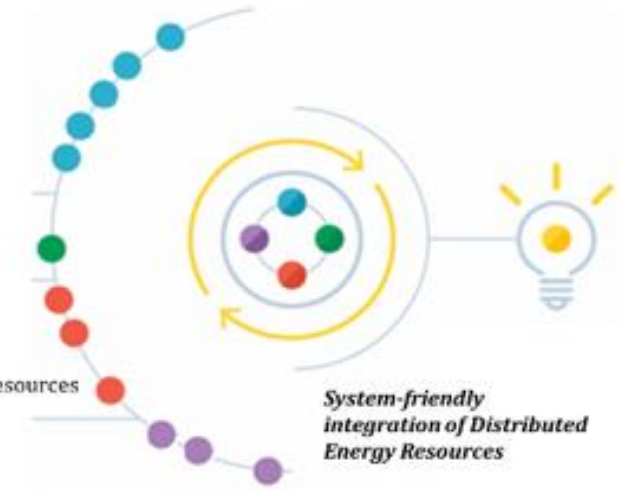
-Aggregators

Market design

-Time-of-Use tariffs
-Innovative ancillary services
-Market integration of distributed energy resources

System operation

-Future role of DSOs
-Co-operation between TSOs and DSOs
-Virtual power lines



System-friendly integration of Distributed Energy Resources

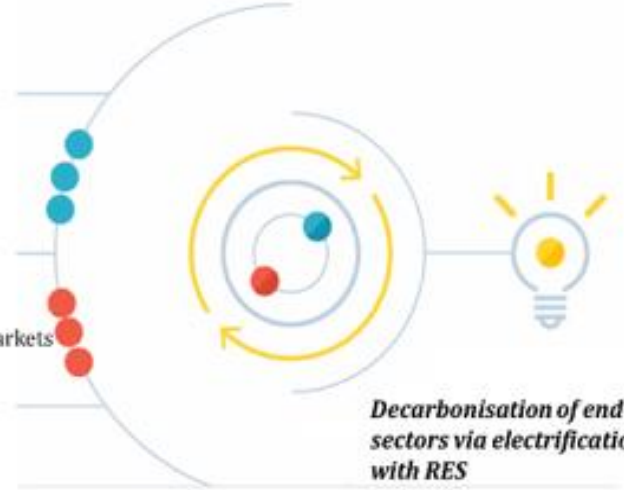
Solution IV

Enabling technologies

-Renewable power-to-heat
-Renewable power-to-hydrogen
-Artificial intelligence and big data

Market design

-Increasing time granularity in electricity markets
-Innovative ancillary services
-Regional Markets



Decarbonisation of end-use sectors via electrification with RES

I. Decarbonisation and electrification of end-use sectors

Solution IV: Decarbonisation of end-use sectors via electrification with RES

Schematic representation of innovative solution IV

Enabling technologies

-Renewable power-to-heat
-Renewable power-to-hydrogen
-Artificial intelligence and big data

Market design

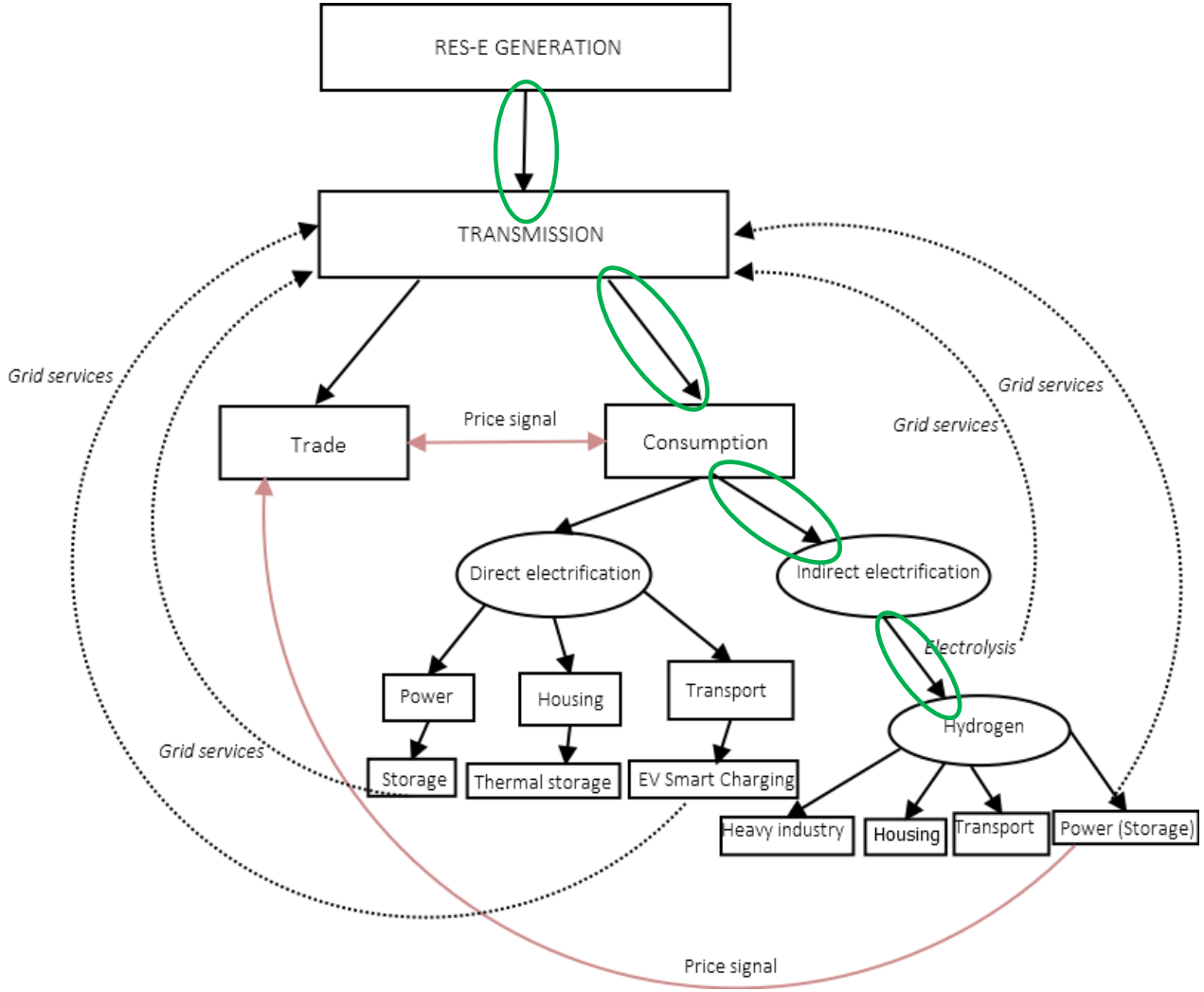
-Increasing time granularity in electricity markets
-Innovative ancillary services
-Regional Markets

IRENA (2020), Innovative solutions for 100% renewable power - Swedish case study (*upcoming*)

Solution IV: Decarbonisation of end-use sectors via electrification with RES

Decision whether to consume or trade renewable power on the regional wholesale electricity market could be based on the market price signals (European context). If released for consumption, renewable electricity can either contribute to:

1) **Direct electrification** of the power-, heat or transport end-use sectors, which in turn opens the door to electricity and heat storage as well as electric vehicle (EV) smart charging;
2) **Indirect electrification**, through the production of hydrogen via electrolysis and its use in transport, housing and industrial applications;
3) **Storing renewable hydrogen** over longer periods of time, which could be reconverted to power and traded on electricity markets when profitable, based on market price signals;
4) **Enabling the provision of ancillary services** to the transmission system operators from electrolysis, hydrogen storage and EV batteries via EV smart charging technologies.



IRENA (2020), Innovative solutions for 100% renewable power - Swedish case study (*upcoming*)

Guiding questions

1. Drawing on '*Solution IV - Decarbonisation of end-use sectors via electrification with RES*', what is your country's stance on **decarbonisation of end-use sectors** via indirect (e.g. renewable power-to-hydrogen) and direct (e.g. renewable power-to-heat) electrification? E.g. Have any targets been expressed on renewable power-to hydrogen or on sector coupling?

2. Would it be feasible to **implement solution IV** (or a similar solution) in your country in order to integrate larger shares of VRE in the power system, while decarbonizing other end-use sectors? Which barriers did you identify, and what opportunities could arise?

3. Looking at examples of similar implemented solutions, are there any comparable projects being trialed or planned for the future in your country?

Spain

Sweden

Uruguay

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DISRUPTIVE INNOVATIVE SOLUTIONS URUGUAY

IRENA, NOVEMBER 2019

Decarbonization of end-use sectors via indirect electrification:

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

- Production of green hydrogen based of electricity from the grid (97 % 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

Decarbonization of end-use sectors via indirect electrification:

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

Barriers

- Commercial buses are only urban (there are no commercial Coach Buses)
- Is not easy to buy trucks (serial production doesn't exist)
- Large scale Hydrogen Storage to store Energy surplus (if country doesn't have salt mines)
- Fossil fuels cheaper than hydrogen from electrolysis (until 2030)
- New and expensive infrastructure
- Security perception
- Connection to the grid is expensive. Isolated solar plus Wind parks to produce hydrogen have to be analyzed

Decarbonization of end-use sectors via direct electrification:

Power to heat with energy surplus

- Electric boiler uses only energy surplus
- Functions in parallel with fossil fuel boiler

Electric Boiler to generate steam

Fossil fuel Boiler to generate steam

Industry

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

Decarbonization of end-use sectors via direct electrification:

Power to heat with energy Surplus

Barriers

- Energy surplus hours are not equal every year (Hydro's share is 50% with high annual variability). The Utility can guarantee a quantity of surplus hours in 7 years.

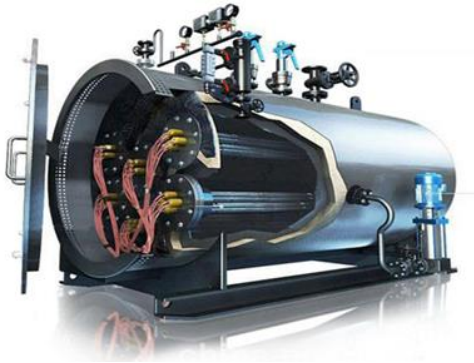
- Connection to the grid is expensive.

Regulatory initiatives

Regulatory initiatives:

Power to heat with energy surplus

- demands 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 ensures a number of hours of energy surplus for 7 years
- utility turns the general key on and off remotely
- take or pay



Thank you….

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DISRUPTIVE INNOVATIVE SOLUTIONS URUGUAY

IRENA, NOVEMBER- 2019

Interactive discussion

II. Social innovation and regulatory sandboxes

Guiding questions

4. What is your view on the topic of **social acceptance**? Could you share any examples or initiatives aimed at increasing the social acceptance of technology-driven innovations in the context of integrating higher shares of renewables in the power mix?

5. Are there any insights or best practices from **regulatory initiatives** encouraging actors to experiment and test technology-driven innovations in the context of integrating higher shares of renewables in the power mix?

Interactive discussion

III. Discussion on future engagement

Guiding questions

6. What role should IRENA play to accelerate innovation in the area of decarbonization of end-use sectors with renewables?

7. Would you like to engage on this (or similar) subject in the future? If yes, which topics do you perceive as particularly important to discuss within an international arena?

Next steps

Next steps

➔ **December 2019**: IRENA shares feedback survey and minutes of this online workshop

➔ **10 January 2020**: "*Enhancing Dialogue among Countries with High Shares of Renewables in their Energy Systems* with a panel about innovation

➔**11-12 January 2020:** IRENA Assembly

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**