IRENA
International Renewable Energy Agency

Identifying challenges for achieving 100% renewable power systems by mid-century

Online workshop

6th June 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) and rationale behind the series of workshops on the topic of 100% renewable power (Sweden)**	**Paul Durrant**, Programme Officer, Renewable Energy Innovation (IRENA) **Truls Borgström**, Deputy Director, Energy Division, Ministry of Infrastructure (Sweden)
16:05	**16:10**	**Introductory remarks**	**Elena Ocenic**, Programme Officer, Innovation Networks (IRENA)
16:10	**16:20**	**Setting the scene:** *the systemic innovation approach proposed by IRENA in the Innovation Landscape Report*	**Arina Anisie**, Associate Programme Officer, Renewable Energy Innovation (IRENA)
16:20	**16:30**	**Q&A**	**Arina Anisie**, Associate Programme Officer, Renewable Energy Innovation (IRENA)
16:30	**17:30**	**Challenges in the adoption of a systemic innovation approach as a key enabler to achieve high shares of renewable power by mid-century** *5 presentations of 8 minutes, each followed by a 4-minute question and answer session*	**Hanna Ek-Fälth**, Renewable Energy Analyst, Swedish Energy Agency (Sweden) **Ruben García**, National Director of Energy, DNE-Ministry of Industry, Energy, and Mining, MIEM (Uruguay) **Wilson Sierra**, Manager of the Renewable Energies Department, MIEM (Uruguay) **Rolando Castro**, Viceminister of Energy, Ministry of Environment and Energy (Costa Rica) **Laura Lizano**, Director of the Energy Planning Secretariat, Ministry of Environment and Energy and **Mr Alfonso Herrera** (Costa Rica) **Bilun Müller**, Deputy Head of Unit International cooperation on energy, Federal Ministry for Economic Affairs and Energy (Germany) **Hugo Lucas Porta**, Ministry for Ecological Transition, Institute for Energy Diversification and Energy Saving (Spain)
17:30	**17:45**	**Interactive discussion**: *common challenges, helping identify innovations and innovative solutions in subsequent workshops*	**All speakers/participants**
17:45	**18:00**	**Next steps**	**Elena Ocenic**, Programme Officer, Innovation Networks (IRENA)

Welcome address

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

Rationale behind the series of workshops on the topic of 100% renewable power from Sweden's perspective

Truls Borgström, Deputy Director
Energy Division, Ministry of Infrastructure (Sweden)

Introductory remarks

Elena Ocenic, Programme Officer,
Innovation Networks (IRENA)

Introductory remarks

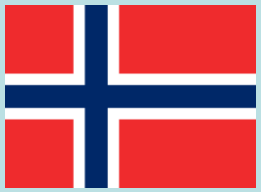
IRENA activities on 100% Renewable Energy (selection):

- Knowledge Framework for Power Sector Transformation – *Capturing of learnings, benchmark experiences and successful measures made by front runner countries to achieve power system decarbonization*
- Addressing Variable Renewable Energy in Long-term Energy Planning – *Identification of the best practices in long-term planning and modelling to expand high shares of VRE*
- IRENA FlexTool – *Detailed optimization tool analyzing power system flexibility in order to identify pathways and solutions to achieve 100% RE*
- Coalition for Action – 100% RE Working Group co-chaired by the European Renewable Energies Federation and the International Solar Energy Society – *Launched a white paper on "Towards 100% Renewable Energy: Status, Trends, and Lessons Learned" focusing on global mapping of 100% renewable energy targets, case studies and policy recommendations*
- Innovative solutions for very high shares of renewable power by mid-century - **Experience-sharing programme** – *series of 4 online and in-person workshops in 2019, benefiting from financial support from the government of Sweden and in collaboration with the government of Uruguay*

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 is a frontrunner in the operation of a power system with very high shares of renewable power with 98% of its power generated in 2017 from renewable energy sources.*

Costa Rica	Germany	Norway	Spain	Sweden	Uruguay
					
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

Introductory remarks

Key challenge:

How to best transform the national power systems with **innovative solutions** to ensure the cost-effective integration of high shares of renewable power, including variable renewable energy (VRE) sources?

Objective:

Exchange of perspectives, plans and good practices in working towards very high levels of renewable power, with a particular focus on countries that have pledged very high (over 80%, and in some cases 100%) renewable power targets in the coming decades, as well as frontrunners in the operation of power systems with very high shares of renewable power. The activities will be open to countries that have less specific targets and would like to explore a high ambition for renewable power.

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 (16th July).	Montevideo, Uruguay
Online	October 2019 (TBC)	Focus on sharing national **experiences** with the **application** of innovative solutions	Remote
In-person	November 2019 (TBC)	Focus on **disruptive innovative solutions** enabling 100% renewable power systems	Europe (TBC)

Setting the scene:
the Systemic Innovation Approach proposed by IRENA in the Innovation Landscape Report

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

Wind & solar PV at the core of the energy transition

Cost reduction in the period 2010 - 2018

77%
Solar PV

30%
Onshore Wind

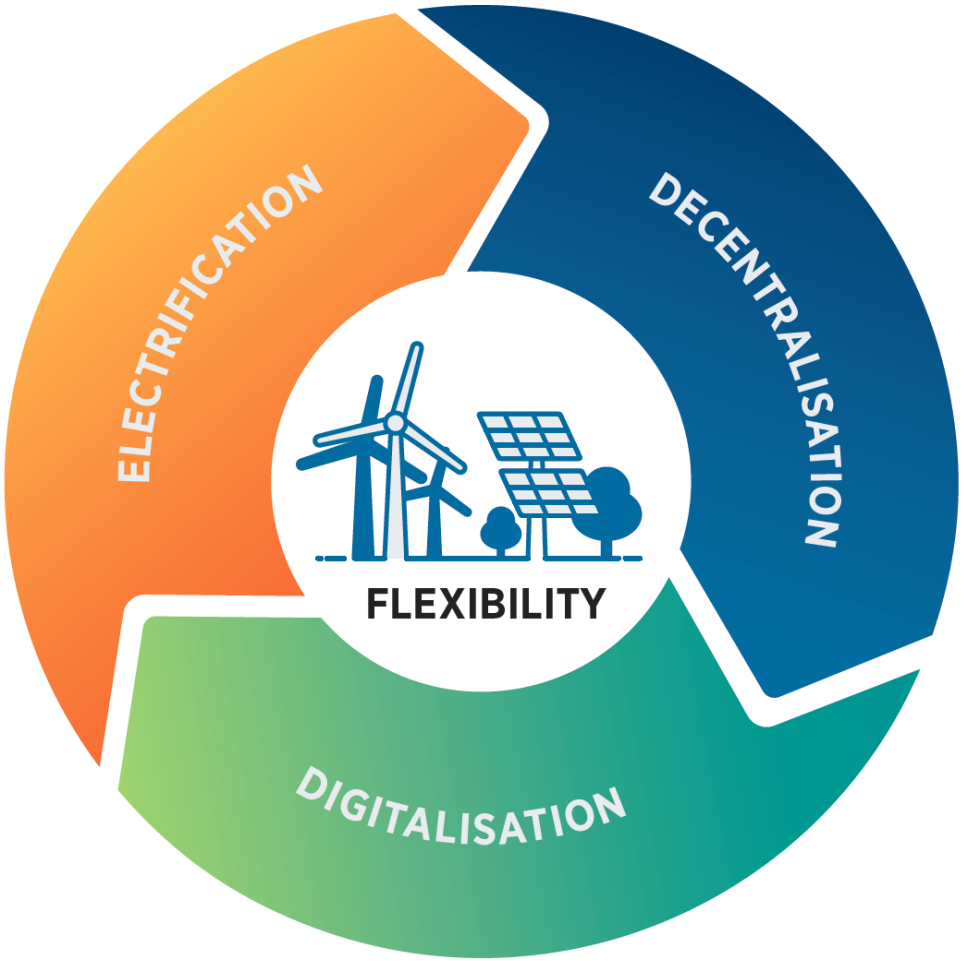
Wind and PV electricity share in generation mix 2015 and 2050

	Today	In 2050
Solar PV	3%	23%
Onshore Wind	7%	37%

- Wind and PV are **variable energy sources** – addressing variability is crucial for high deployment.
- Today's challenge – **integrating high shares of wind and PV** in power systems.
- **Power-system flexibility** is key to the cost-effective use of renewables.

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables, IRENA (2019), Global energy transformation: A roadmap to 2050 (2019 edition)

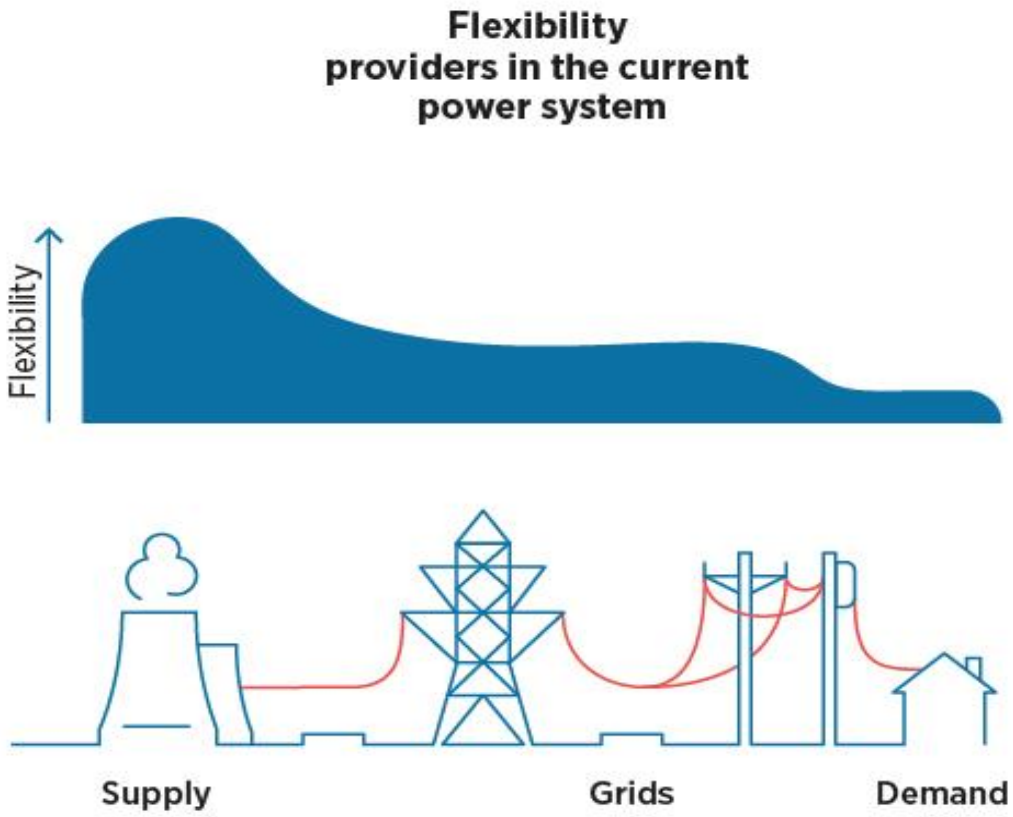
Three innovation trends

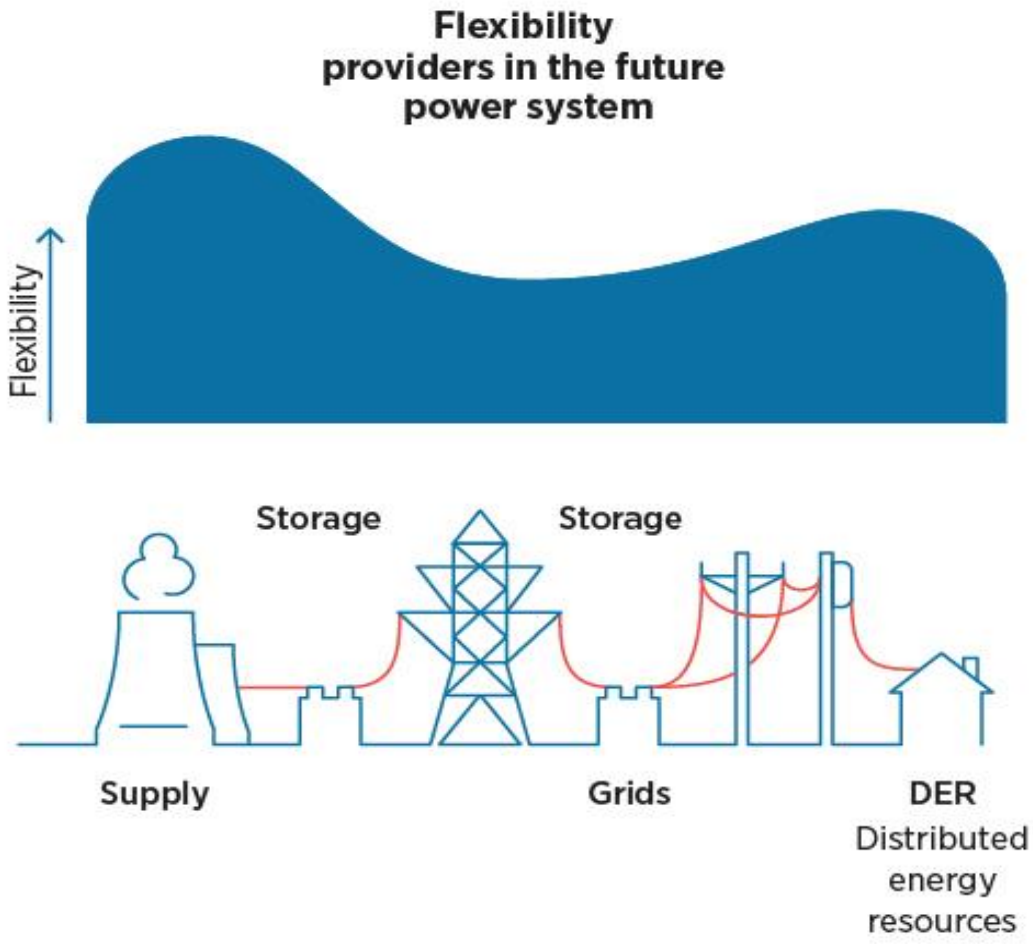


- The increasing deployment of Distributed Energy Resources (DERs) turns the consumer into an active participant, **fostering demand-side management**.
- Electrification of end-use sectors is an emerging solution to **maintain value and avoid curtailment of VRE**, and help decarbonize other sectors
- Digital technologies enable **faster response, better management of assets, connecting devices, collecting data**

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

Innovation unlocks flexibility across the power system





Flexibility sources: Flexible generation

Flexibility sources: Flexible generation; Regional interconnections and markets; Demand response; Storage; Power to X

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

Systemic innovation for VRE integration

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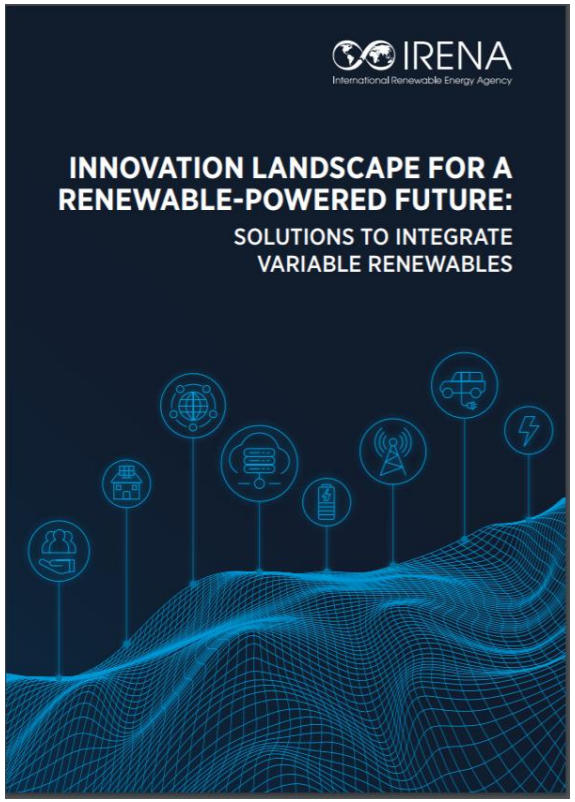
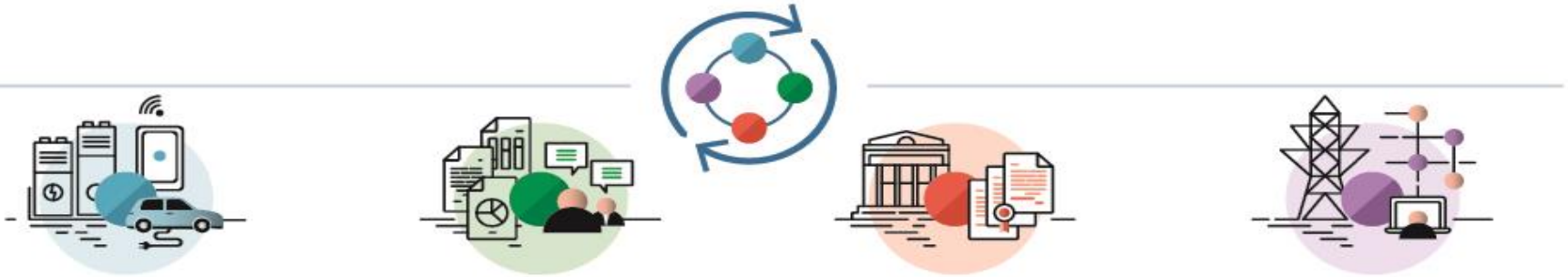
International Renewable Energy Agency



Innovation Landscape Report



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

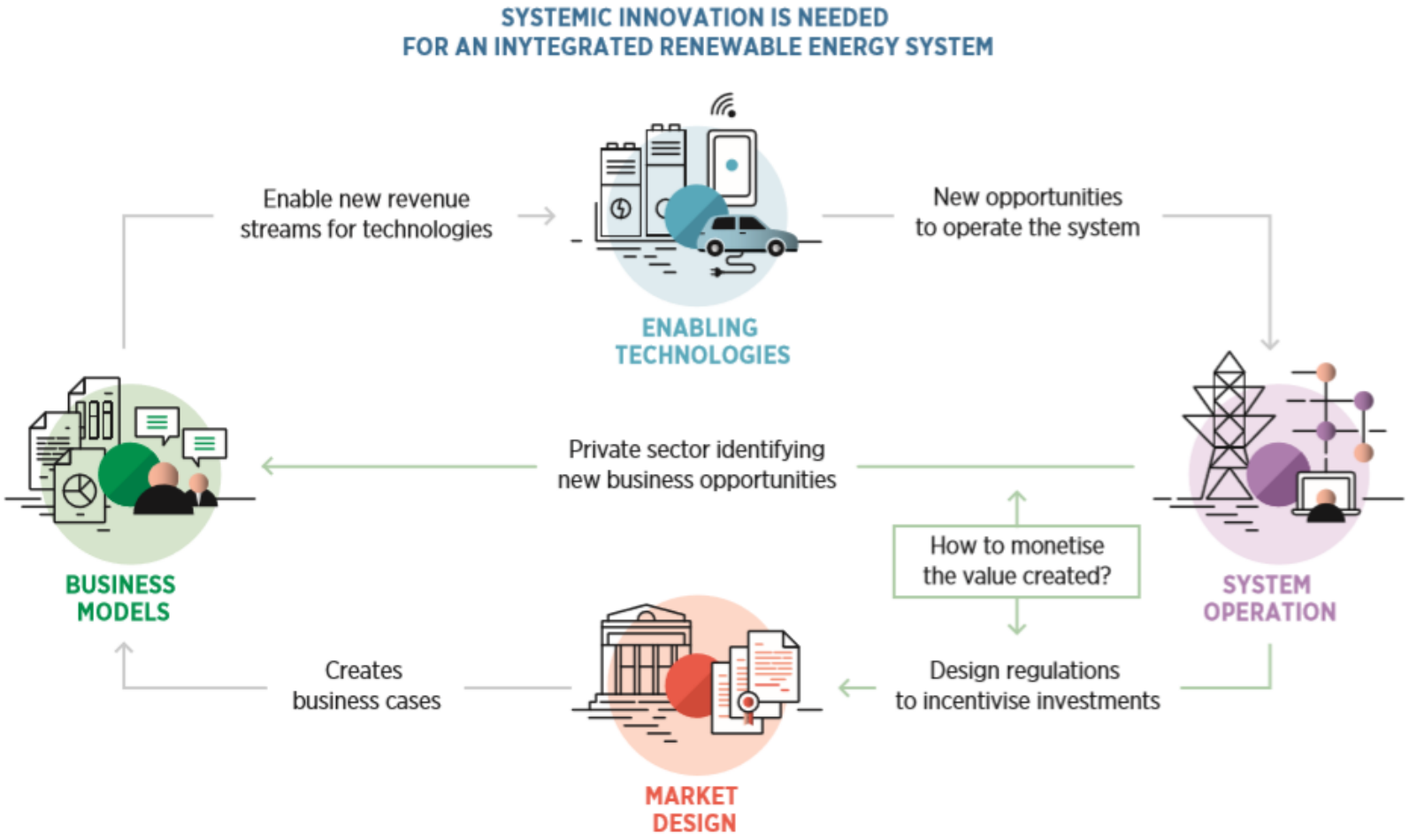
17	Increasing time granularity in electricity markets
18	Increasing space granularity in electricity markets
19	Innovative ancillary services
20	Re-designing capacity markets
21	Regional markets
22	Time-of-use tariffs
23	Market integration of distributed energy resources
24	Net billing schemes

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

Systemic Innovation for a Renewable-Powered Future



Innovations do not emerge in isolation
→ Synergies between innovations are needed

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

Systemic Innovation for a Renewable-Powered Future

Example of solution: Distributed energy resources (DERs) providing services to the grid

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

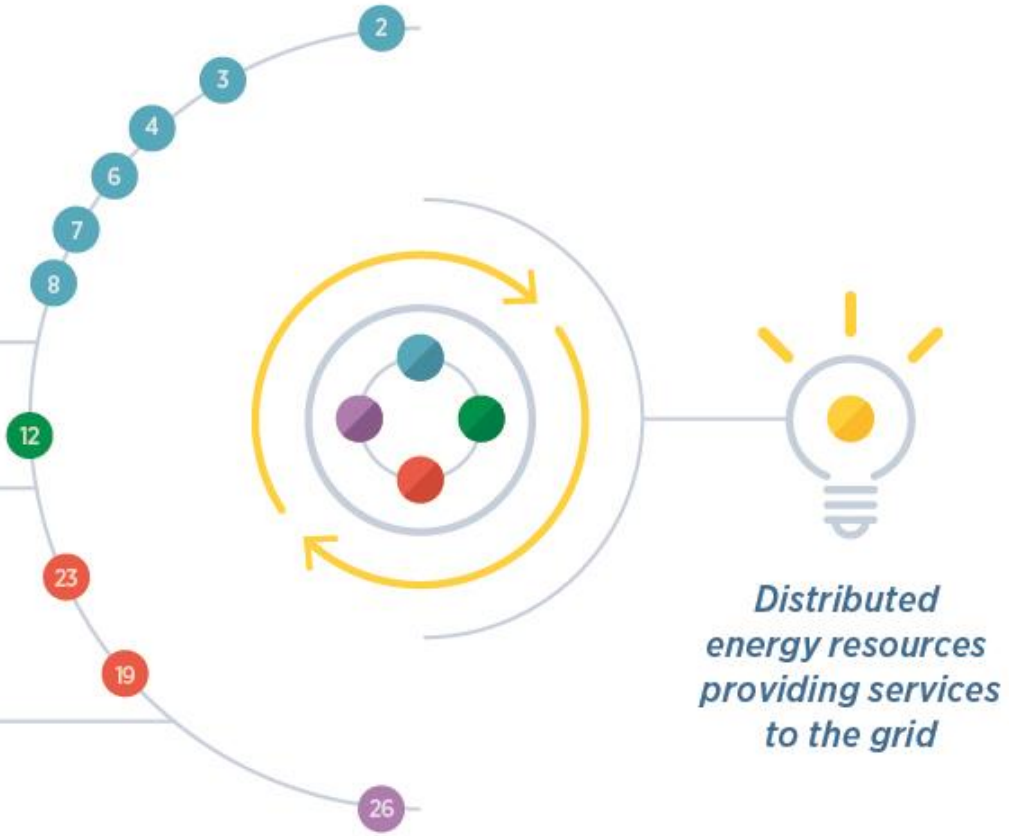
- Aggregators

Market design

- Market integration of distributed energy resources
- Innovative ancillary services

System operation

- Co-operation between transmission and distribution system operators



11 solutions explored in depth in the report, including advice on their suitability and impact.

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

Q&A

Challenges in the adoption of a systemic innovation approach as a key enabler to achieve high shares of renewable power by mid-century

Guiding questions

1. What is the status on renewable share in your national power system (e.g. share of renewable power, share of variable renewable energy (VRE) in the power system, overall energy mix, policy targets, ambitions, etc.)?
2. What enabling measures were taken already in the past to achieve these shares (if any)?
3. What are the current challenges with the system operation of the existing share of renewables (including, but not limited to VRE)?
4. What (other) challenges do you foresee with an increased share of renewables in your power system?
5. What are the main priorities for the power sector for the next two or three decades?

Sweden

Hanna Ek-Fälth, Renewable Energy Analyst
Swedish Energy Agency

Towards a 100% Renewable Power System

What is the status in **Sweden?**

Swedish Energy Agency

Power Production Today

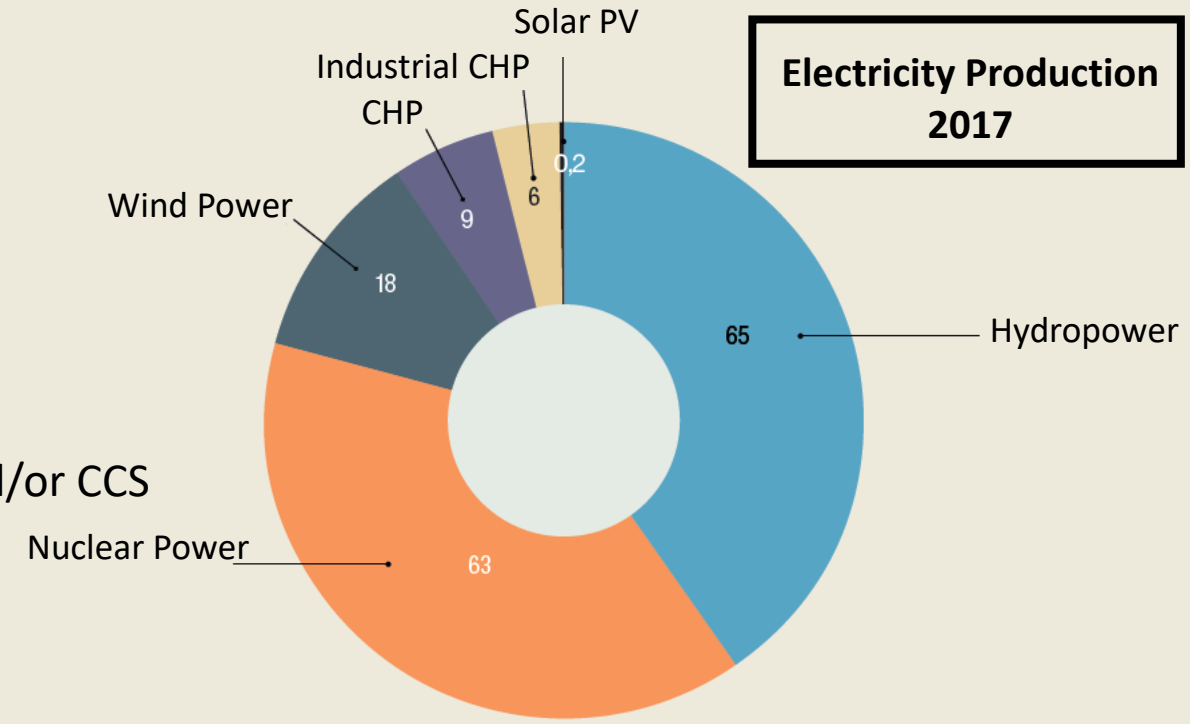
- ~ 140 TWh Electricity Demand and 160 TWh Power Production
- ~ 60-65 % Renewable power (70% in a couple of years)
  - ~13% Variable renewable power
- ~ 36% Nuclear power
- ~ 2-3% fossil fuels and waste in CHP

- 400 TWh of total energy-use with 55% renewable supply

Targets

- 100 % Renewable power system by 2040
  (not a stop-date for nuclear power)

- Net-Zero Emissions by 2045
  - At least 85% from emission reductions
  - The rest from international measures, carbon sinks and/or CCS



Swedish Energy Agency

Actions taken

- Market Based Electricity Certificate System
  - Started 2003 with a common market with Norway since 2012
  - 28,4 TWh 2020
  - Another 18 TWh in Sweden 2030 (forecast: will be reached in 2021-2022)
- Carbon Tax
- Different Support Schemes for Solar PV and direct capital subsidy for storage systems
- Liberalized energy-only market
- Dissemination of information
- Research and innovation support

Swedish Energy Agency

Challenges in the Current Power System

- Sweden is a part of a Nordic power system, with common challenges in e.g. frequency stability
  - The Swedish TSO has noticed an increased challenge with frequency
  - The power reserve has not been activated in the last few years

Swedish Energy Agency

Challenges towards a 100% renewable power system

- Replacing about 100 TWh of electricity from power units reaching the end of their economical life
- Need of more flexibility in the power system
- Local/regional shortage of grid capacity
- New sectors are electrified (i.e. transport, industry), likely to lead to an increased and changed demand
  - Could be a possibility for more flexibility
- Cost-efficient transmission expansion
  - Inline with the geographical and temporal changes in both production and demand, coming from the increased share of VRE
- A large expansion of wind power
  - National wind power strategy
  - Well-working authorization processes
  - Likely less power production close to areas with high demand
- Electricity market improvements
  - Markets for system services
  - Handling of price volatility

However, we see that Sweden has good conditions for reaching a 100% renewable power system

Swedish Energy Agency

Main priorities for the power sector in the coming decades

- Security of supply
- Cost-efficiency
- Ecological Sustainability

Swedish Energy Agency

Uruguay

Ruben García, National Director of Energy (DNE-Ministry of Industry, Energy, and Mining (MIEM)

Wilson Sierra, Manager of the Renewable Energies Department (MIEM)

MIEM
MINISTERIO DE INDUSTRIA, ENERGÍA Y MINERÍA

IDENTIFYING CHALLENGES FOR ACHIEVING 100% RENEWABLE POWER SYSTEMS BY MID-CENTURY

URUGUAY

Wilson Sierra

Renewable Energies Unit

Secretary of Energy

Ministry of Industry, Energy and Mining

Montevideo (VC), *June 6th, 2018*

Overview of Uruguay

Country name:	República Oriental del Uruguay
Capital city:	Montevideo
Land area:	176.215 sq.km
Population:	3,45 million inhabitants
Life expectancy:	76 years
Gross Domestic Product:	16.246 USD per capita

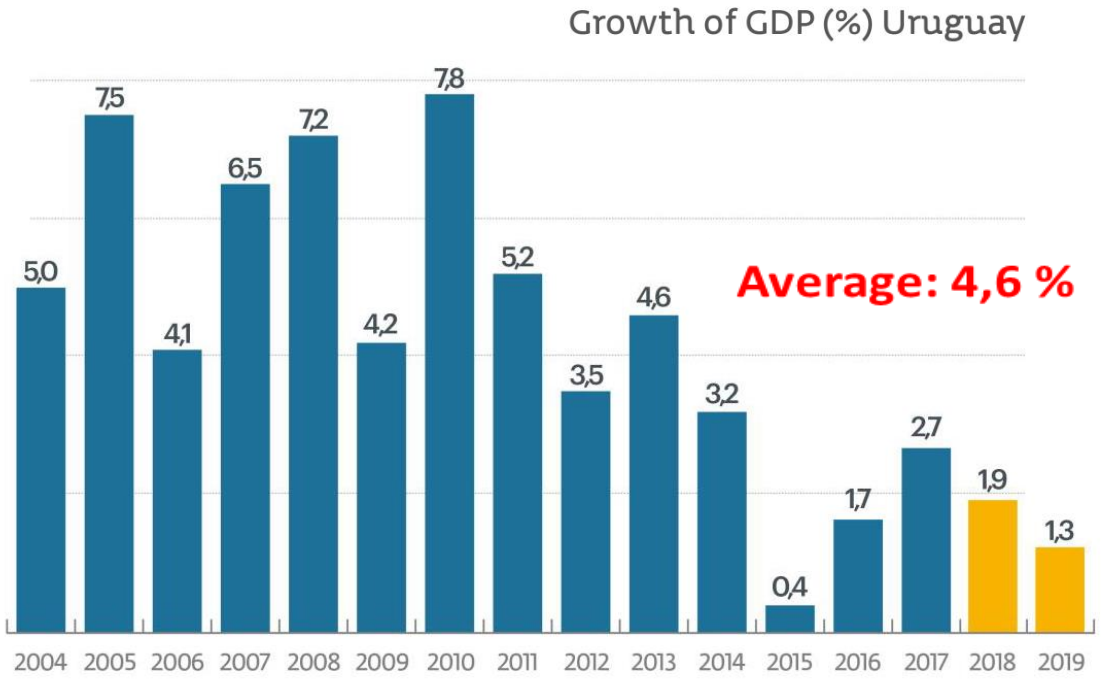
Energy sector

- **No oil**
- **No coal**
- **No Natural Gas**

Mean annual power demand:	1.100 MW
Electrification rate:	99,8 %
Peak power demand:	1.997 MW (summer 2018)

Overview of Uruguay

Economically sustainable

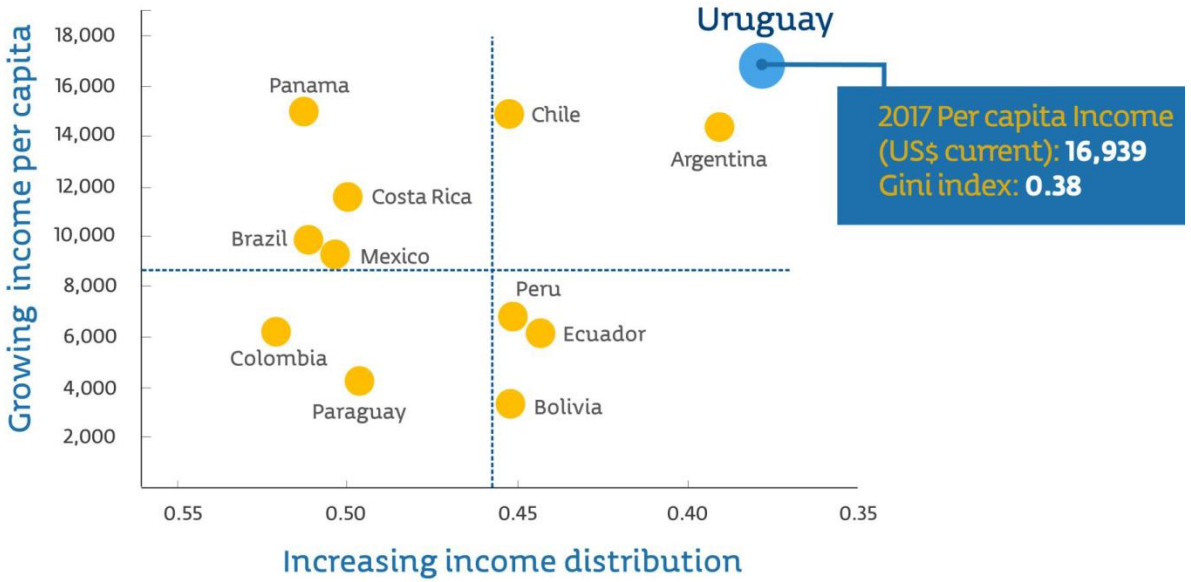


Environmentally sustainable

Socially sustainable

Growth with equity

Income level and distribution in Latin America
(US$ per cápita and Gini index, 2017)

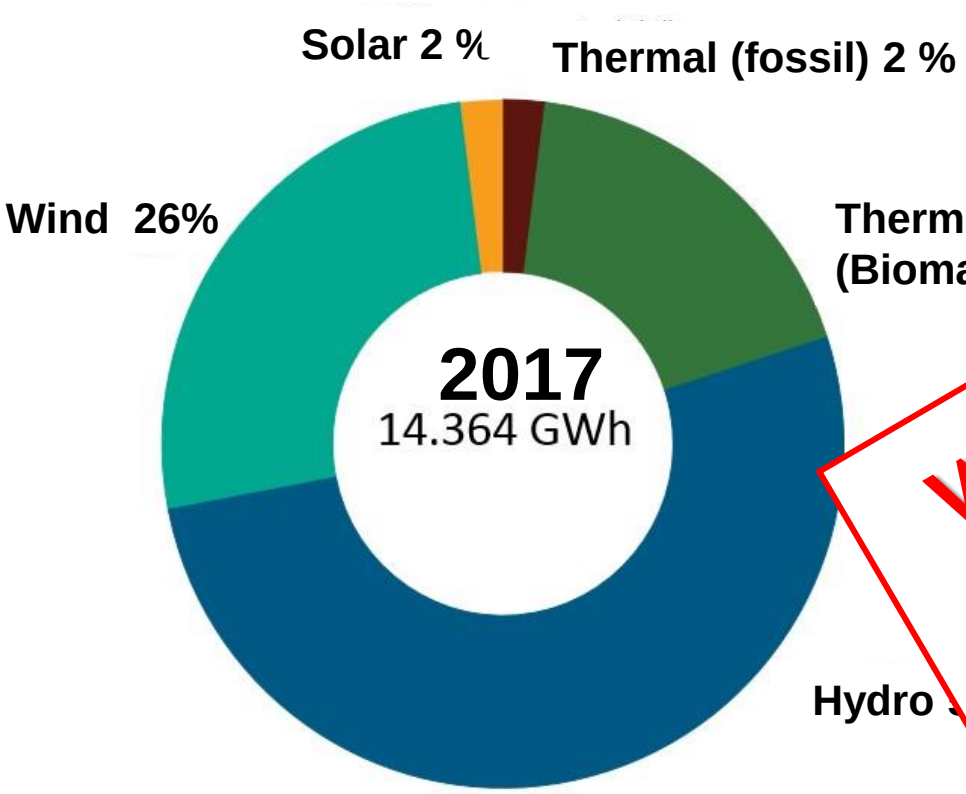


Political and social stability

URUGUAY #1 in LAC (2017)	Transparency	Democracy	Equity
	#1 Low corruption perception Transparency International	#1 Democracy The Economist	#1 Inclusive Development World Economic Forum
Other indicators in Latin America	#1 Control of corruption The World Bank	#1 Rule of Law World Justice Project #2 Press Freedom Reporters without borders	#1 Prosperity Legatum Institute #1 Quality of life Mercer

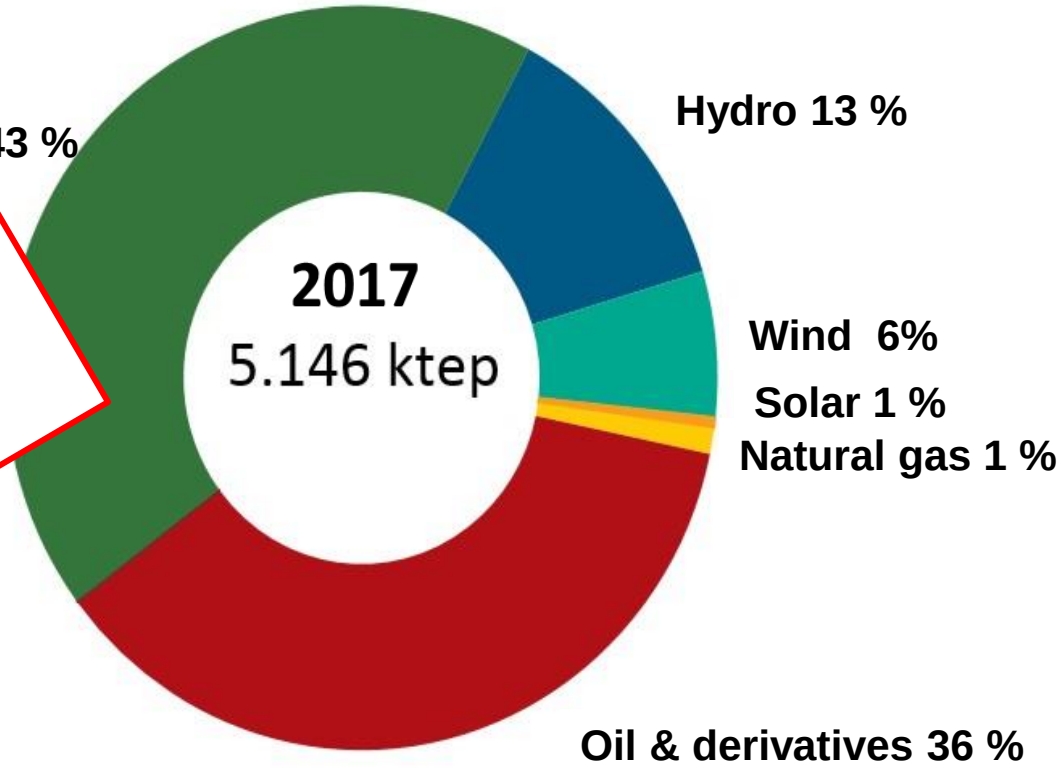
RE STATUS IN URUGUAY

ELECTRICITY GENERATION 2017



98 % - RENEWABLE SOURCES

ENERGY SUPPLY IN 2017



WITHOUT SUBSIDIES

63 % - RENEWABLE SOURCES

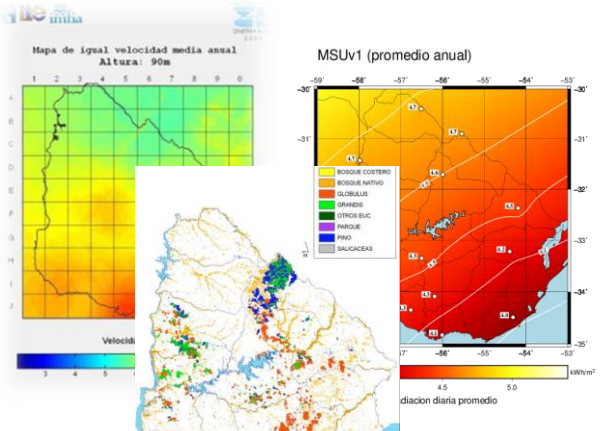
BIOMASS > OIL & NATURAL GAS

Enabling Measures

State Policy

Organized civil society

Public utility & NOC

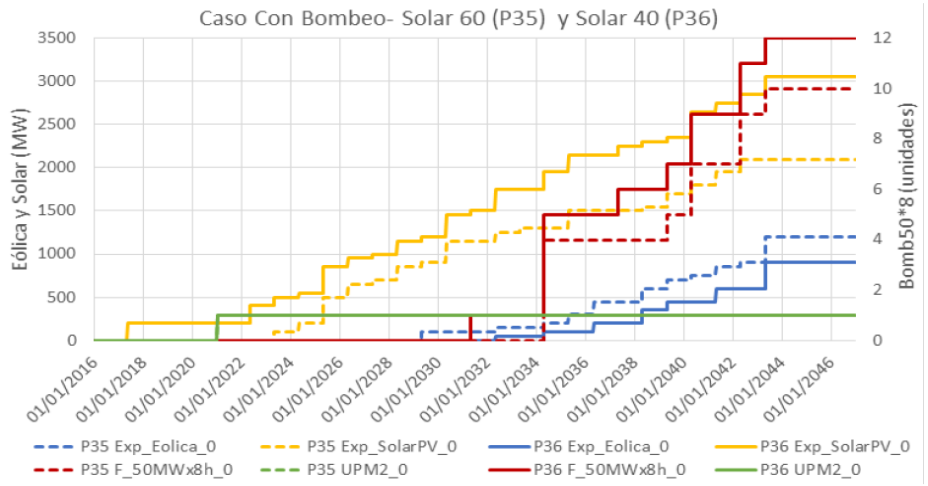


Capacity building

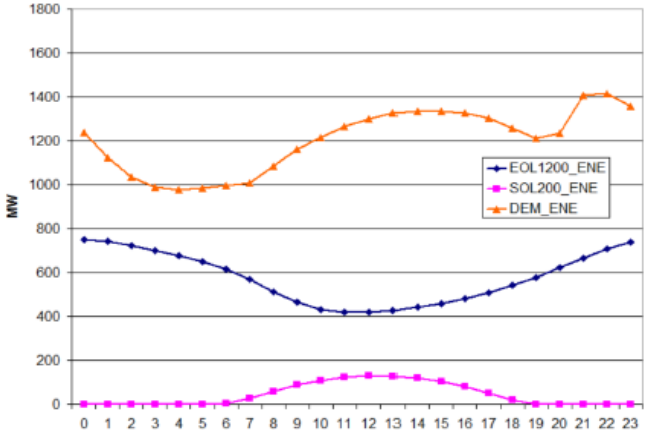
Financial institutions and investors

CURRENT CHALLENGES

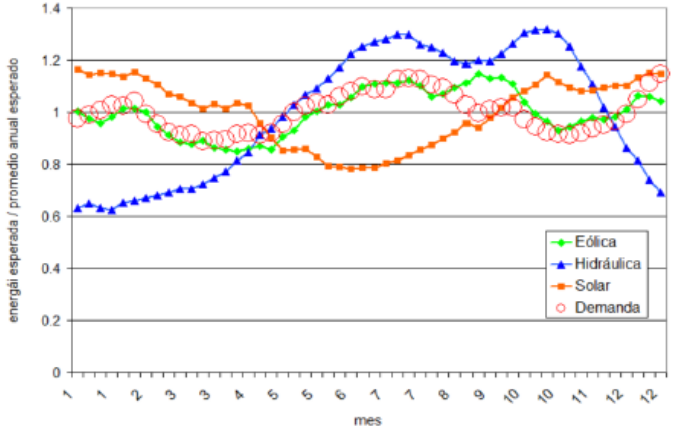
DEMAND MANAGEMENT AND SHORT-TERM ACCUMULATION



COMPLEMENTARITY HYDRO-WIND-SOLAR

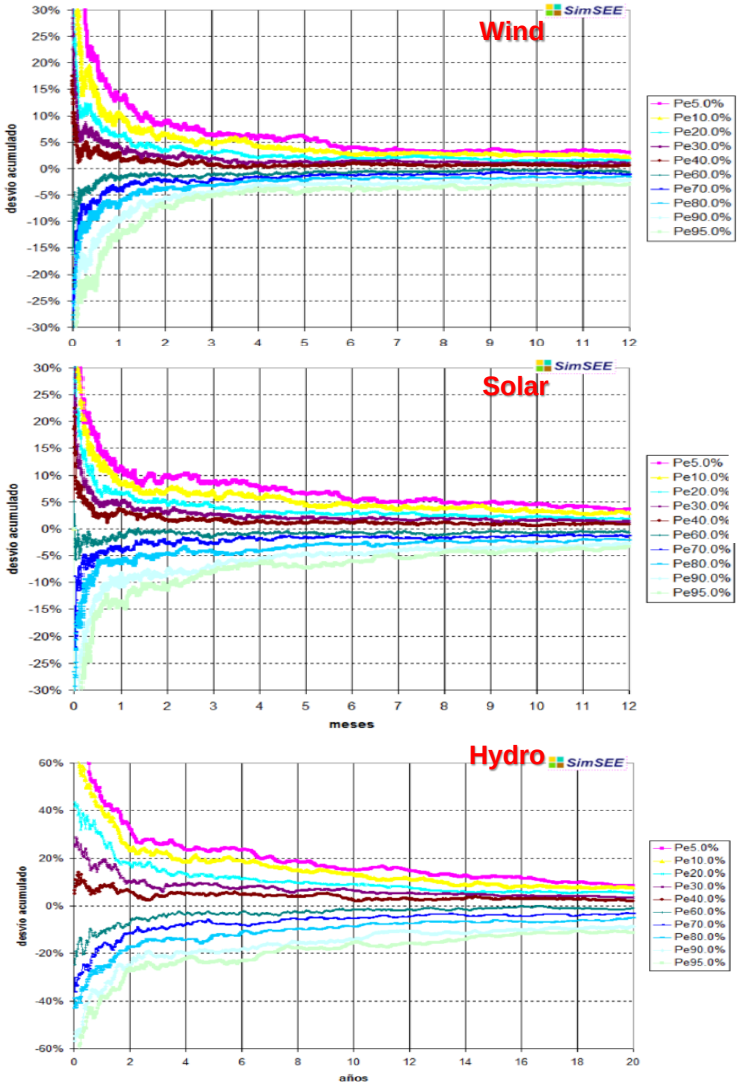


Intra-day complementarity



Annual complementarity

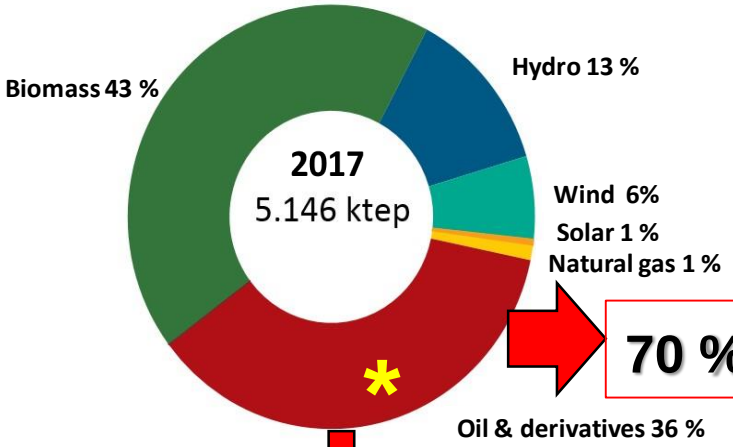
ENERGY SURPLUSES



Generation deviations (for different probabilities by sources)

MAIN PRIORITIES POWER SECTOR (2030-2040)

ENERGY SUPPLY IN 2017

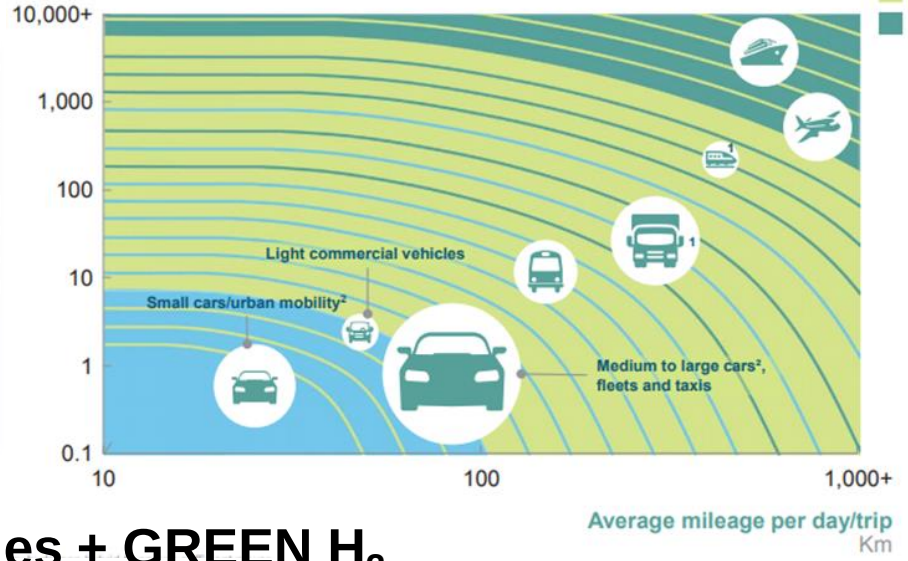


63 % - RENEWABLE SOURCES

BIOMASS > OIL & NATURAL GAS

70 % TRANSPORT

RUTA ELÉCTRICA



Batteries + GREEN H_2

INDUSTRY (heat)

Huge opportunity

…electrify to decarboni

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Thanks for your attention!

Wilson Sierra
Renewable Energies Unit
Secretary of Energy
Ministry of Industry, Energy and Mining

Montevideo (VC), *June 6th, 2018*

Costa Rica

Rolando Castro, Viceminister of Energy,
Ministry of Environment and Energy

Laura Lizano, Director of the Energy Planning Secretariat
Ministry of Environment and Energy

Identifying challenges for achieving 100% renewable power systems by mid-century

(6th June, 2019)

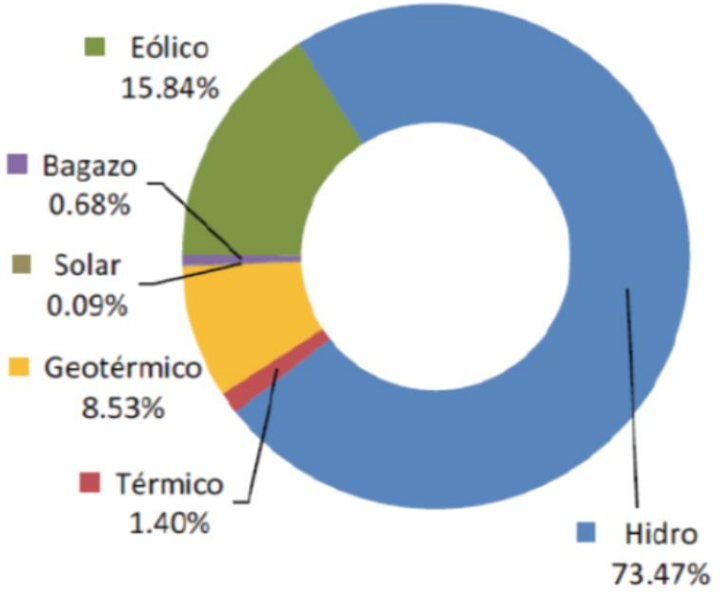
Costa Rica

Rolando Castro Córdoba
Energy Viceminister

Costa Rica

Energy mix – Energy production

Data for 2018



GWh 2018	
Geotérmico	968.57
Solar	9.89
Bagazo	76.67
Eólico	1,798.87
Hidro	8,342.90
Térmico	158.55
Producción bruta	11,355.45
Intercambio	(240.75)
Demanda	11,114.70
% Crecimiento	**0.87%**

con respecto al 2017

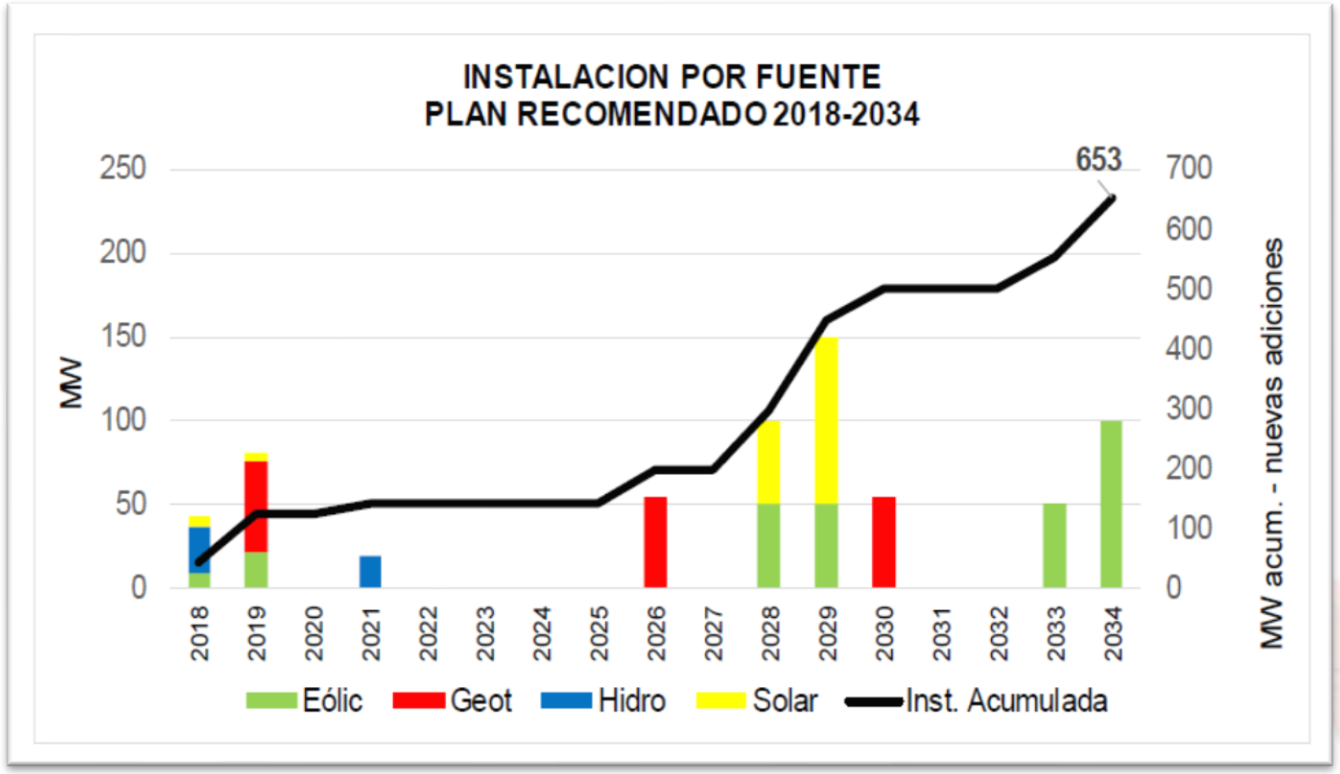
Tipo de Fuente	GWh	%	Tipo de Fuente	GWh	%
No renovable	158.55	1.40%	Renovable	11 196.6	98.60%

Main challenges

- Achieve greater levels of economic competitiveness.
- Planning and dispatch optimization.
- Reduce the risks associated with variations in renewable sources (effects on the electricity grid).
- Adapt to climate change impacts (increase of the National Electric System´s resilience).
- Access to funding.

Plan 2018-2034

Additional production



Identifying challenges for achieving 100% renewable power systems by mid-century

(6th June, 2019)

Costa Rica

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Germany

Bilun Müller, Deputy Head of Unit
International cooperation on energy, Federal Ministry for Economic Affairs and Energy (Germany)

Spain

Hugo Lucas Porta, Head of Department
Regulation & Strategy for Energy Transition

MINISTERIO
PARA LA TRANSICIÓN ECOLÓGICA

IDAE
Instituto para la Diversificación y Ahorro de la Energía

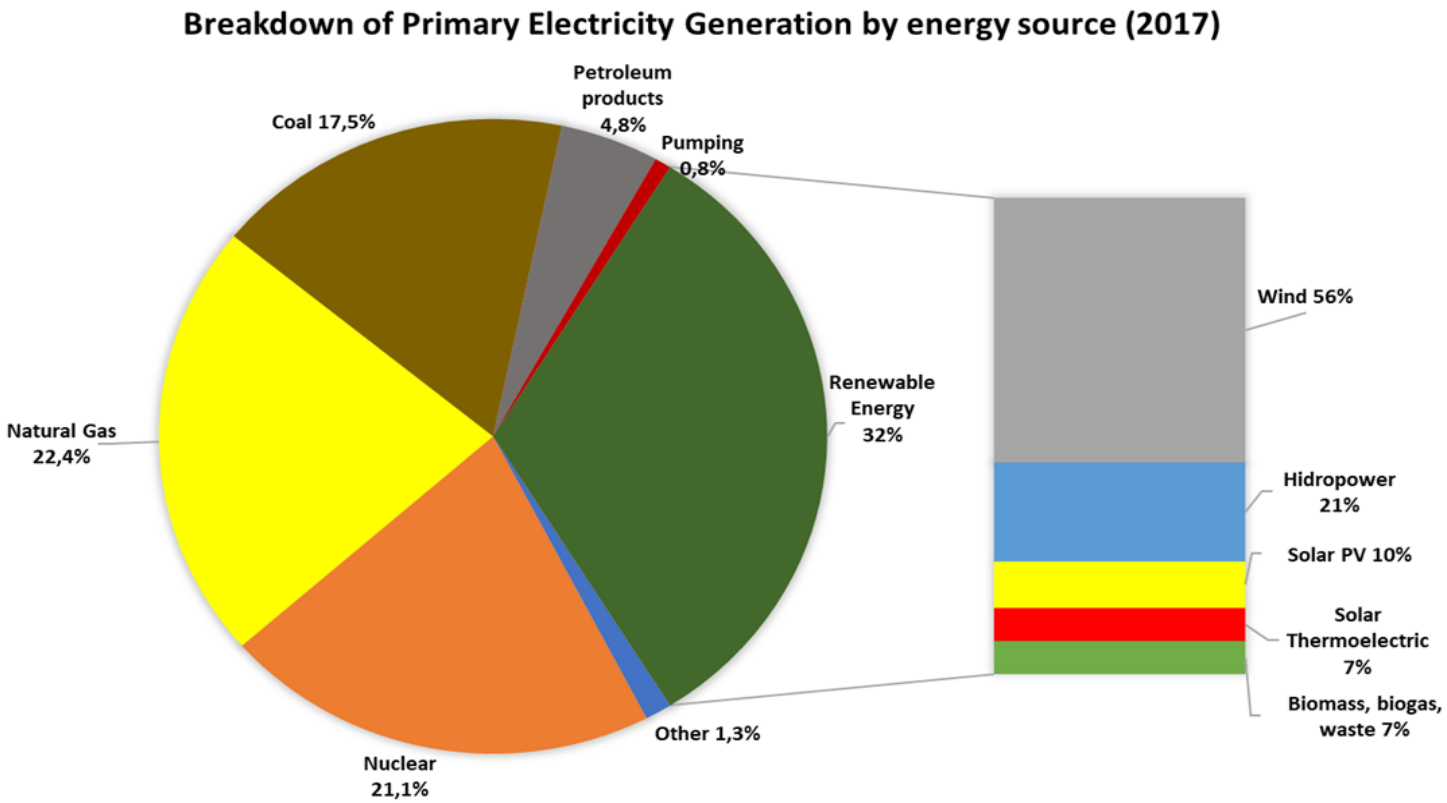
Identifying challenges for achieving 100% renewable power systems by mid-century

Challenges in the adoption of a systemic innovation approach as a key enabler to achieve high shares of renewable power by mid-century: vision from Spain

Hugo Lucas Porta
Head of Department
Regulation & Strategy for Energy Transition

Electricity balance

2017: Low hydro output caused a drop on the contribution of renewables within the power production mix (32% of RES-e)



Enabling measures

CECRE: Control Centre of Renewable Energies

Predictive models

Operative procedures

GEMAS (Maximum Generation Admissible by the System)

Integrated National Energy and Climate Plans

2030 Goals

	2016	2030	2050
Emission reduction from 1990	+13%	-20%	-100%
Renewable share in final energy	16%	42%	100%
Electricity from renewables	41%	74%	100%

Integrated National Energy and Climate Plans

2030 Goals

Year	2015	2020*	2025*	2030*
Wind	22,925	27,968	40,258	50,258
Solar Photovoltaic	4,854	8,409	23,404	36,882
Thermoelectric Solar	2,300	2,303	4,803	7,303
Hydropower	15,741	15,746	15,996	16,246
Pumping	4,387	4,387	5,262	7,887
Biogas	223	235	235	235
Geothermal	0	0	15	30
Marine energy	0	0	25	50
Biomass	677	877	1,077	1,677
Coal	11,311	10,524	4,532	0 – 1,300
Combined cycle	27,531	27,146	27,146	27,146
Coal cogeneration	44	44	0	0
Gas cogeneration	4,055	4,001	3,373	3,000
Cogeneration of oil products	585	570	400	230
Fuel/Gas	2,790	2,790	2,441	2,093
Renewable cogeneration	535	491	491	491
Cogeneration with waste	30	28	28	24
Municipal solid waste	234	234	234	234
Nuclear	7,399	7,399	7,399	3,181
Total	**105,621**	**113,151**	**137,117**	**156,965**

Challenges to RES capacity implementation

SYSTEM OPERATION	REGULATION
Visibility (Small & DSO)	Hybridization
Intertripping	Auctions
Network capacity; long-term development for grids	Avoid “cannibalism”
Less inertia, enhanced services. Daily and seasonal storage.	Manage curtailment risks

Challenges to RES capacity implementation

ECONOMIC	TERRITORIAL
Competitiveness	Protection of natural spaces and species
Mobilising investments	Social acceptability
Enabling system cost reductions	Territorial diversity and legal framework

Long term priorities

- Decarbonization
- Flexibility
- Sector coupling
- Smart grids
- Storage: multiple technologies
- Behaviour changes
- Digitalization

MINISTERIO
PARA LA TRANSICIÓN ECOLÓGICA

IDAE
Instituto para la Diversificación y Ahorro de la Energía

Identifying challenges for achieving 100% renewable power systems by mid-century

Challenges in the adoption of a systemic innovation approach as a key enabler to achieve high shares of renewable power by mid-century: vision from Spain

Hugo Lucas Porta
Head of Department
Regulation & Strategy for Energy Transition

Interactive discussion

Next steps

Next steps

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	October 2019 (TBC)	Focus on sharing national **experiences** with the application of innovative solutions	Remote
In-person	November 2019 (TBC)	Focus on **disruptive innovative solutions** enabling 100% renewable power systems	Europe (TBC)

Next steps

Next workshop, as part of the IRENA Innovation Day in Uruguay:

IRENA INNOVATION DAY 2019

Dates: 15-17th July 2019
Place: Montevideo, Uruguay
Registration: innovationday@irena.org
Website: https://www.irena.org/events/2019/Jul/IRENA-Innovation-Day-Solutions-for-a-renewable-powered-future

Agenda:

- **Monday, 15th July:** Site-visit of ADME, the National Energy Dispatch Center of Uruguay
- **Tuesday, 16th July:** Innovation Day
- **Wednesday, 17th July:** Workshop on innovative solutions for achieving 100% renewable power systems by mid-century

Next steps

Workshop in Uruguay (17th July 2019) – Agenda:

Time		Session
9:30	10:30	**Session I: Challenges in the implementation of ambitious policy targets to achieve power systems with high shares of renewable power by mid-century:** this session will focus on short-, medium- and long-term challenges, focusing on the technical, as well as long-term challenges arising once a power system is entirely renewable-based (e.g. how to make use of the surplus electricity to avoid curtailment - by trading with neighboring countries, having long-term storage solutions, electrifying end-user sectors, etc.).
11:00	12:30	**Session II: Technical feasibility of a 100% renewable power system by 2050:** this session will focus on the technical requirements to enable a 100% renewable power system by 2050, discussing generation adequacy assessments, transmission capacity requirements, stability-related operational constraints and flexibility solutions to be adopted.
14:00	15:00	**Session III: Showcase of experiences from leading countries operating power system with very high shares of renewables:** this session will focus on experience and lessons learned from leading countries that have already high or very high penetration rates of renewables in their national power system, which could benefit other member countries, including challenges and measures taken to address those challenges.
15:30	17:00	**Session IV: Innovative solutions for 100% renewable power systems:** this session will focus on decentralization, digitalization and electrification being the main innovation drivers enabling the rapid uptake of a high share of renewables in the power system of the participating countries by mid-century: • **Decentralization**: market-integration of distributed energy resources (e.g. distributed energy resources providing services to the grid as one potential solution) • **Digitalization**: artificial intelligence, blockchain and internet of things (e.g. a combination of these innovations into demand-side response) • **Electrification**: Electrifying end-use sectors with renewable power (e.g. industry, heating and transport) as a solution for decarbonization and avoiding curtailment of surplus renewable power

Next steps

➔ **14 June 2019:** IRENA will share the minutes of this online workshop

➔ **Ongoing**: Please register to the IRENA Innovation Day

➔ **21 June 2019:** Please provide feedback on the workshop agenda,

including suggestions for participants and speakers

Thank you very much for your participation!

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

Innovation Outlook: Smart Charging for Electric Vehicles:
https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Innovation_Outlook_EV_smart_charging_2019.pdf