IRENA
International Renewable Energy Agency

Regional markets

A key innovation in the global energy transition

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Webinar on Cross-border Electricity Trade in SAARC Countries, 9 March 2020

Agenda

1. *IRENA's systemic innovation approach for the energy transition*
2. *Regional markets*
3. *Pan-European electricity market*

1. IRENA's systemic innovation approach for the energy transition

Wind & solar PV at the core of the energy transition

IRENA
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Cost reduction 2010 – 2018

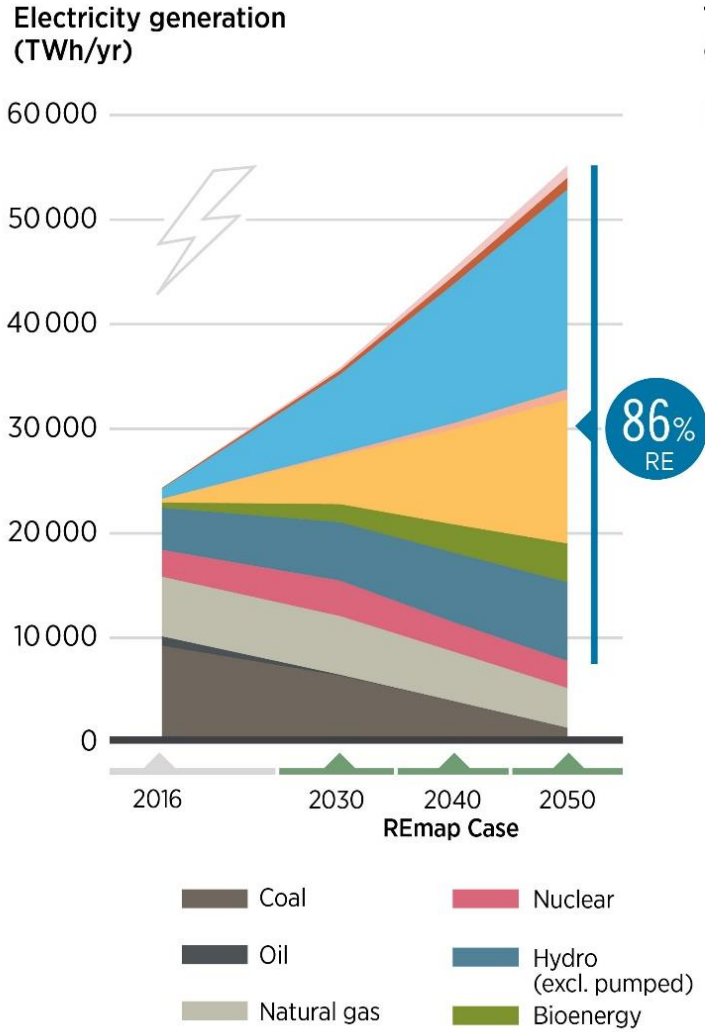
35% ↓

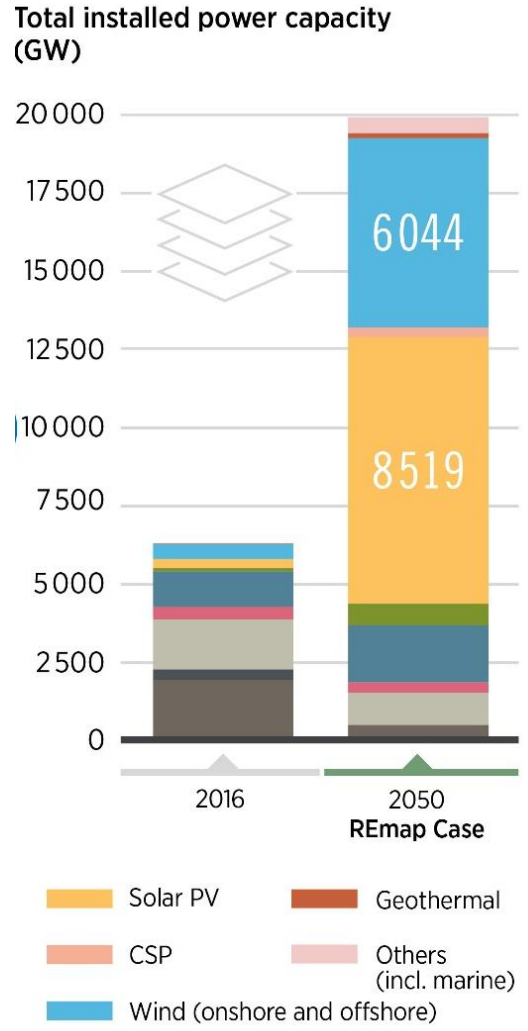
77% ↓

Onshore wind & solar PV share in generation mix (2018 vs. 2050)

6% → 35%

2% → 25%





Sources: IRENA (2019), Global energy transformation: A roadmap to 2050, IRENA (2019), Renewable Power Generation Costs in 2018

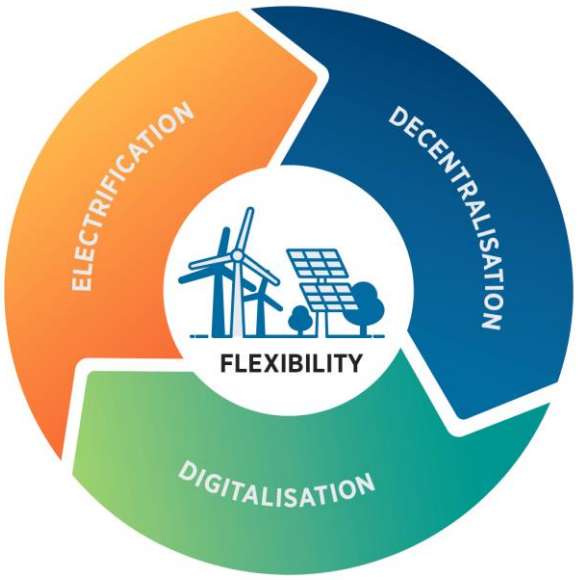
Innovation knowledge products

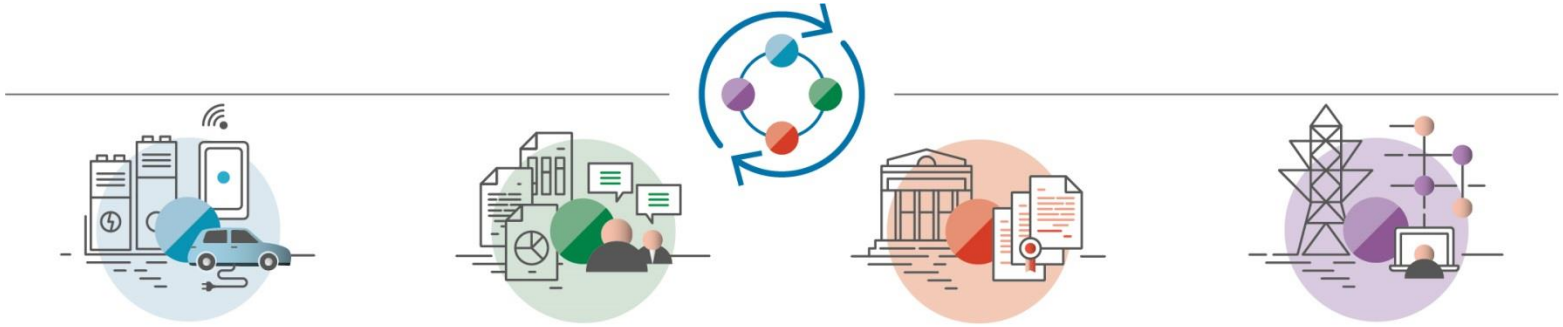
Innovation Landscape Report for wind & solar PV integration + 30 Innovation Landscape Briefs

+ Swedish innovation case study

Sources:
IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
IRENA (2020), Innovative solutions for 100% renewable power in Sweden

30 key innovations for wind & solar PV 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

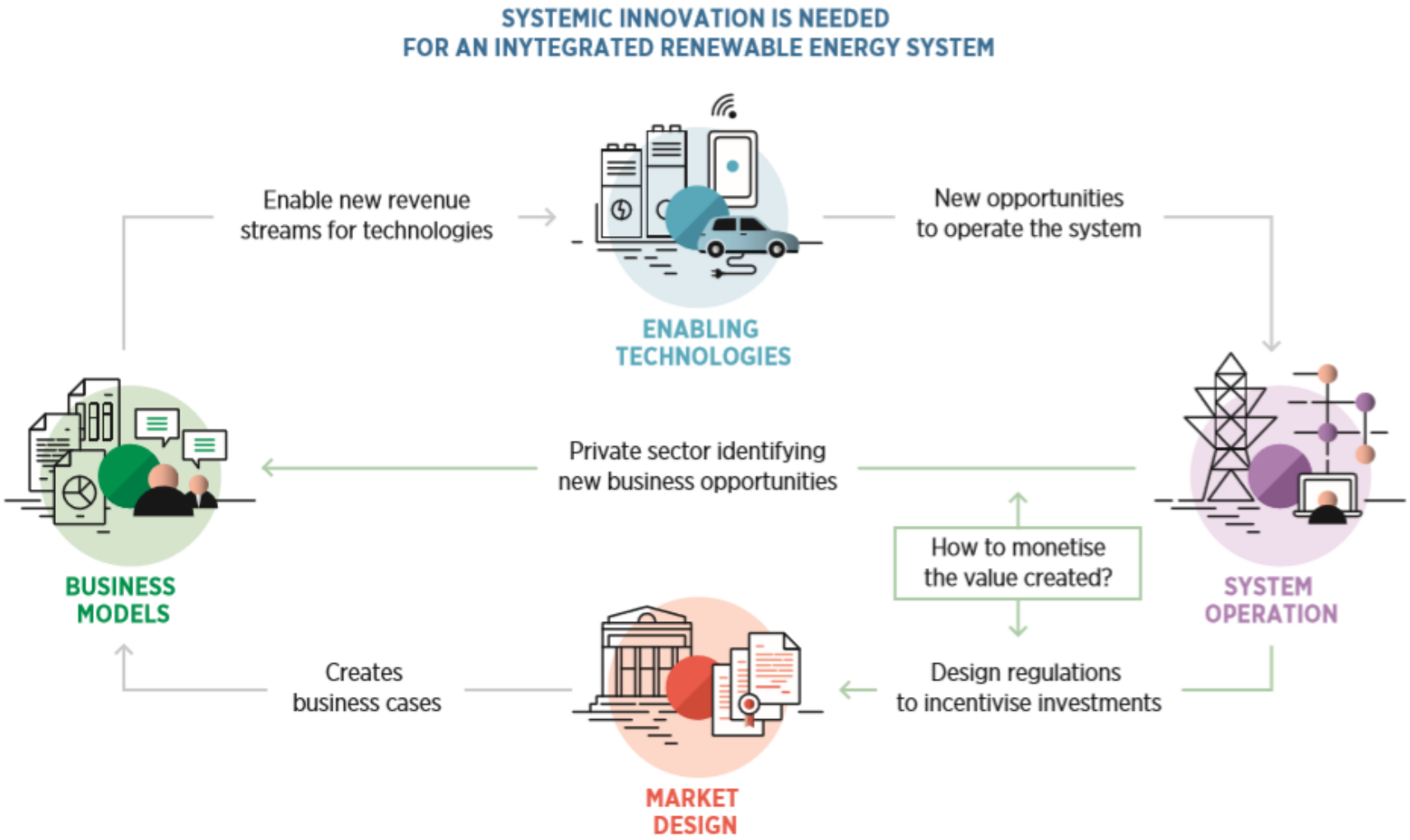
17	Increasing time granularity in electricity markets
18	Increasing space granularity in electricity markets
19	Innovative ancillary services
20	Re-designing capacity markets
21	Regional markets
22	Time-of-use-tariffs
23	Market integration of distributed energy resources
24	Net billing schemes

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

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

Systemic innovation approach



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

Solutions are combinations of innovations

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		

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

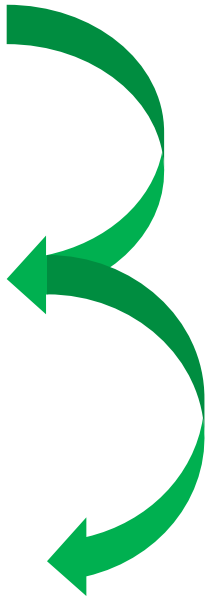
Interconnections & regional markets as flexibility provider

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

2. Regional markets

Different levels of regional market integration

Market integration level	Interconnectivity level	Trading arrangements	Harmonisation rules
Early stage of market integration	Physical interconnection between two countries	Long-term, bilateral, over-the-counter (OTC)[3] power purchase agreements (PPAs)	Simple rules agreed for the operation of the interconnected system
Shallow market integration	Physical interconnection between several neighbouring countries	Long-term PPAs supplemented with short-term wholesale markets	Harmonisation of market rules, grid codes, and transmission tariffs
Deep market integration	Full synchronous operation of a multi-country interconnected system	Well-functioning markets with competition achieved through trading in different timeframes and various markets (OTC vs. power exchanges, capacity vs. power markets, day-ahead vs. intraday markets, etc.)	Regional regulatory agencies, regional market operators and harmonisation of market rules, grid codes, and transmission tariffs



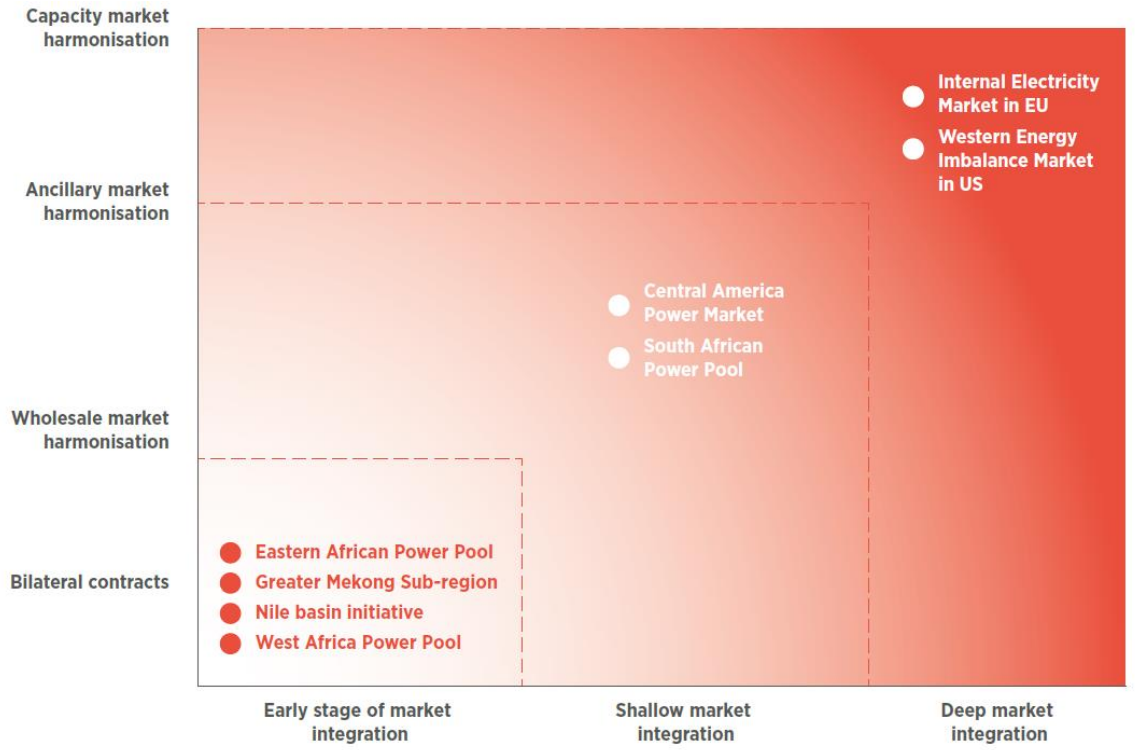
Source: IRENA (2019), Innovation landscape brief: Regional markets

International examples

Regional market	Participating countries/systems	Year of establishment
Central America Power Market[1]	**6 countries:** Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama	2013
European Union[2]	**23 countries (day-ahead market):** Austria, Belgium, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Great Britain, Hungary, Italy, Lithuania, Latvia, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Slovenia, Slovakia and Sweden	1990s (NordPool was created)
	14 countries (intraday market): Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, Norway, the Netherlands, Portugal, Spain and Sweden	2018 (XBID Project – intraday market)
Eastern Africa Power Pool[3]	**10 countries:** Burundi, the Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda, Tanzania, Libya, Uganda and Sudan	2005
Greater Mekong Sub-region[4]	**6 countries:** Kingdom of Cambodia, Guangxi Zhuang Autonomous Region and Yunnan Province of the People's, Republic of China (PRC), Lao People's Democratic Republic (Lao PDR), Union of Myanmar, Kingdom of Thailand and the Socialist Republic of Viet Nam	1995
South African Power Pool (SAPP)[5]	**12 countries:** Angola, Democratic Republic of Congo (DRC), Tanzania, Malawi, Zambia, Zimbabwe, Mozambique, Swaziland, South Africa, Lesotho, Namibia, Botswana	1995
Western Energy Imbalance Market (EIM), United States[7]	**8 active members:** Idaho Power Company, Powerex, Portland General Electric, Puget Sound Energy, Arizona Public Service, NV Energy, PacifiCorp, CAISO and Balancing Authority of Northern California/SMUD	2014

Sources:

1. Navarrete (2016)
2. ENTSO-E (2018c)
3. The Eastern Africa Power Pool (2016); Olingo (2018)
4. Asian Development Bank (2016)
5. SAPP (2016)
6. Westerneim (2019)

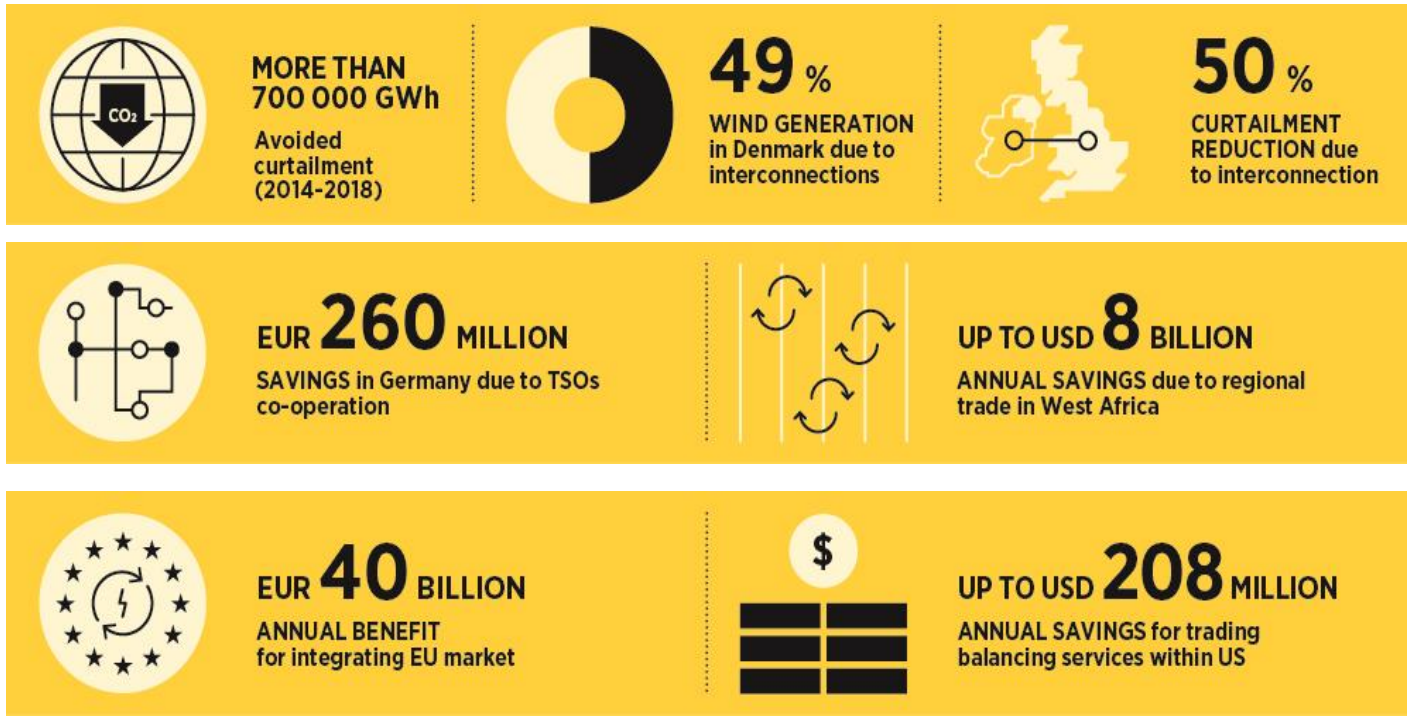


Source: IRENA (2019), Innovation landscape brief: Regional markets

Impact of regional markets for wind & solar integration

BENEFITS

- Increased flexibility through expanding balancing area
- Advantages of spatial complementarity of VRE generation
- Co-ordinate generation planning
- Reduce system operation cost



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

Costs, benefits & complexity for the implementation

Interconnections and regional markets as flexibility providers	Low	Moderate	High	Very high
BENEFIT				
Potential increase in system flexibility				
Flexibility needs addressed	from seconds to days (with a big enough region, regional markets can deliver flexibility over longer time frames)			
COST and COMPLEXITY				
Technology and infrastructure costs				if interconnections are not in place
Required changes in the regulation framework		to partially integrate markets	to fully integrate markets	
Required changes in the role of actors		co-ordination between transmission system operators and market players in different markets – for partially integrated markets	co-ordination between transmission system operators and market players in different markets – for fully integrated markets	
Other challenges	• Political and regulatory challenges • Regional mindset and trust, strong institutional arrangements and governance model			

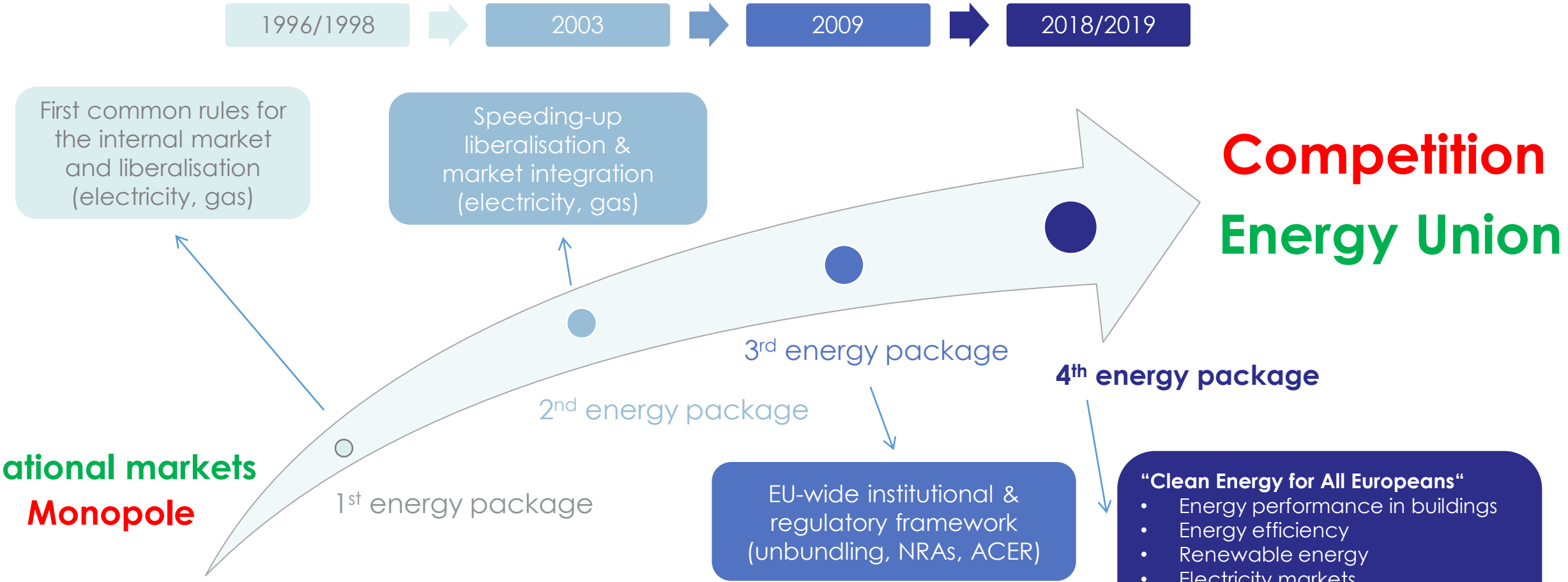
KEY ENABLING FACTORS

- Physical interconnections with sufficient capacity
- Regional mindset, strong institutional arrangements and governance model
- Robust IT system for market operation

Sources:
IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
IRENA (2019), Innovation landscape brief: Regional markets

3. Pan-European electricity market

Policy context

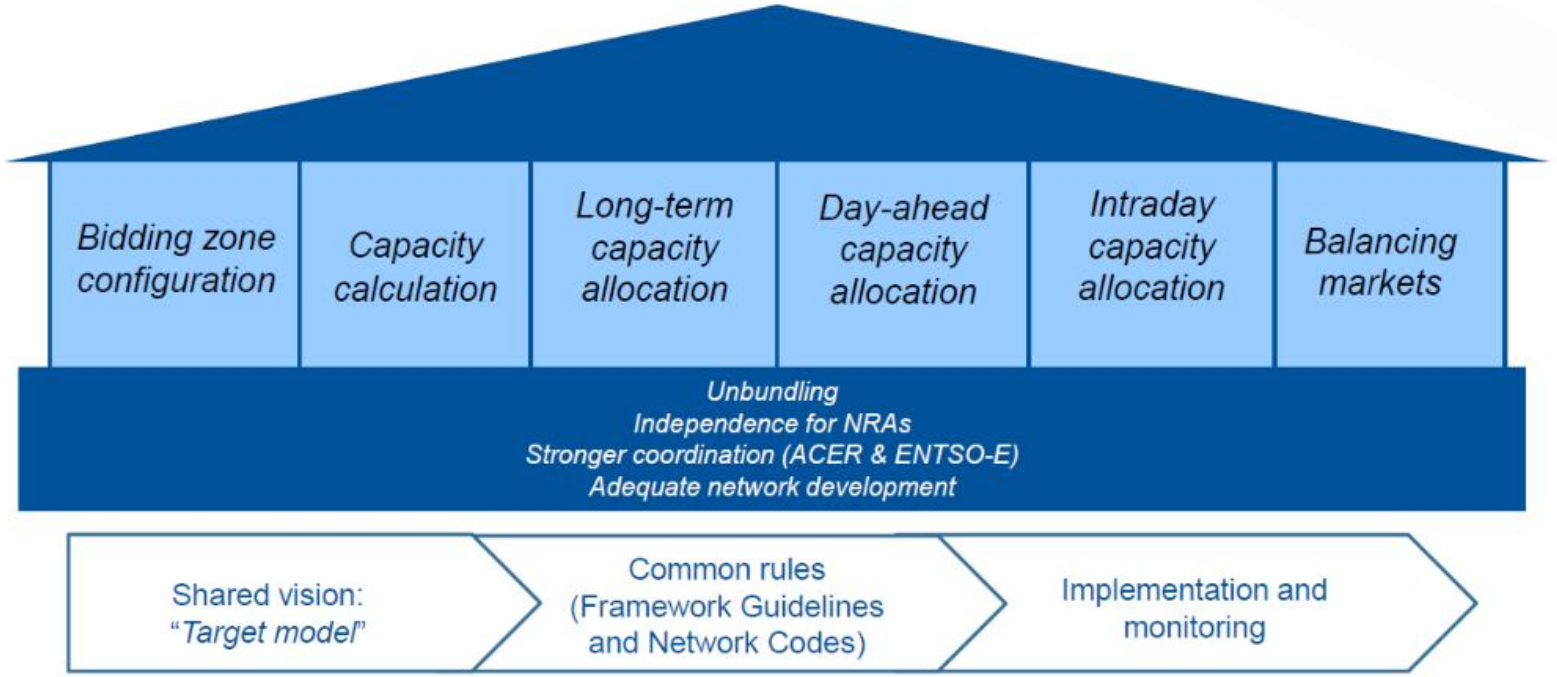


*"The Regulation aims to set fundamental principles for well-functioning, **integrated electricity markets**, which allow all resource providers and electricity customers **non-discriminatory** market access, **empower consumers**, ensure **competitiveness** on the global market as well as **demand response**, **energy storage** and **energy efficiency**, and facilitate **aggregation** of distributed demand and supply, and enable market and **sectoral integration** and market-based remuneration of electricity generated from **renewable** sources."*

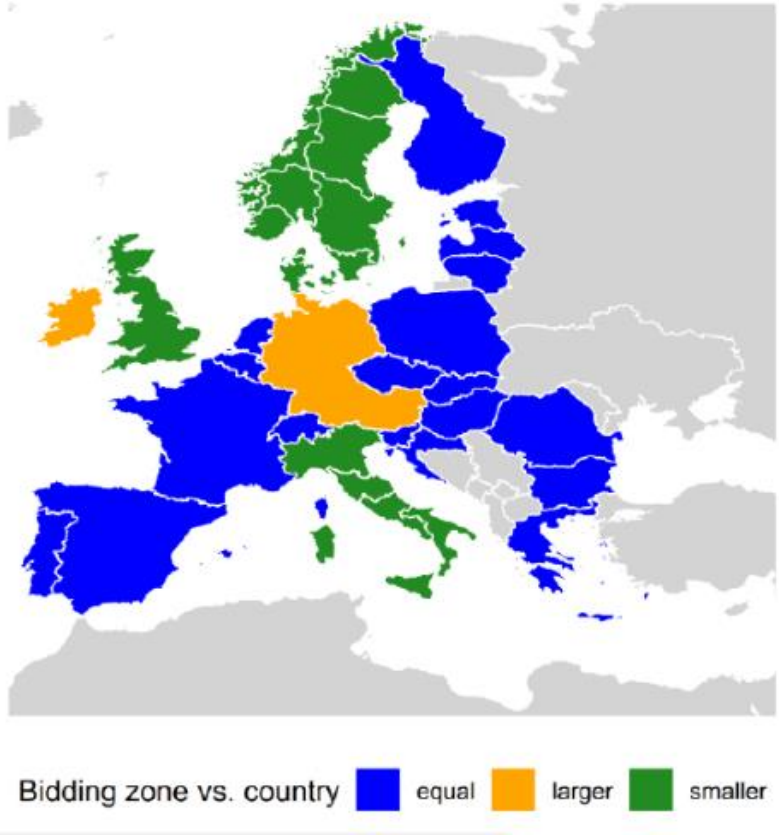
Reg. 2019/943 on the internal market for electricity

Overview of the Internal Energy Market

Electricity Target Model



Bidding zones (2017)



„Efficient decarbonization of the electricity system via market integration requires systematically ***abolishing barriers to cross-border trade*** *to overcome market fragmentation and to allow th Union energy consumers to fully benefit from the advantages of integrated electricity markets and competition."*

Reg. 2019/943 on the internal market for electricity

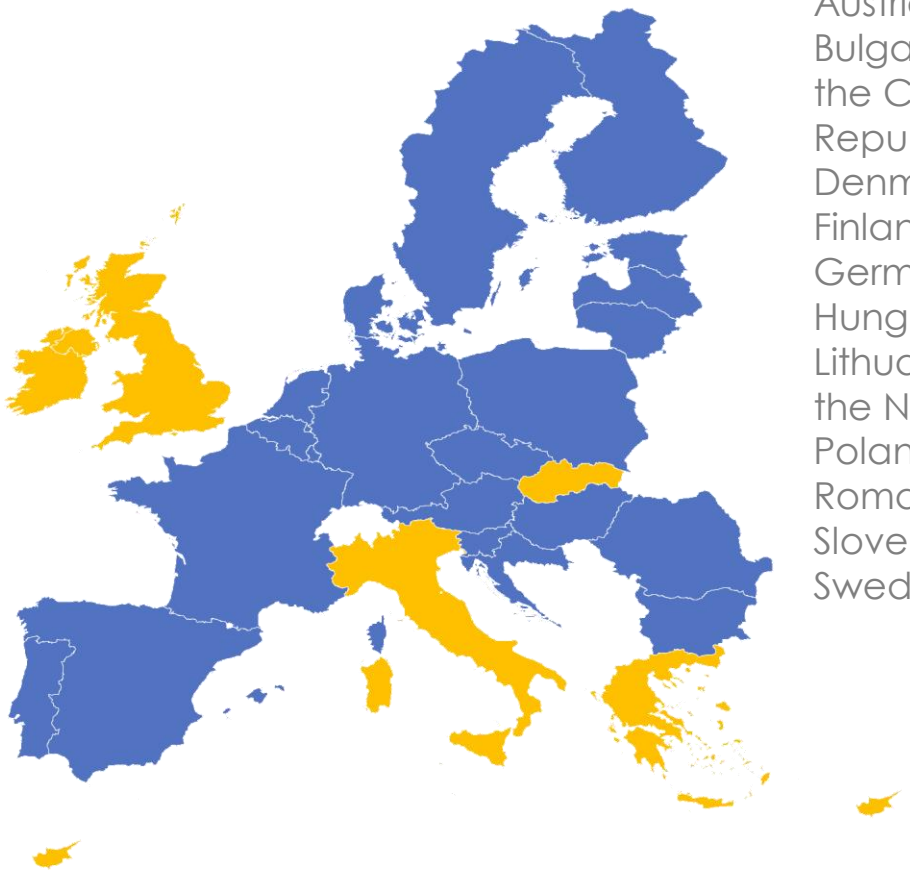
Source: IRENA – Energy Community Joint Workshop on Grid Integration of Variable Renewable Energy Sources, 7 November 2018

Implementation status in the EU…

Day-ahead market coupling
26 countries

Austria, Bulgaria, Belgium, Croatia, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden, UK

Intraday market coupling
21 countries



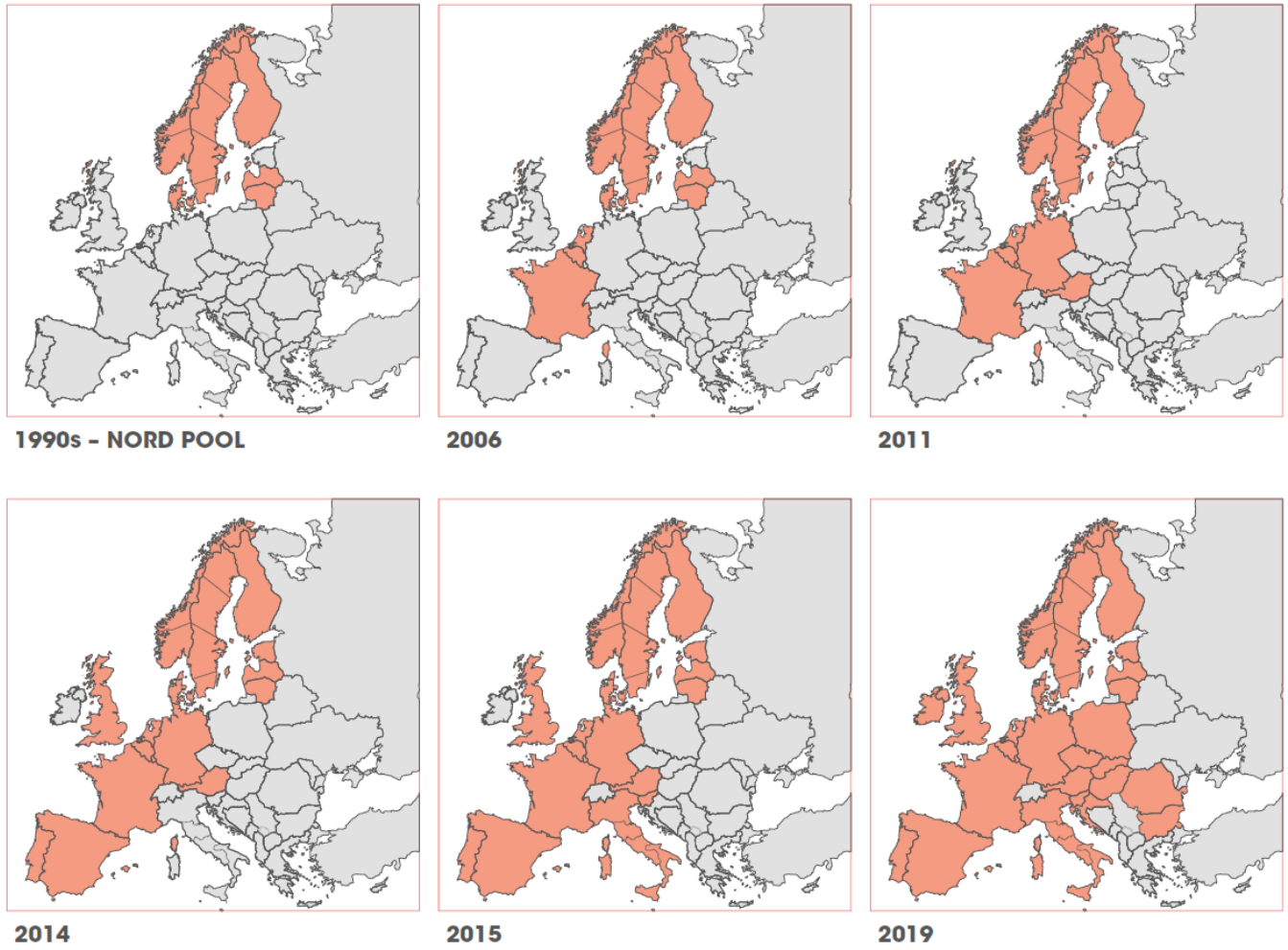
Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Latvia, Lithuania, Norway, the Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden

Source: ACER (2019), Market Monitoring Report, Electricity Wholesale Markets Volume

Coupled Not coupled

…achieved gradually over time

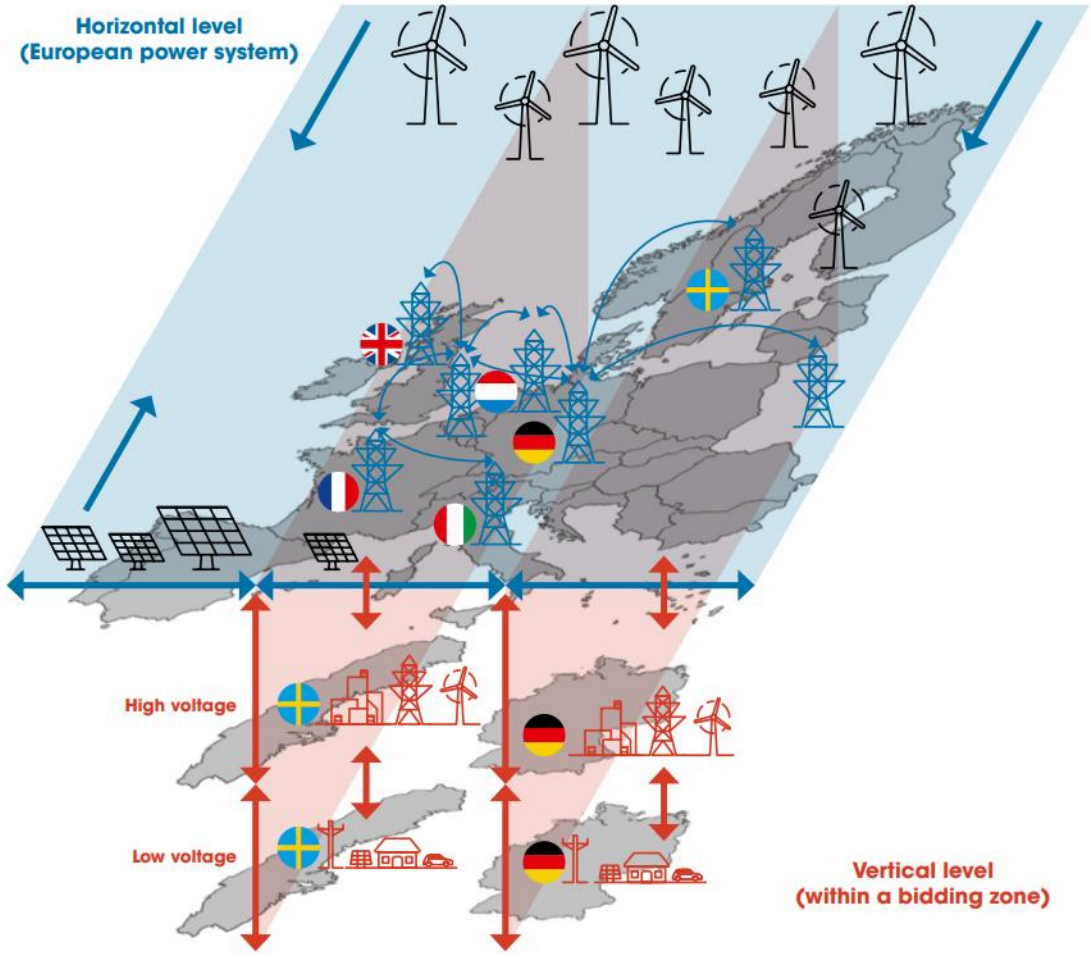
Gradual integration of the European regional wholesale market (day-ahead timeframe)



Sources: IRENA (2020), Innovative solutions for 100% renewable power in Sweden

Cooperation, interconnection & harmonization levels

Horizontal and vertical dimensions of the interconnected European power system



Source: Adapted from IEA-ISGAN, 2019

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

Sources: IRENA (2020), Innovative solutions for 100% renewable power in Sweden

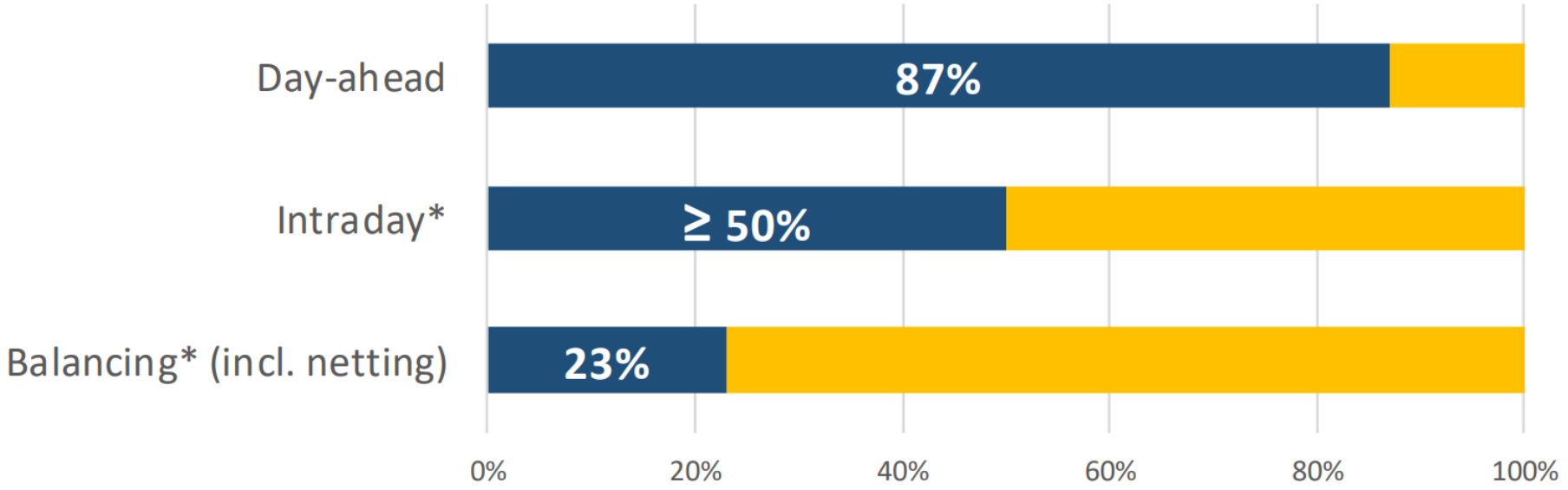
Benefits include trades between non-adjacent borders

Share of total traded volumes in intraday markets in Europe (2017-2018)

Source: ACER (2019), Market Monitoring Report, Electricity Wholesale Markets Volume

Various degrees of economic efficiency observed

Efficient use of interconnectors in various timeframes, 2018 (%)

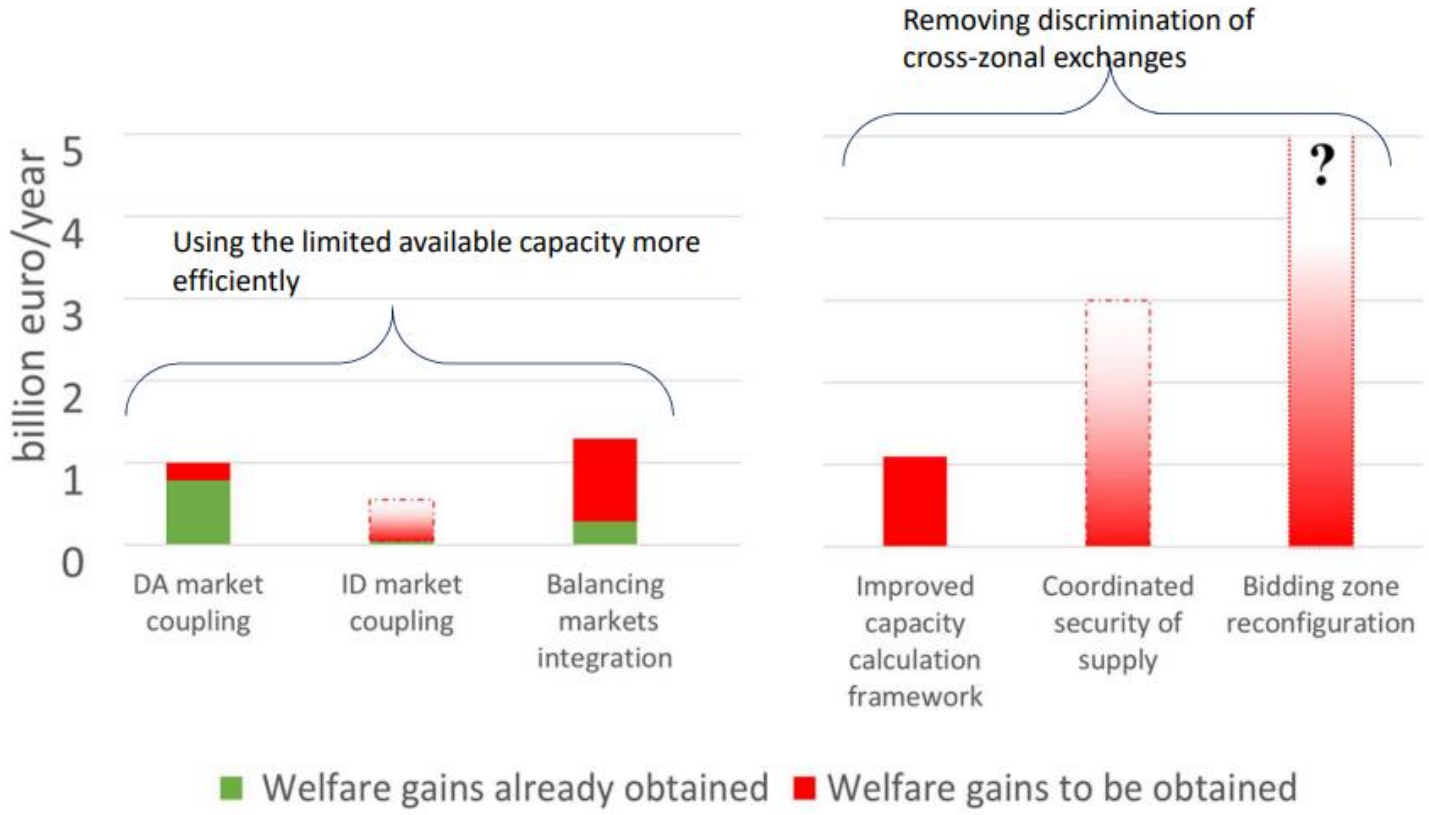


* Selection of borders

Source: ACER (2019), Market Monitoring Report, Electricity Wholesale Markets Volume

Social welfare gains still to be obtained

Social welfare benefits obtained and to be obtained from actions to increase European market integration



Source: ACER (2019), Market Monitoring Report, Electricity Wholesale Markets Volume

4. References

New webinar series

IRENA
International Renewable Energy Agency

#IRENAinsights

Tuesday, **17 March 2020**, 10:00–10:30 CET

"Innovations for 100% renewable power: a systemic approach"

Registration:
https://www.irena.org/renewables/Knowledge-Gateway/webinars/2020/Jan/IRENA-insights

Save-the-date

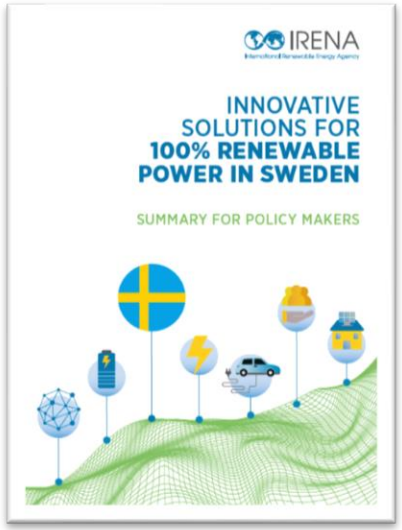
IRENA
International Renewable Energy Agency

IRENA
INNOVATION WEEK 2020

8-10 September 2020
Bonn, Germany

https://www.irena.org/events/2020/Sep/IRENA-Innovation-Week-2020

Selection of 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**
    - ➢ **Regional markets: Link**
  - ✓ **Enabling technologies: Link**
  - ✓ **Business models: upcoming**
  - ✓ **System operation: upcoming**

- **Innovative solutions for 100% renewable power in Sweden: Link**

Thank you very much for your attention!

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