

Power Sector Flexibility

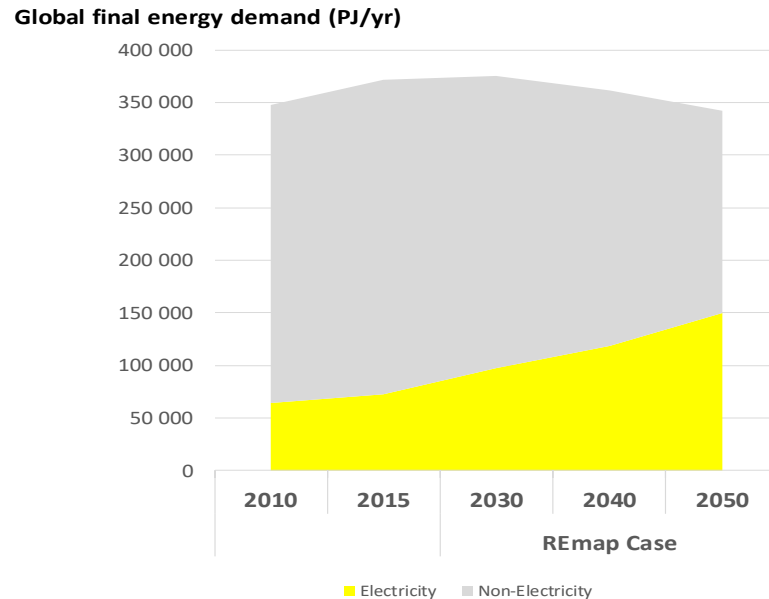


Power Sector Transformation Strategies

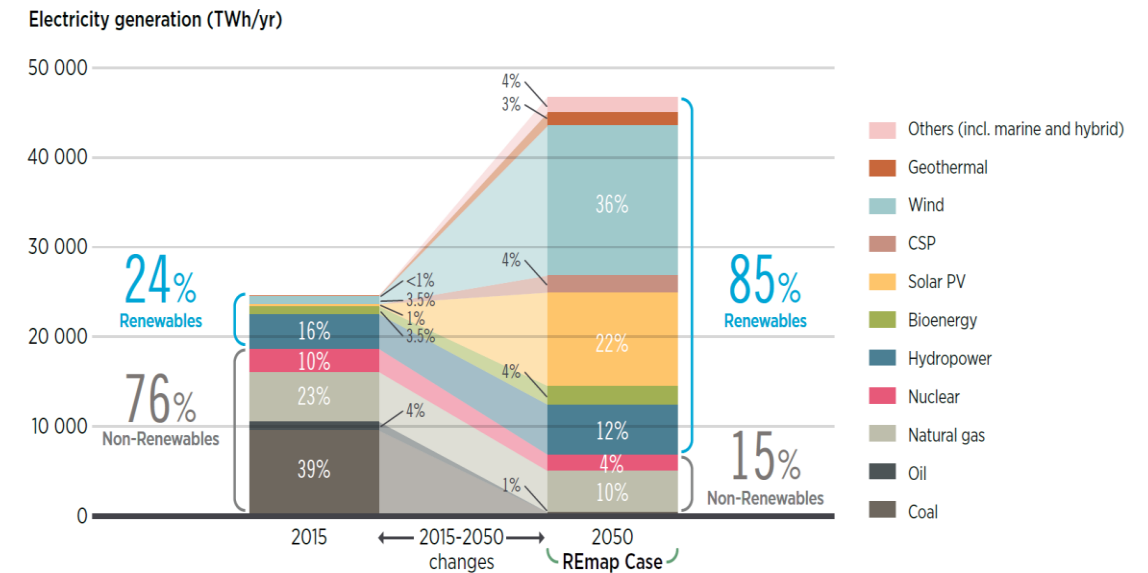
Electrification through sector coupling and dominance of VRE in the future electricity mix are key for the energy transition

REmap Case, 2015-2050

Share of electricity in total final energy consumption



Share of electricity in total final energy consumption



Source: Global Energy Transformation: A Roadmap to 2050, IRENA, 2018

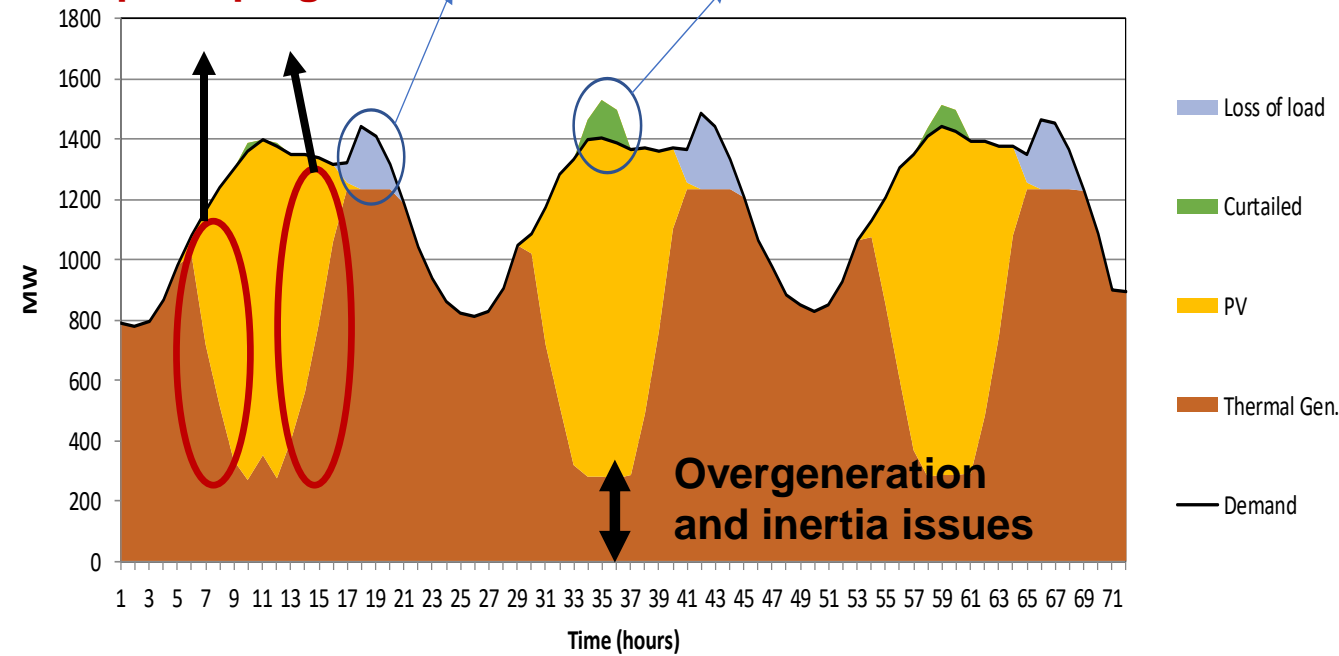
- » REmap analysis suggests the share of electricity in global final energy demand could nearly triple by 2050 through sector coupling
- » Variable renewables like solar and wind power will supply up to 60% of total electricity generation
 - » This practically means many countries will have VRE shares more than 60% into their power mix
 - » System flexibility issues might arise

Impacts of Variability and Uncertainty into Power Systems Operations

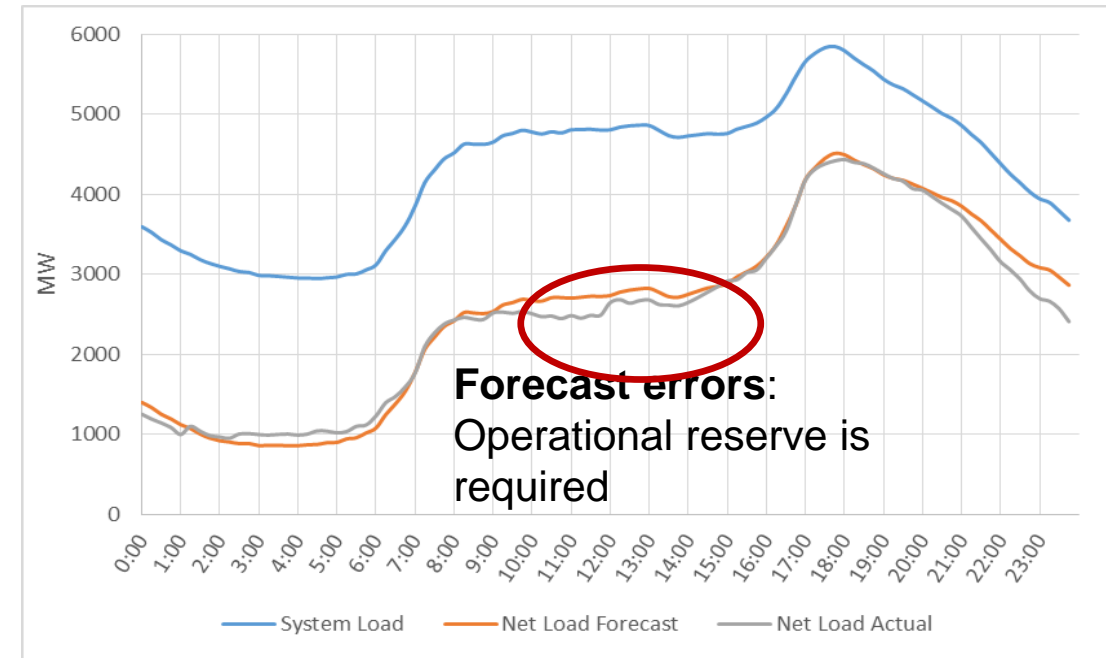
Variability

Step -down and -up ramping

Loss of load
VRE Curtailment



Uncertainty

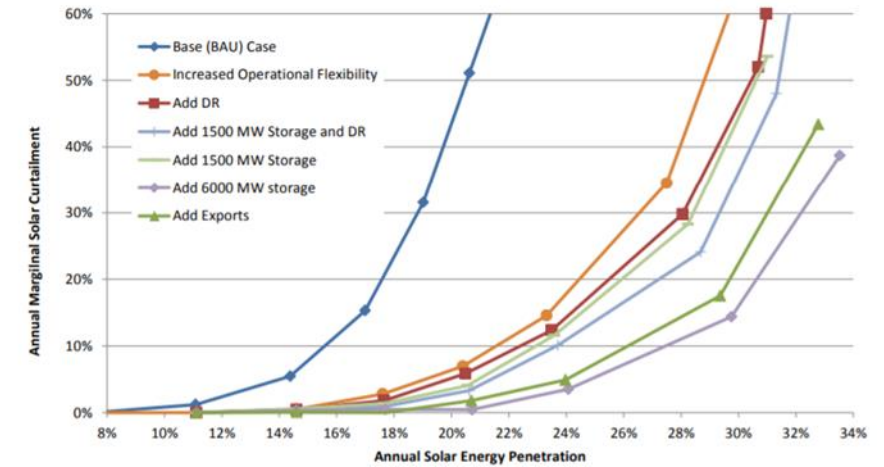


» Operational impacts of VRE

- » Variability: Increased ramp-rates, increased ramping-range, overgeneration
- » Uncertainty: Increased need for operational reserves
- » Indicators of lack of flexibility: VRE curtailment, loss of load, fluctuating/negative electricity prices

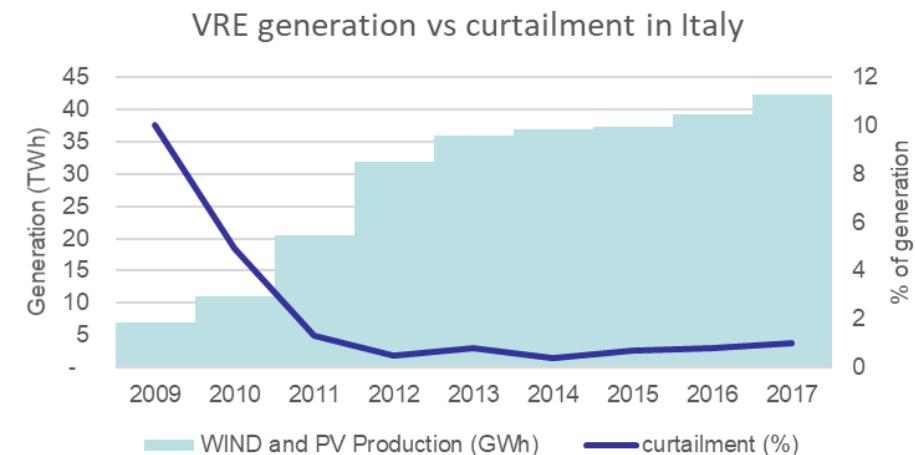
Practical experience has shown it is possible to achieve high share of VRE in a cost effective way

- » Denmark and Ireland are frontrunners of wind integration
 - » shares of 44% and 27% respectively
 - » Synchronous interconnections key for flexibility (NSPS of 65% in Ireland vs instantaneous penetration of 150% in Denmark)
 - » Start by unlocking flexibility: Denmark co-optimizes hydro and thermal generation; Creation of intra-day markets and implementation of advanced forecasting; flexible operation of CHPs



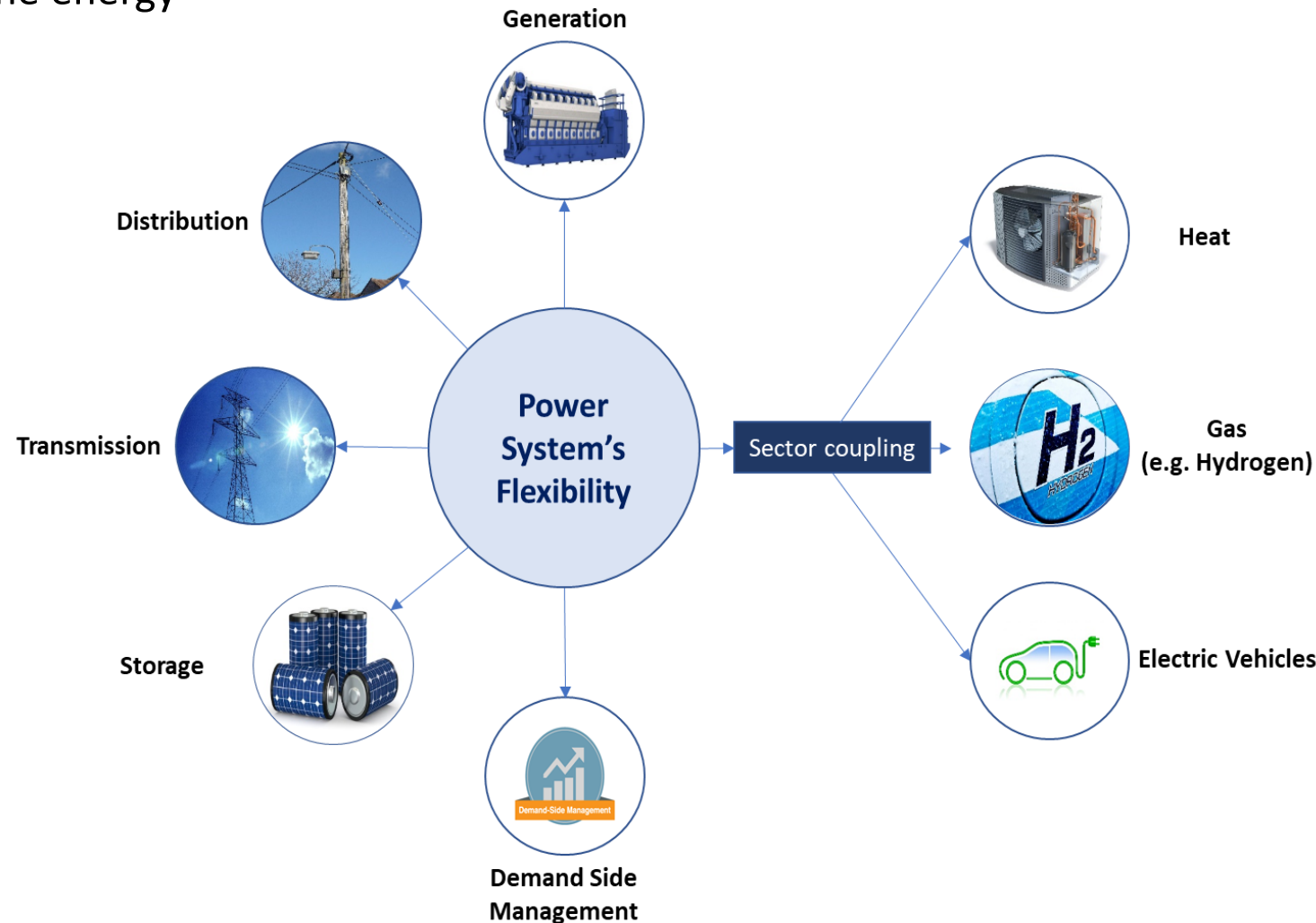
Source: Denholm, Clark, and O'Connell (2016)

- » Global lessons learned
 - » Plan for flexibility early: Much higher levels of VRE can be integrated in flexible systems (China vs Denmark)
 - » Many times cheaper solutions are the most efficient ones-
 - » Implement grid codes
 - » Weak grid can be an inhibitor
 - » Storage is key flexibility attribute (Norway sharing hydro flexibility with other Nordic countries)



Sector coupling is key to transform our energy system towards one dominated by renewable energy

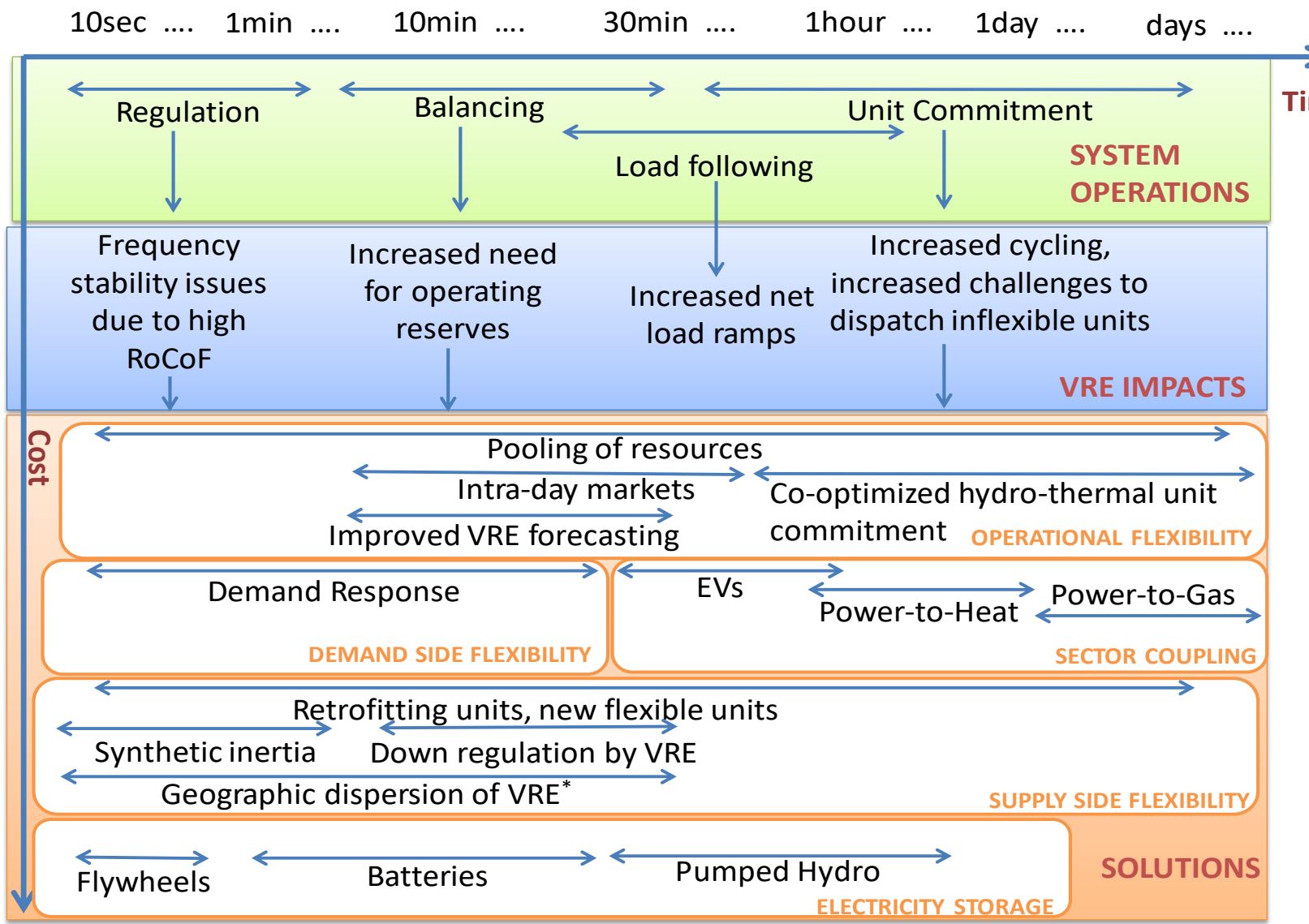
- » Flexibility needs to be harnessed in all sectors of the energy system
- » Main flexibility sources
 - » Generation
 - » Hydro, gas
 - » Grid
 - » Variable rating lines, T&D enhancement
 - » Smart Grids
 - » Storage
 - » Pumped Hydro
 - » Batteries
 - » V2G
 - » Demand
 - » Conventional: DSM, aggregation
 - » Sector coupling: Heat pumps, boilers, H2
 - » Market/Institutional
 - » Unlock flexibility/remove barriers
 - » Regulation needs to support flexibility



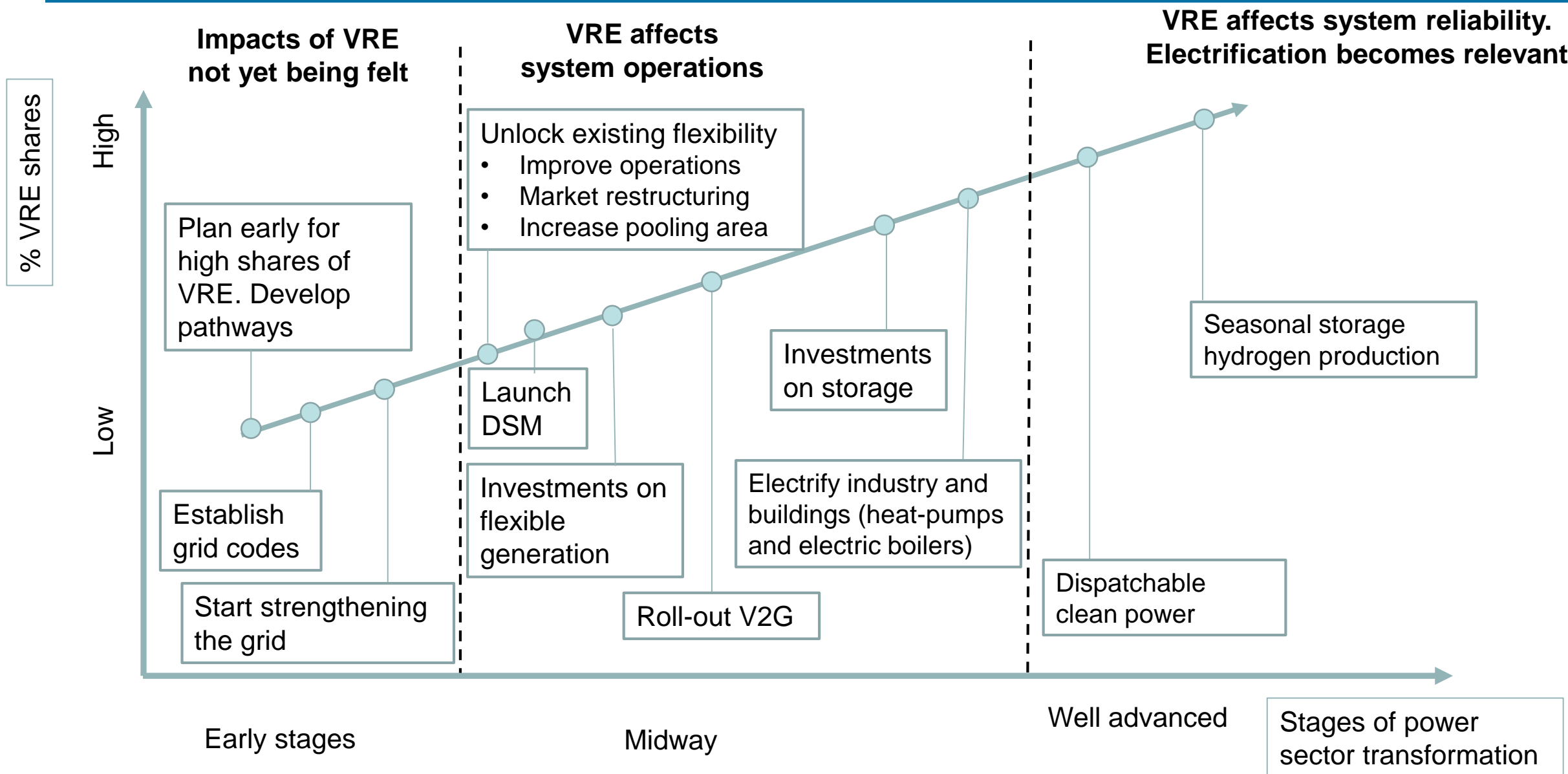
A set of solutions is needed to transform the power sector: Each solution has specific applicability and cost



- » Power system operations have specific time frames
- » Variability impacts power system operations at different time frames
- » Each solution has its own applicability. Costs need to be considered when developing a pathway



Planning early is key: Each pathway is unique to each power system



» IRENA supports its member countries in planning for flexibility with providing:

» An overview for policy makers with a proposed methodology

» The FlexTool to support analytical work

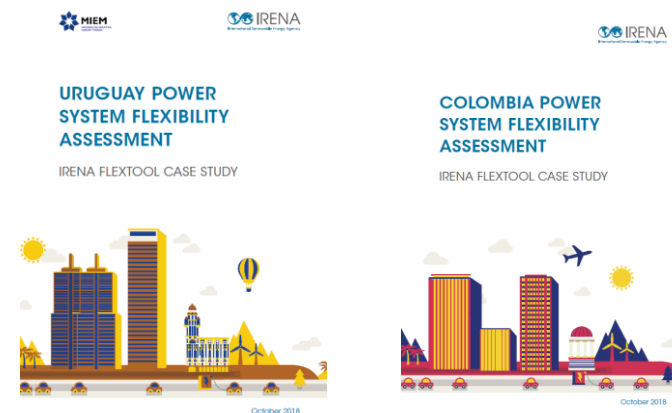
» Technical manual for FlexTool users

» Case studies developed in co-operation with a number of member countries



To be launched the **13th November** in the 16th IRENA Council (Abu Dhabi):

- **Part 1: Overview for policy makers**
- Part 2: Methodology report



Case studies developed

- **Colombia**
- **Uruguay**
- Panama
- Thailand

IRENA's methodology to plan for flexibility: Least-cost approach

Step 1: Assess current flexibility

- 1. Production cost modeling**
 - Assess current levels of curtailment and loss of load
 - Assess overgeneration incidents and fluctuation of prices
 - Assess cycling of units (start-up ramping and min gen incidents)
 - Assess if operating reserves are adequate
- 2. Network studies**
 - Assess if system can efficiently regulate frequency and voltages
 - Assess if system can recover from unexpected events
 - Assess if system has sufficient inertia
 - Assess if transmission elements get overloaded

If flexibility gaps are identified go to step 2. Else, directly to step 3

Step 2: Bridge gaps following least-cost approach

- 1. Unlock existing flexibility**
 - Regulatory, market changes
 - Dispatch units based on merit order
 - Train staff at generating units to operate plants flexibly
 - Pooling with neighbors
 - Adjust operating reserves based on new needs
- 2. Implement DSM schemes**
- 3. Invest in new assets**
 - Transmission enhancements
 - Retrofit existing units
 - Invest on new generation and/or storage

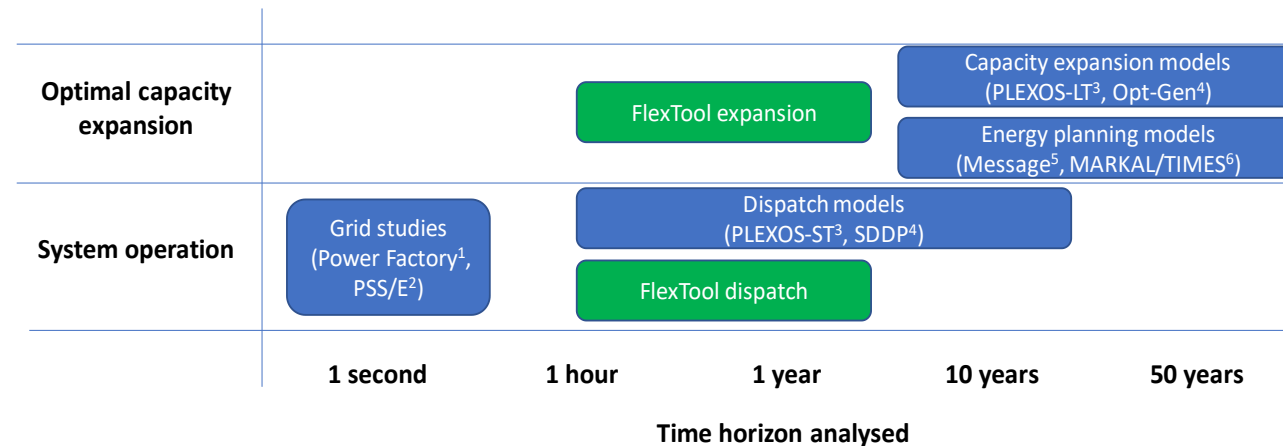
Step 3: Assess future flexibility

- 1. Optimize VRE sitting using geospatial optimization**
 - Optimize VRE capacity mix
 - Estimate VRE production based on location and policy goals
 - Estimate future net-load
- 2. Least-cost capacity expansion to identify future assets**
 - Study the net-load to assess needs for cycling
 - Optimize non-VRE capacity mix based on future technologies
 - Identify additional flexibility assets (e.g storage, DSM)
 - Assess benefits of sector coupling
- 3. Repeat step 1**
 - Assess operability of long-term plan identified on previous steps

Introduction IRENA's FlexTool

» Main attributes:

- » Performs both short-term (dispatch) to assess flexibility in a given system
- » Performs long-term (generation expansion) optimization to optimize investments that enhance flexibility
- » Representative of real world power system operations
- » **Free and Publicly available**



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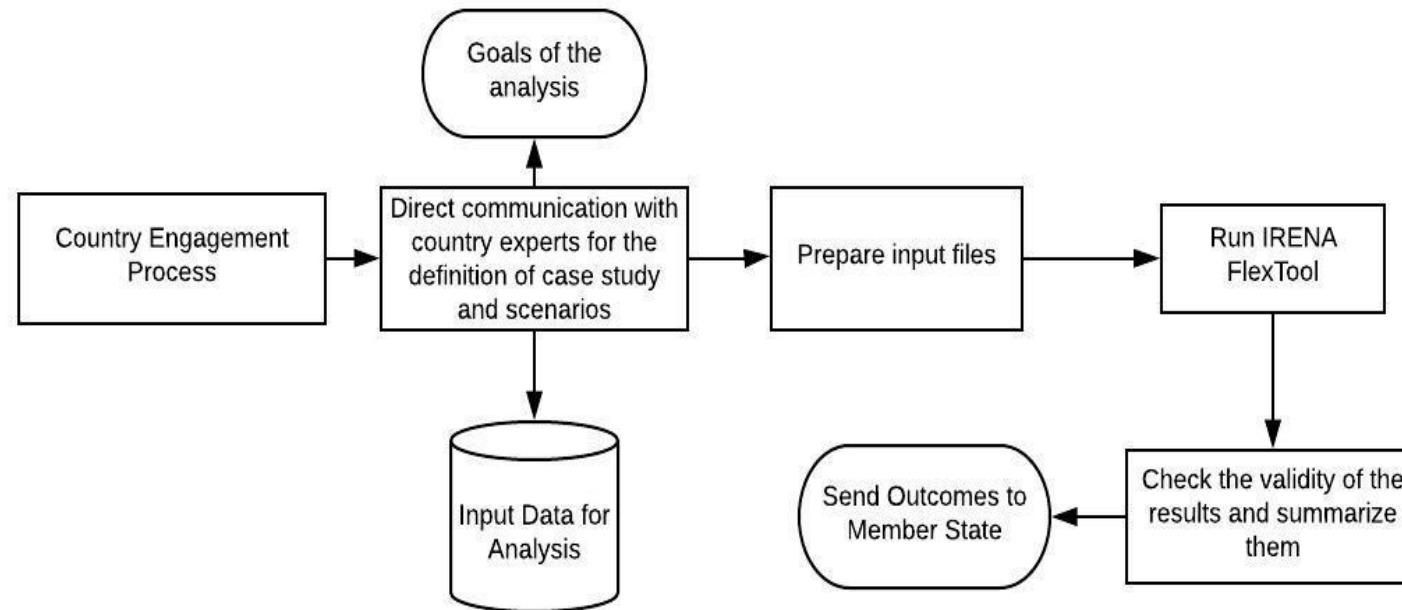
⁴Developed by PSR

⁵Developed by the International Atomic Energy Agency (IAEA)

⁶Developed by the International Energy Agency (IEA)

- » The **IRENA FlexTool** was developed by the VTT Technical Research Centre of Finland Ltd to assist IRENA Members in a quick assessment of potential flexibility gaps

Engagement process and analysis



» Future potential case studies

- » Chile, which is a state in accession, expressed interest in a FlexTool analysis focusing on power to hydrogen
- » Mexico, expressed interest in a FlexTool analysis and IRENA will share information as a next step
- » Other countries showed interest in the II Energy Planners Forum in Santiago de Chile

The Knowledge Framework: Transition Pathway

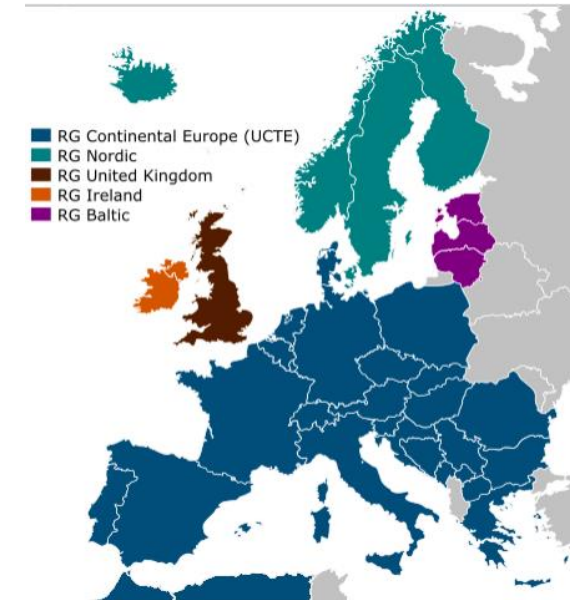
Front runners: DK: 40% / IE: 20%

- Low national storage
- High PPs Flexibility

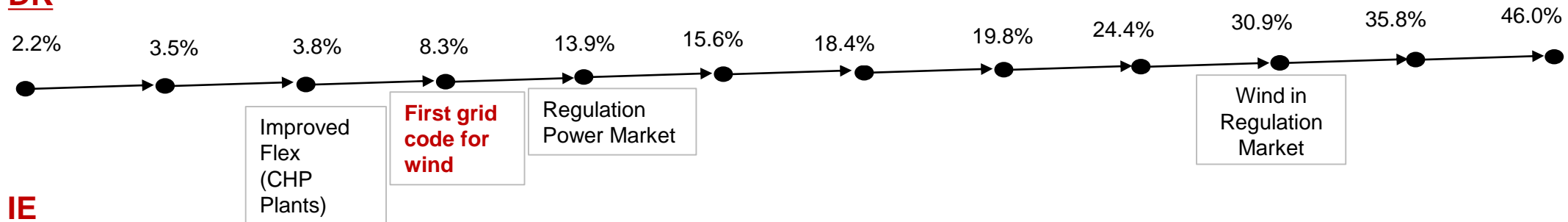
- Synchronized Grid (2015)
 - DK: 1.28% <-> IE: 74%
- Interconnectors (2015)
 - DK: 50% <-> IE: 7%

Same measures but at different times!

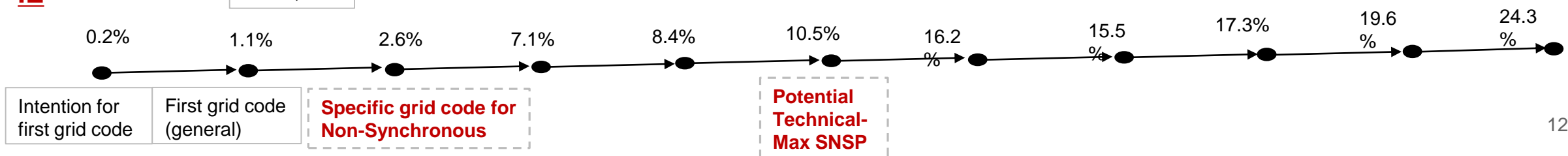
Also different measures!

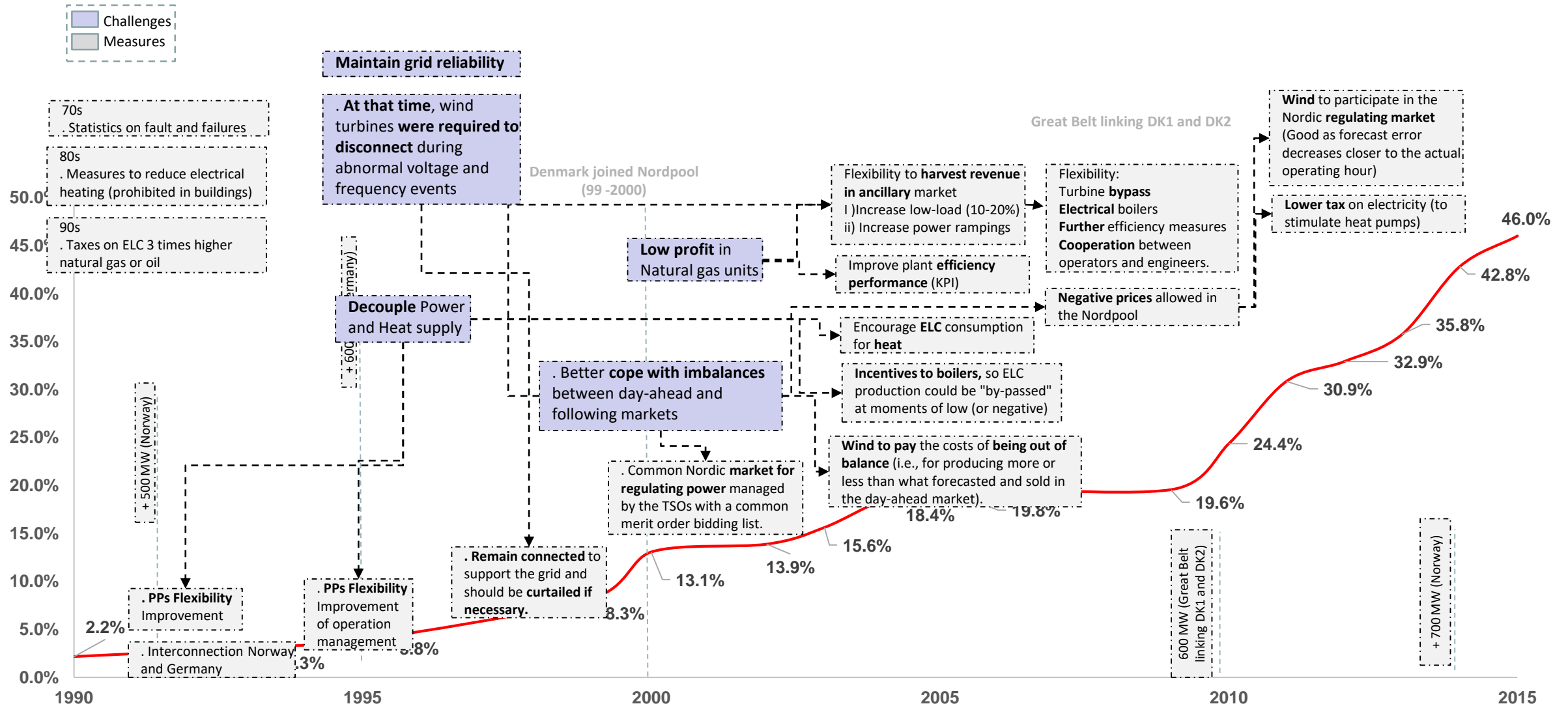


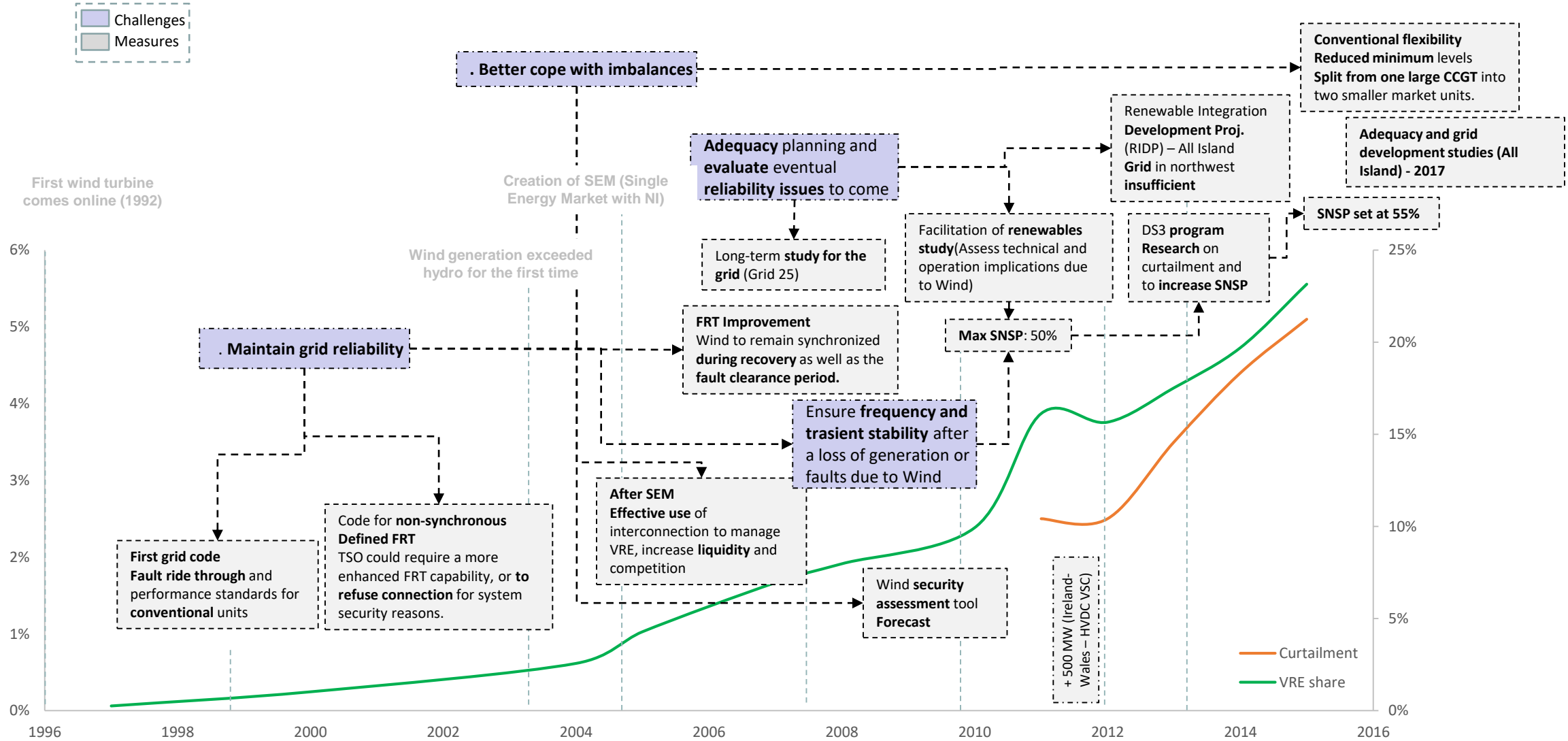
DK



IE







Sources: EIRGRID (2011, 2012, 2013, 2014))

REmap analysis for CESEC

Methodological approach and expected outputs

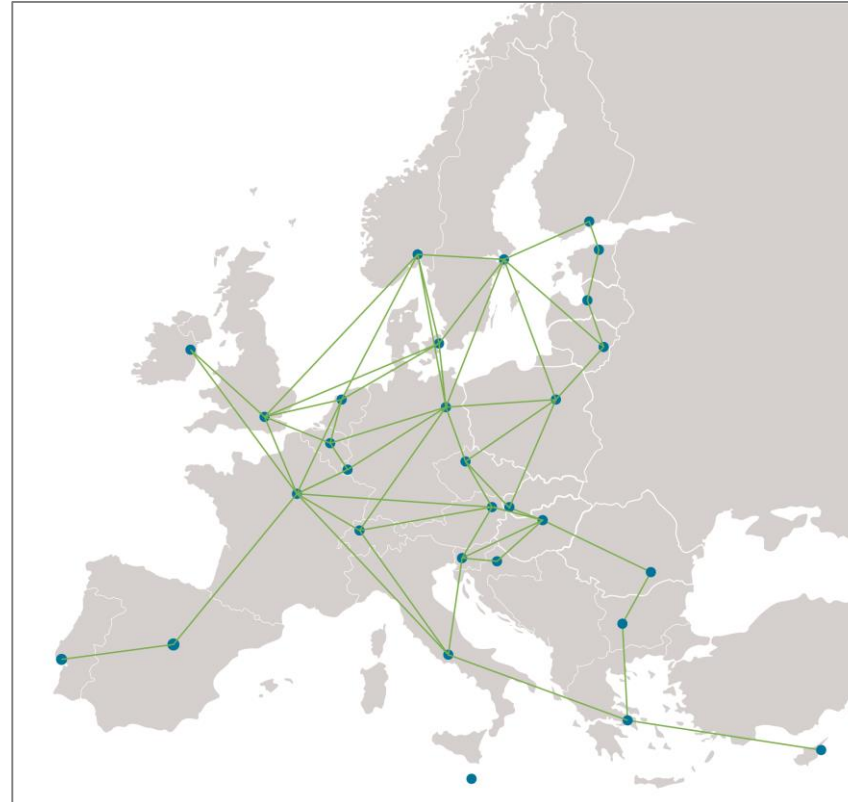
Ongoing work and data needs

Engagement process, timeline

Ongoing work: expansion of the EU-wide power sector model to all CESEC members

Europe-wide power system dispatch model

- **Generation capacities in 2030**
- **Interconnection between Member States**
- **Power demand profiles per Member State**
- **RE generation profiles per Member State**



- **RE curtailment levels**
- **Wholesale prices**
- **Cross-border trade**
- **Interconnector congestion**
- **Operation of conventional plants**
- **Emissions intensity**

Collins, S., Saygin, D., Deane, J.P., Miketa, A., Gutierrez, L., Ó Gallachóir, B. and Gielen, D (2018) Planning the European power sector transformation: The REmap modelling framework and its insights. Energy Strategy Reviews, forthcoming.

Main data gaps for the REmap CESEC power sector analysis

Contracting Party	Data gaps for the power sector analysis
Albania	<ul style="list-style-type: none"> • Hourly demand profile from a previous relevant year • Hydro inflows with the highest available granularity (e.g., monthly) and pumped hydro storage capacity (if any)
Bosnia and Herzegovina	<ul style="list-style-type: none"> • Hydro inflows with the highest available granularity (e.g., monthly) and pumped hydro storage capacity (if any)
Kosovo*	<ul style="list-style-type: none"> • Hydro inflows with the highest available granularity (e.g., monthly) and pumped hydro storage capacity (if any)
Macedonia	<ul style="list-style-type: none"> • Hydro inflows with the highest available granularity (e.g., monthly) and pumped hydro storage capacity (if any)
Moldova	<ul style="list-style-type: none"> • Hourly demand profile from a previous relevant year together with growth expected for 2030 • Non-renewable generation capacity installed classified by generation type • Interconnection capacity with other countries
Montenegro	<ul style="list-style-type: none"> • Hydro inflows with the highest available granularity (e.g., monthly) and pumped hydro storage capacity (if any)
Serbia	<ul style="list-style-type: none"> • Hydro inflows with the highest available granularity (e.g., monthly) and pumped hydro storage capacity (if any)
Ukraine	<ul style="list-style-type: none"> • Hourly demand profile from a previous relevant year together with growth expected for 2030 • Non-renewable generation capacity installed classified by generation type • Interconnection capacity with other countries



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Power Sector Transformation Strategies

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