Workshop

Innovative solutions for achieving 100% renewable power systems by mid-century

Session II – Technical feasibility of a 100% renewable power system by 2050

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17th July 2019
Montevideo, Uruguay

Structure

1. **Knowledge Framework**
   - Best practices
   - Chinese example
   - Measures & indicators

2. **Power sector flexibility assessment**
   - Definitions, sources of flexibility, FlexTool
   - Flexibility analysis for Uruguay's 2030 power system

Knowledge Framework

Best practices

Identify renewable energy **integration challenges** that have been resolved by front-runners	Identify **key measures** used to resolve the challenges	Measure the **impact** of such measures	Estimate the **applicability** of each measure based on enabling conditions
• Line congestion • Frequency and voltage deviation • Lack of system Inertia • Insufficient flexibility • Insufficient storage	• Dynamic Line rating • VRE to provide frequency reserves • Synchronous condensers • Retrofit powerplants • Increase Interconnection	• Curtailment variations • Redispatch costs • Negative prices	• Measures filtering: ✓ "Manually" (now) ✓ Statistical Inference

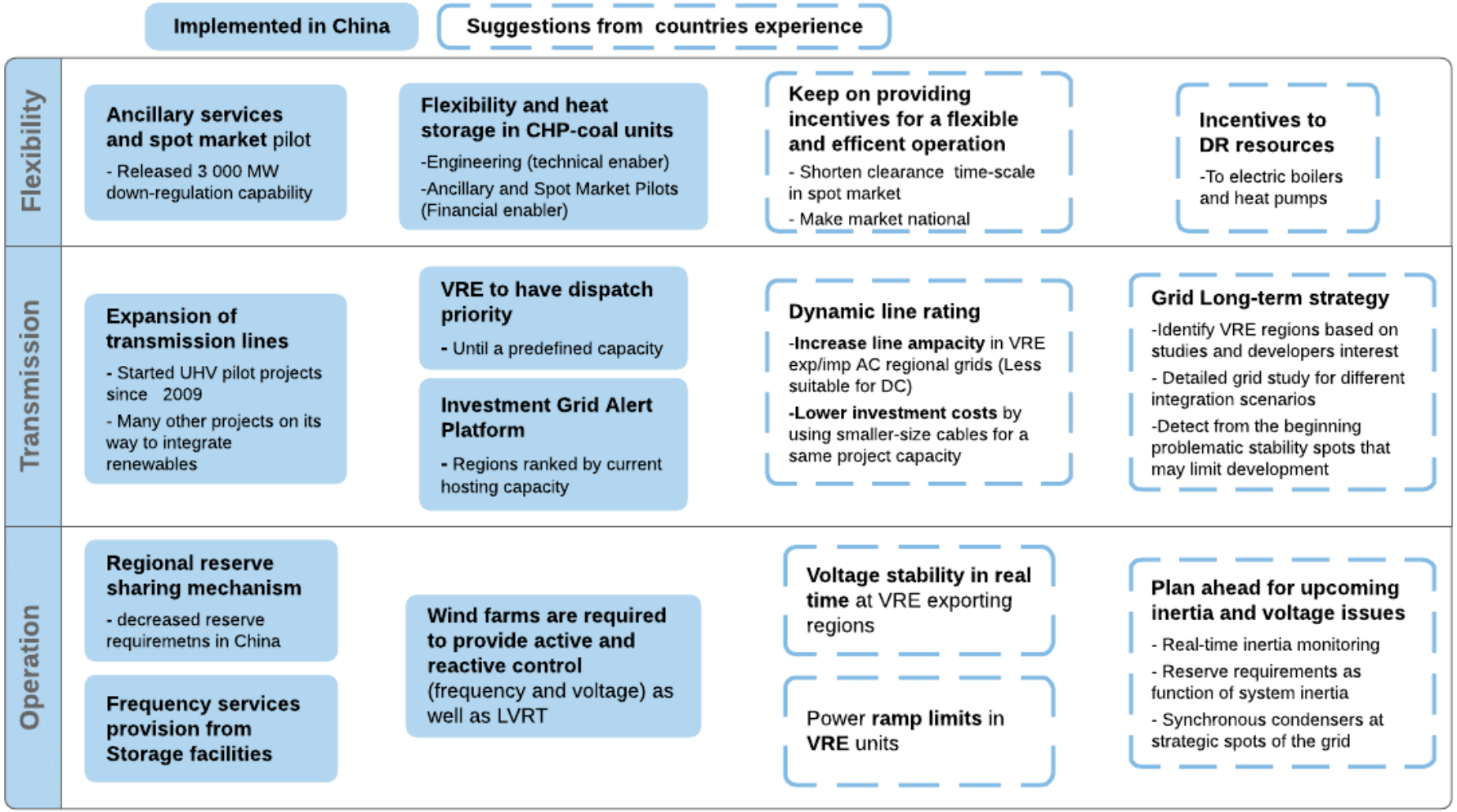
Integration challenges in China

- **Flexibility:** Keep on providing incentives for generators to operate flexibly
- **Transmission:** Energy congestion throughout the grid
- **Operation:** Address current grid stability concerns and plan ahead in time for future issues

Key measures applied in countries

Knowledge Framework

Keeping pace with the Chinese transition

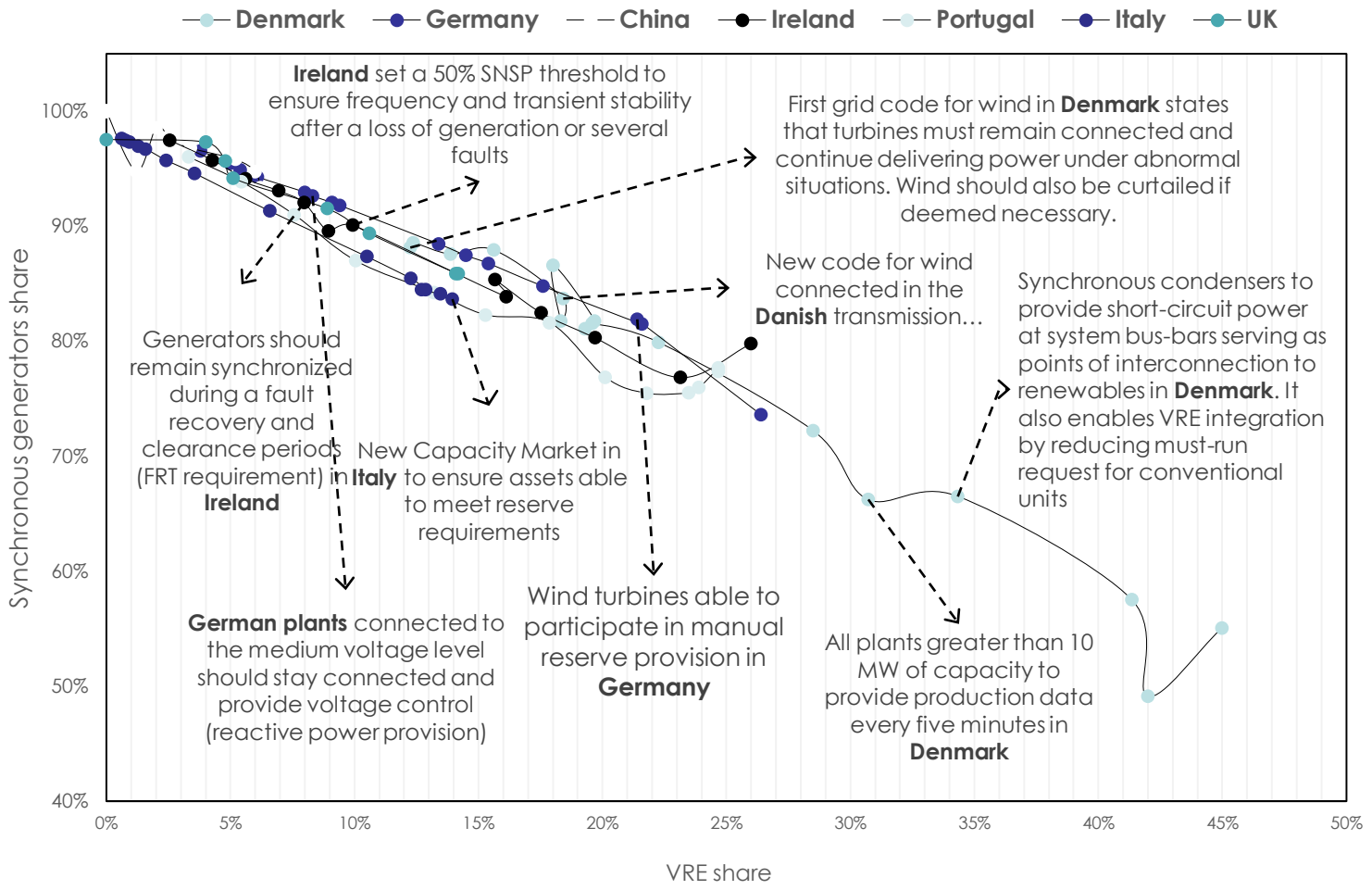


Knowledge Framework

Measures-Indicators link

- Measure applied in a given year

- **Indicators** (country profile) for the same particular year
  - Flexibility share
  - Synchronous generation
  - CHP share
  - Distributed generation
  - Storage availability
  - Supply-load mismatch
  - Flexibility and storage availability in neighboring countries
  - Reserve requirements
  - Market information
  - Others



Power sector flexibility assessment

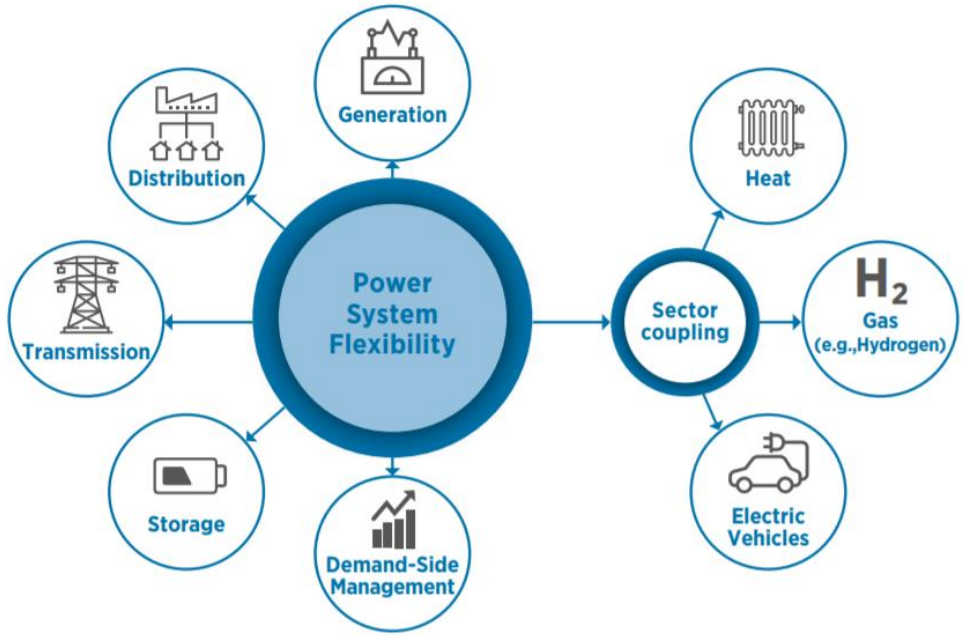
Definitions

Flexibility *is the capability of a power system to cope with the* ***variability*** *and* ***uncertainty*** *that VRE generation introduces into the system at different time scales, from very short to the long term, avoiding curtailment of VRE and reliably supplying all the demanded energy to customers*

- ✓ ***Variability*** *is the fluctuating nature of solar and wind resources, which translates into potentially rapid changes in electricity output.*
- ✓ ***Uncertainty*** *is the inability to predict perfectly the future output of solar and wind power sources.*

Main flexibility sources

- **Generation**: Hydro, gas
- **Grid**: Dynamic line rating, T&D grid 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



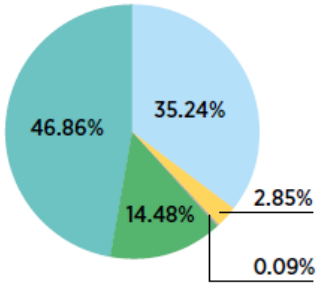
Source: IRENA (2018), Power System Flexibility for the Energy Transition

URUGUAY POWER SYSTEM FLEXIBILITY ASSESSMENT

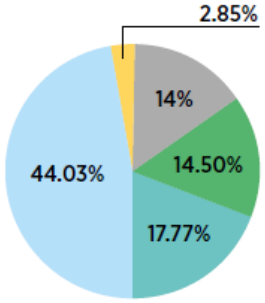
IRENA FLEXTOOL

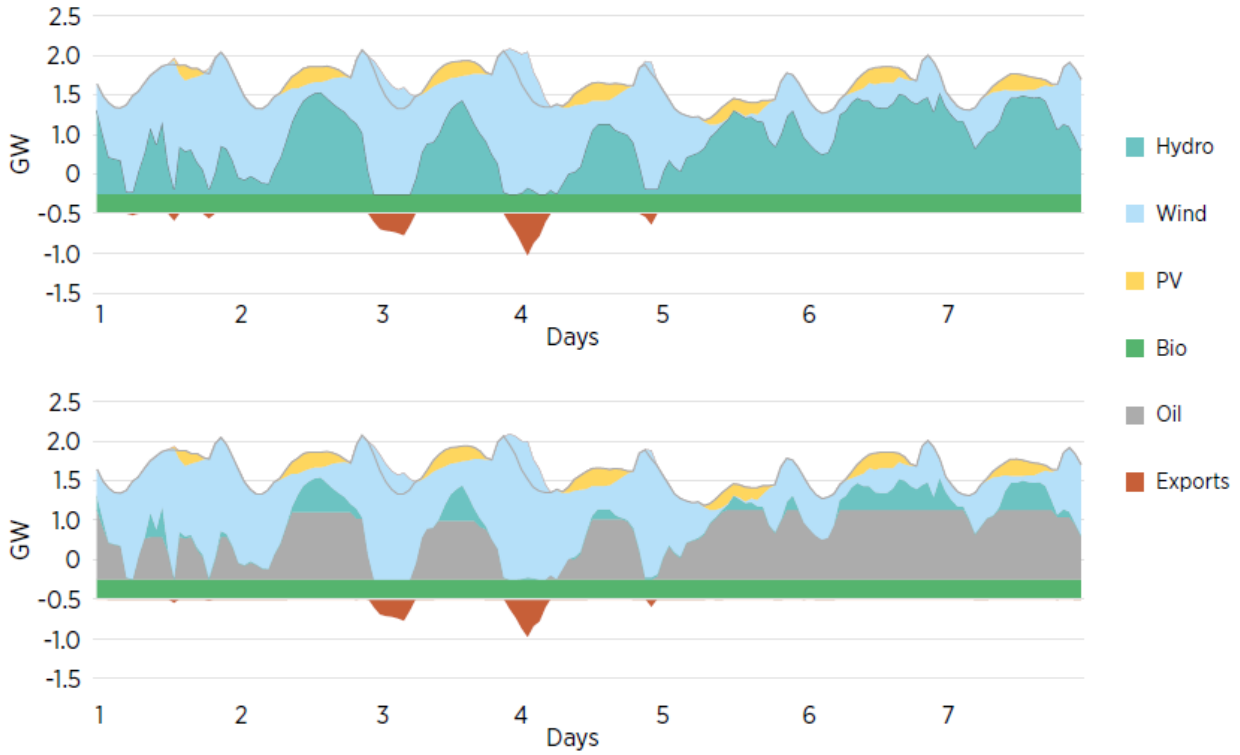
Flextool, Uruguay, 2030

2030 Reference



2030 Dry-year





	2030 Reference		2030 Dry Year	
	Total (GWh)	Peak (MW)	Total (GWh)	Peak (MW)
Curtailment*	1 920	2 397	609	1 102.7
Loss of load	0	0	0	0
Spillage	0	0	0	0
Reserves inadequacy	0	0	0	0

Thank you for your attention!

IRENA
International Renewable Energy Agency