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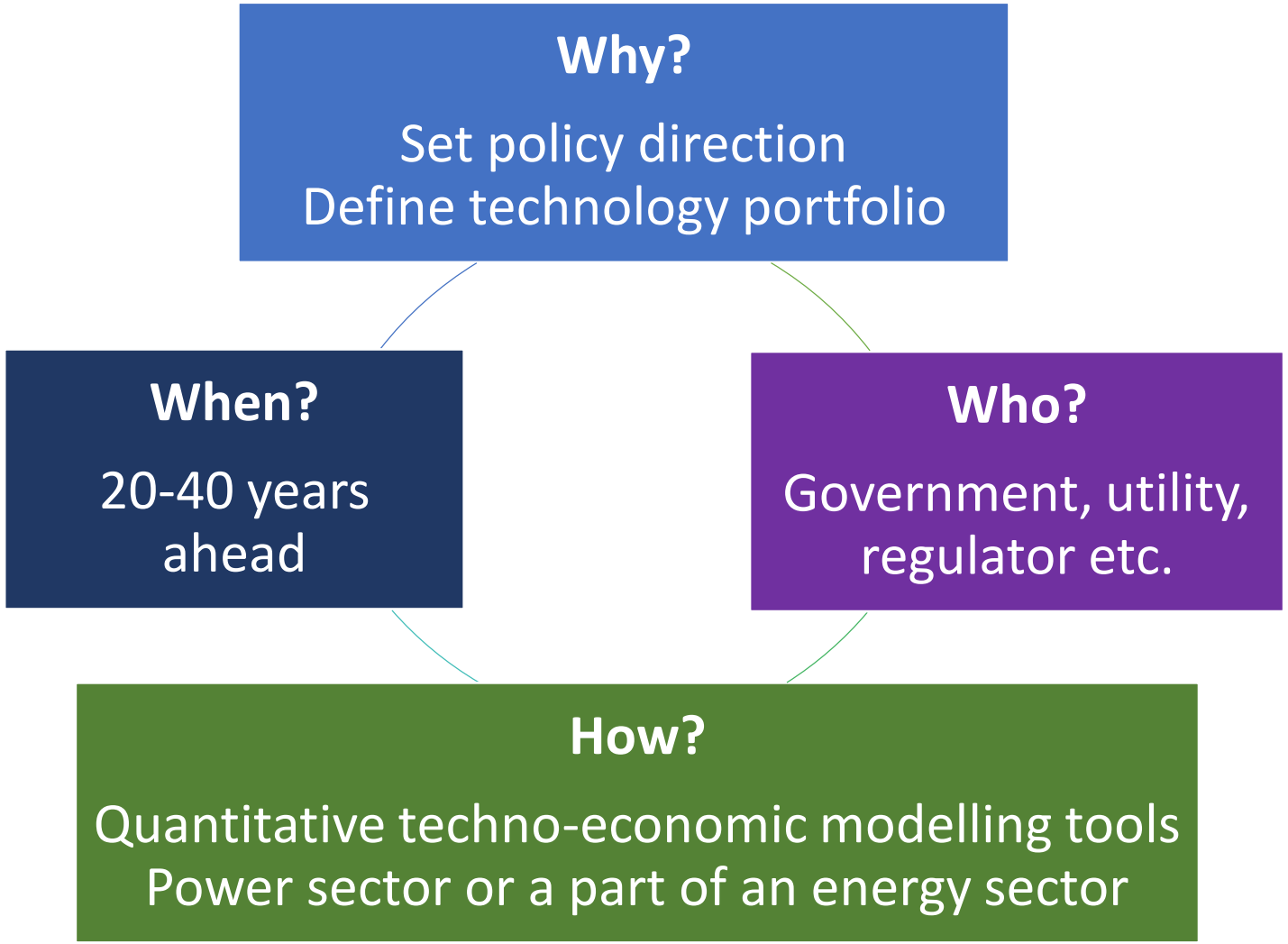
International Renewable Energy Agency

IRENA Expert Workshop
Addressing the Geo-Spatial Aspects of Variable Renewable Energy in Long-Term Planning

Scene Setting Presentation

12 December 2019

Long-term generation capacity expansion planning



Latin American context

Summary from ""*Exchanging best practices to incorporate variable renewable energy into long-term energy/power sector planning in South America*"

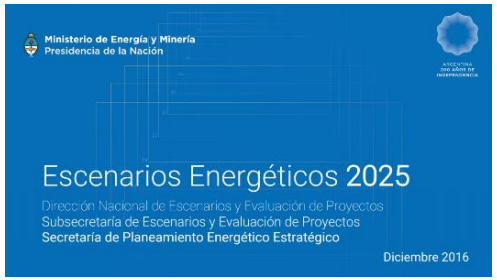
Colombia:
Basis for policy making, establishing **signals for investment** and capacity expansion needs

Brazil:
To be used as a **basis for formulating public policies**

Uruguay:
To design policies to support technologies to promote and **investment needs**

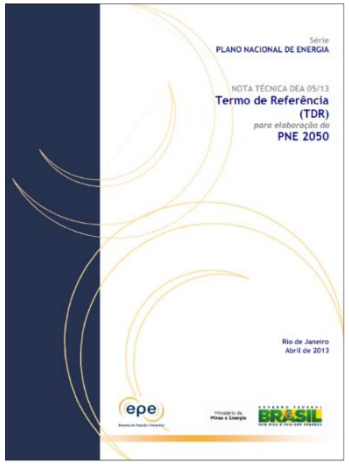
Argentina:
To establish a framework of discussion for the **design of new policies** and for the **discussion with actors of the sector**.

Planning reports from governments in LATAM



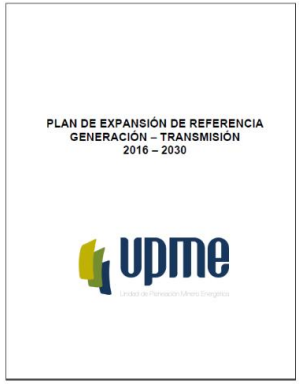
Argentina

Bolivia



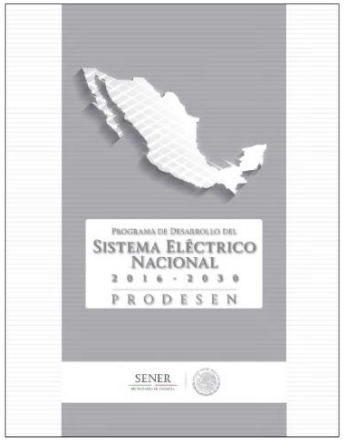
Brazil

Chile



Colombia

Ecuador



Mexico

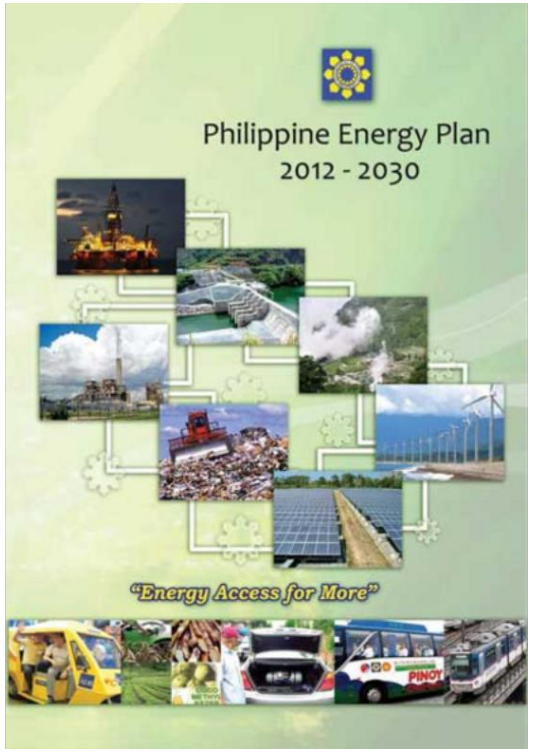
Peru

Paraguay

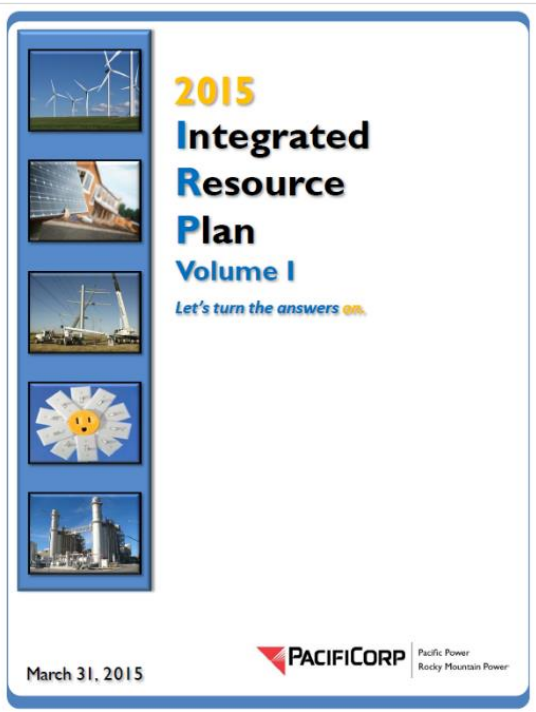
Planning scopes in LATAM

Country	Scope	Planning horizon	Update
Argentina	Energy	2025	Annual
Bolivia	Electricity	2025	NA
Brazil	Energy	2050	5 -10 years
Chile	Energy	2046	5 years
Colombia	Electricity	15 years	Annual
Ecuador	Electricity	2025	2 years
Mexico	Electricity	15 years	Annual
Paraguay	Energy / electricity	2040 / 2025	5 / 2 years
Peru	Energy	10 years	2 years
Uruguay	Energy / Electricity	2035 / 2040	Annual

Some more examples

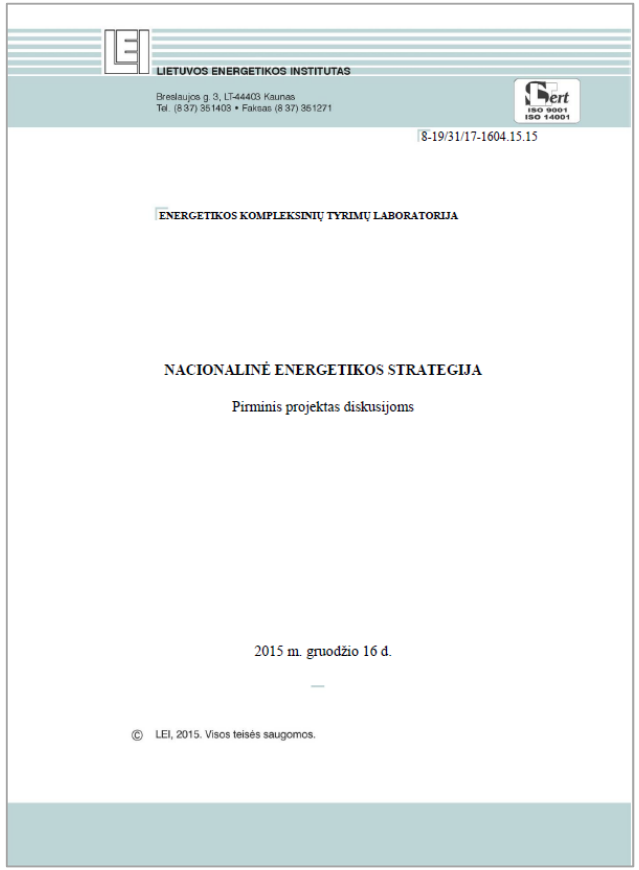


Department of Energy [Philippines]



Utility [USA]

Regulatory commission [Kenya]

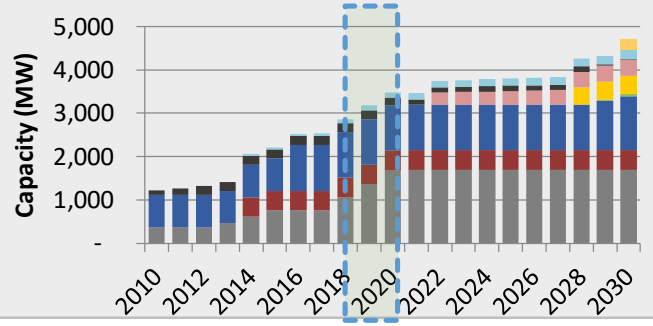


Specialized agency [Lithuania]

Power system planning: Scopes of analysis

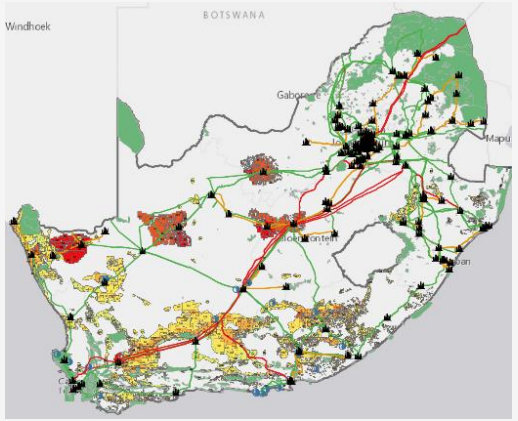
Capacity expansion planning

- Ministry of Energy
- Planning agency
- Utility



Geo-spatial planning

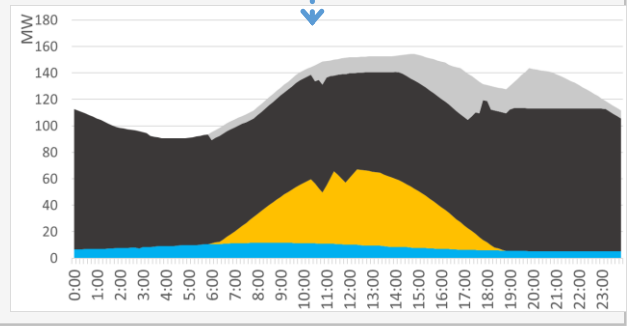
- Government planning office
- Planning agency
- Utility
- TSO



Dispatch simulation

- Utility
- Regulators
- TSO

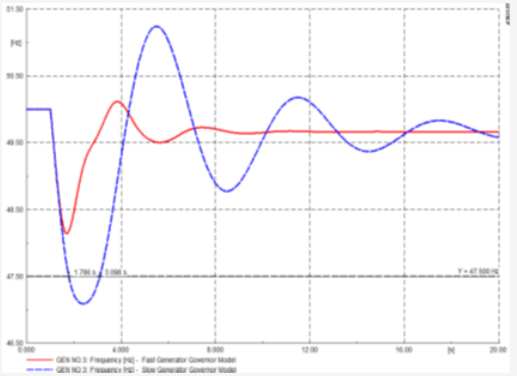
Snapshot of one year



Technical network studies

- TSO
- Regulator
- Project developer

Snapshot of one moment



Modelling software: Indicative coverage

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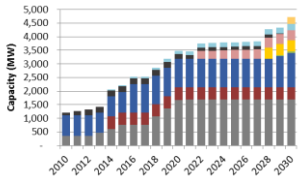
MESSAGE
MARKAL/TIMES
PLEXOS-LT
BALMOREL
OPT-GEN
WASP
GT-MAX

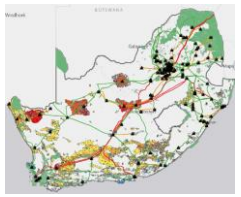
Quantum GIS
ArcGIS

Flextool
PLEXOS-ST
WASP
GT-Max
SDPP
Grid-View

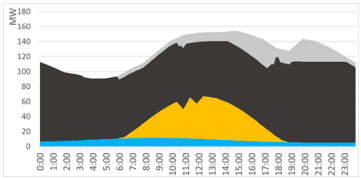
NEPLAN
Power Factory
PSSE



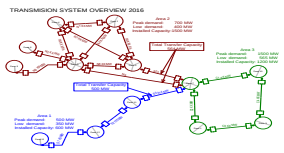
Cap expansion



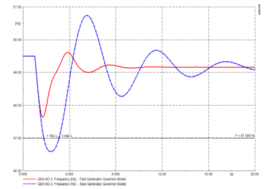
Geo-spatial



Dispatch



Static



Dynamic

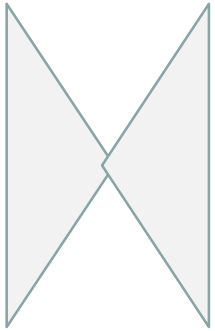
Long-term planning with VRE

Policy makers

"Deploying variable renewables (VRE) is beneficial."

"Our country should adopt ambitious long-term VRE targets."

Energy planning officials



System operators

"VRE's short-term variability endangers power system reliability"

"There is an upper limit of X% VRE"

How can we evaluate impacts of variability?
Are we using right tools?

Addressing VRE in long-term planning (AVRIL) project

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Based on expert inputs

- IEW 2014, 2015
- AVRIL expert meeting, March 2015
- Interviews

In consultation with energy planners in North Africa, and Latin America

Elements of system reliability

Generation from VRE generators is variable, uncertain, location-constrained, non-synchronous, and often distributed (connected to distribution grid).

	Generation	Networks
Adequacy	Sufficient firm capacity	Sufficient and reliable transport and distribution capacity
Security	Flexibility of the system Stability (Robustness to contingency)	Voltage control capability Stability (Robustness to contingency)

Elements of system reliability: Impacts of VRE

	Generation	Networks
Adequacy	**Variability** reduces contribution to firm capacity	**Location-constraints** may require grid extension and reinforcement
Security	**Variability and limited predictability** requires system to follow residual load Lack of inertia and governor response may pose the technical limit to VRE penetration	**Location-constraints** may change voltage control requirements **Distribution** level connection may affect voltages and protection system coordination RE's behavior during fault may affect system stability

VRE: Long-term investment implications

	Generation	Networks
Adequacy	Firm capacity	Transmission capacity
Security	Flexibility	Voltage control capability
	Stability (frequency response and voltage response)	

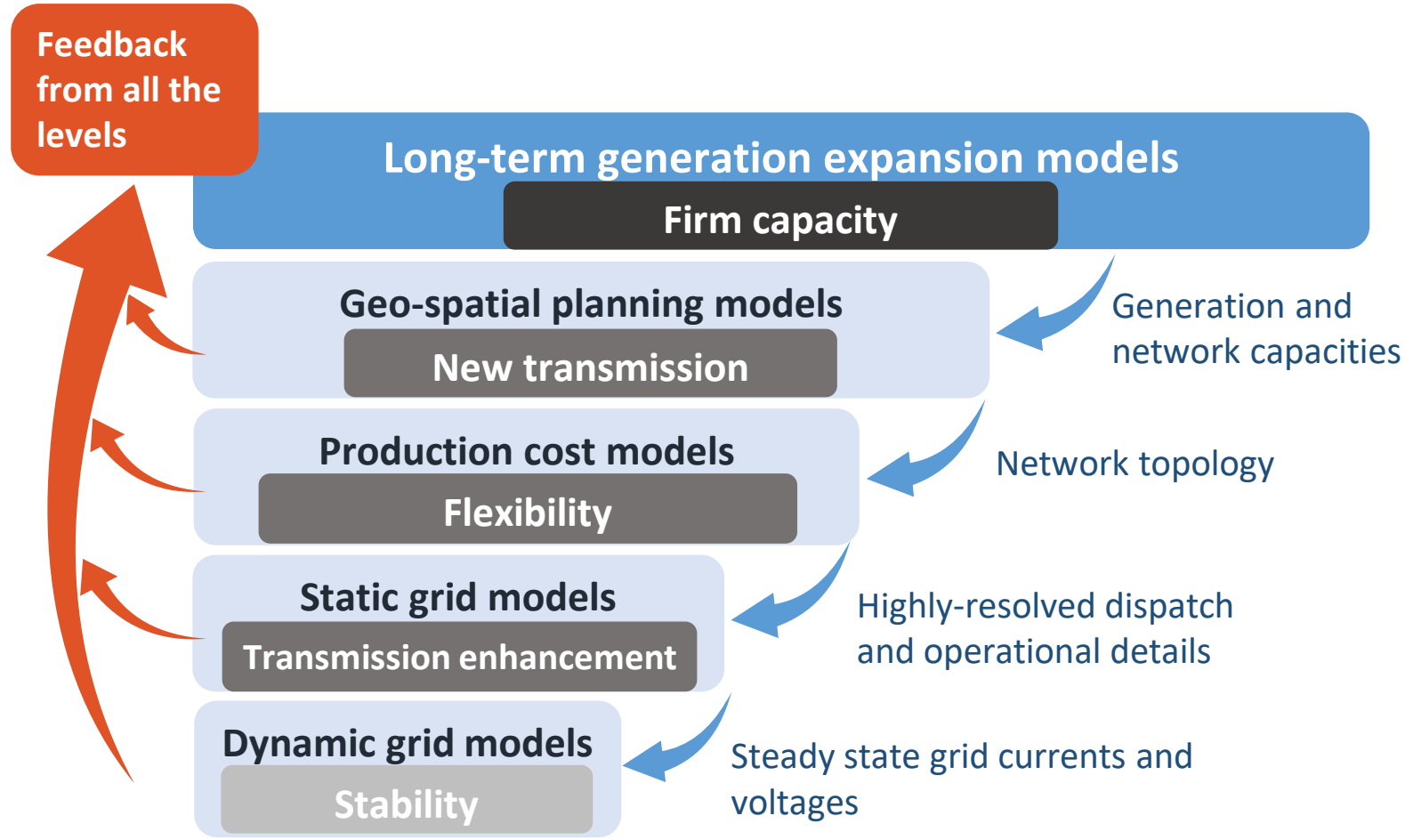
Most relevant

High relevance

System-specific

Near-term relevance

Application of planning tools … with VRE



Better coordination is required!

Low High

Relevance of VRE impact in long-term planning

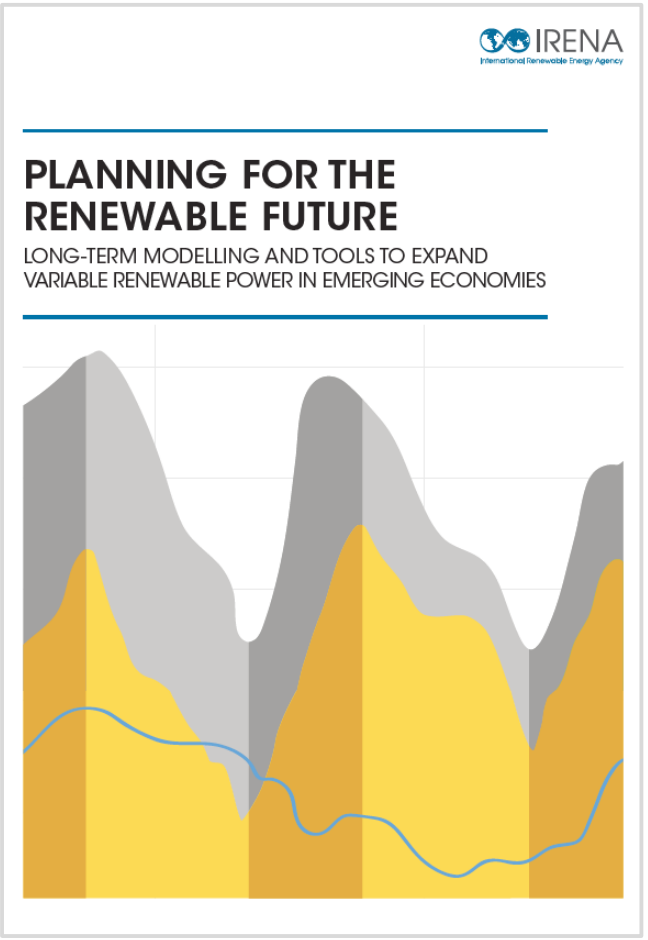
AVRIL report – guide for global best practices

How does long-term generation expansion planning need to change when aiming for a high share of VRE?

- Planning impacts of VRE's distinct features

What needs to change?

- Institutional aspects (Planning process)
- Techno-economic assessment methodologies (Modelling)



Regional AVRIL workshops

2017 – Buenos Aires, Argentina – LATAM

- Co-organised by IRENA and Argentina's Ministry of Energy and Mining; with representatives from NREL, OLADE, and the World Bank
- Representatives from **ten Latin American countries - Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru, and Uruguay**

2019 – Astana, Kazakhstan – Central Asia

- Co-organised by IRENA and Ministry of Energy of Kazakhstan; with representatives from ADB, USAID, EBRD, UNECE, UNDP
- Representatives from **five Central Asia countries - Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan**

2019 – Amman, Jordan – Arab region

- Co-organised by IRENA, League of Arab States, IsDB and RECREEE
- Representatives from **ten Arab countries - Algeria, Bahrain, Egypt, Iraq, Jordan, Libya, Palestine, Qatar, Saudi Arabia, and Somalia**

AVRIL report update

geo-spatial aspect of VRE

Long term spatial impacts of VRE

	Generation	Networks
Adequacy	Firm capacity	Transmission capacity
Security	Flexibility	Voltage control capability
	Stability (frequency response and voltage response)	

Most relevant
High relevance
System-specific
Near-term relevance

Dependent on VRE resource location

- Temporal profiles
- Grid integration requirements
- Resource quality

What AVRIL Report 2017 provided

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Geospatial resolution of cutting edge tools

Model data requirements, key parameter definitions and surveys

Data pre-processing tools & GIS data source insights

Country Application Examples

Solutions for capturing Long term planning impacts of VRE

Identified solutions (AVRIL Report 2017)

Solution-1: Increasing Spatial and Temporal Resolution

Cross-Cutting approach to capture:

- Supply demand alignment
- Supply smoothening by geographical spread

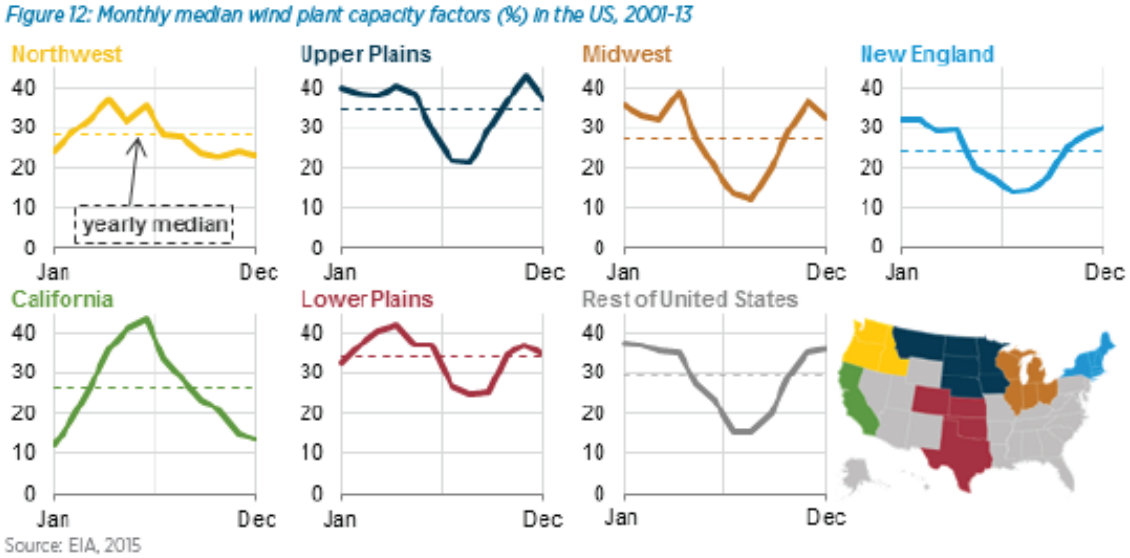
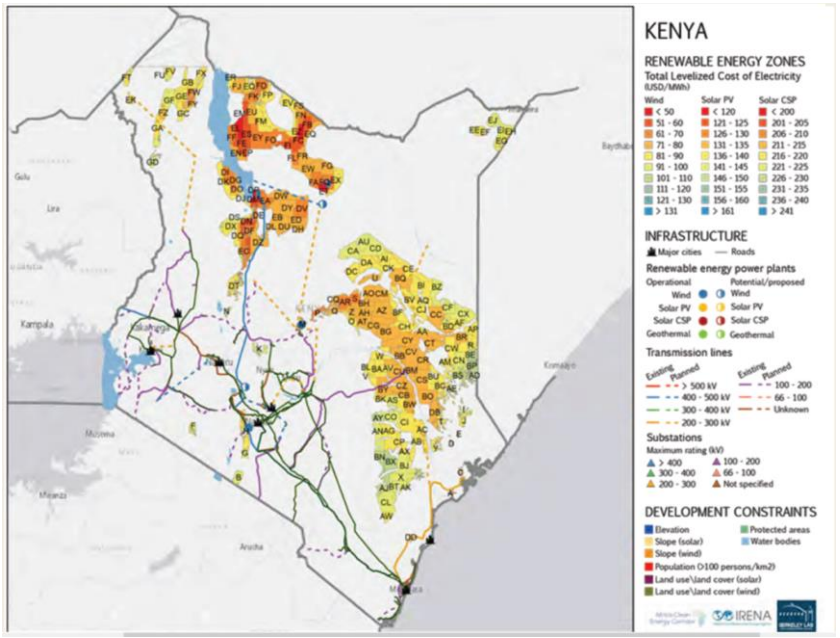


Figure 12: Monthly median wind plant capacity factors (%) in the US, 2001-13

Source: EIA, 2015



- Flexibility options enabled by internode transmission
- Trade-off: Transmission Cost vs VRE Locational resource quality
- Centralized VRE vs distributed VREs

Identified solutions (AVRIL Report 2017)

Solution-2: Linking grid investment needs with VRE expansion

- **Method proposed: Represent transmission costs per unit of VRE capacity**
- **Variation-1:** Generic cost add on
  - Grid reinforcement cost surveys, applicability: country level nodes-regional model
  - Linking set transmission line lengths each capacity unit replaced by VRE
  - GIS analysis of internodal trade potential and resulting grid investments
- **Variation-2:** Grid costs to grow with VRE share
  - Parameterizing grid extension cost function using spatially resolved models

Identified Solutions (AVRIL Report 2017)

Solution-3: Site specific representation of generation and transmission needs

- **To capture the trade-off: New transmission vs VRE resource quality**

Method-I: Endogenous Transmission Cost Representation

Method-II: Incorporating VRE clusters (zones) as explicit investment options

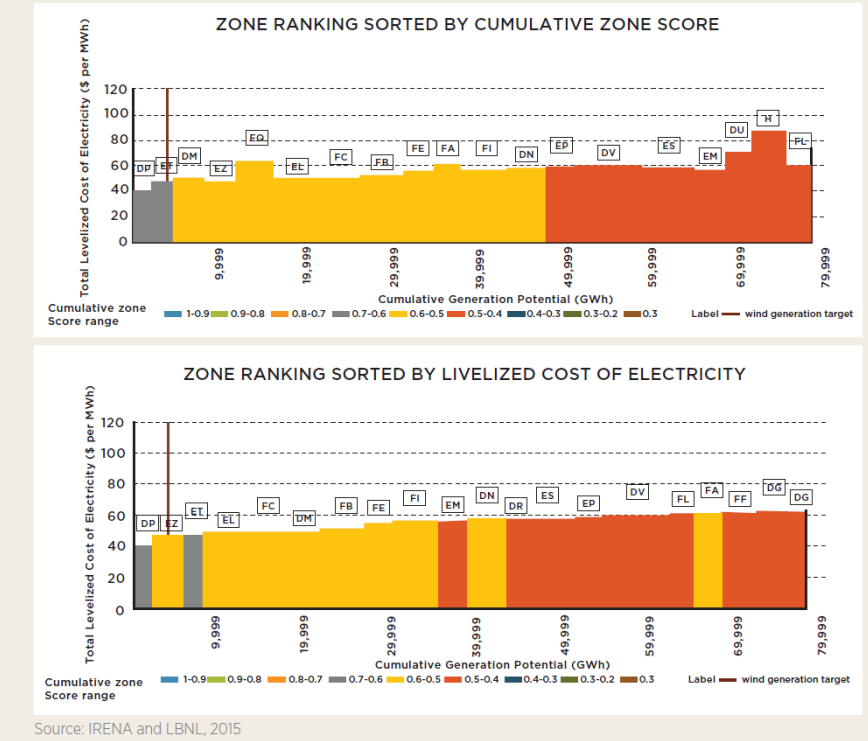
Modelling options to determine internodal transmission

DC/AC grid models to capture flow limits

Grid modelled as transportation network

User based transmission corridors

Figure 21: Zone ranking sorted by levelised cost of electricity (above) and by cumulative zone score



Source: IRENA and LBNL, 2015

Structure of the workshop

- We will discuss the current use of geospatial information in long-term energy planning and collect inputs to incorporate in AVRIL report update
- We want to explore challenges of government planners, solutions applicable for them, data sources and pre-processing tools accessible to them
- In session-2 we will hear country experiences with geospatial planning
- For session 3,4 & 6, we have invited experts/institutions whose work was cited in AVRIL report in geospatial context to know further developments
- During moderated discussions we would request you to contribute most, duly considering the ease of adaptability of solutions by governments

Structure of the workshop (New topics)

- Some new topics are included this time keeping in view their rising importance for Member States of IRENA
- Capturing climate impacts in long term planning scenarios will be discussed shortly in Session-4
- Session-5A would discuss the representation of Grid Connected Distributed VREs in long term generation expansion planning
- Session-5B would discuss the representation of Off-grid Distributed VREs / Rural Electrification in long term energy planning frameworks

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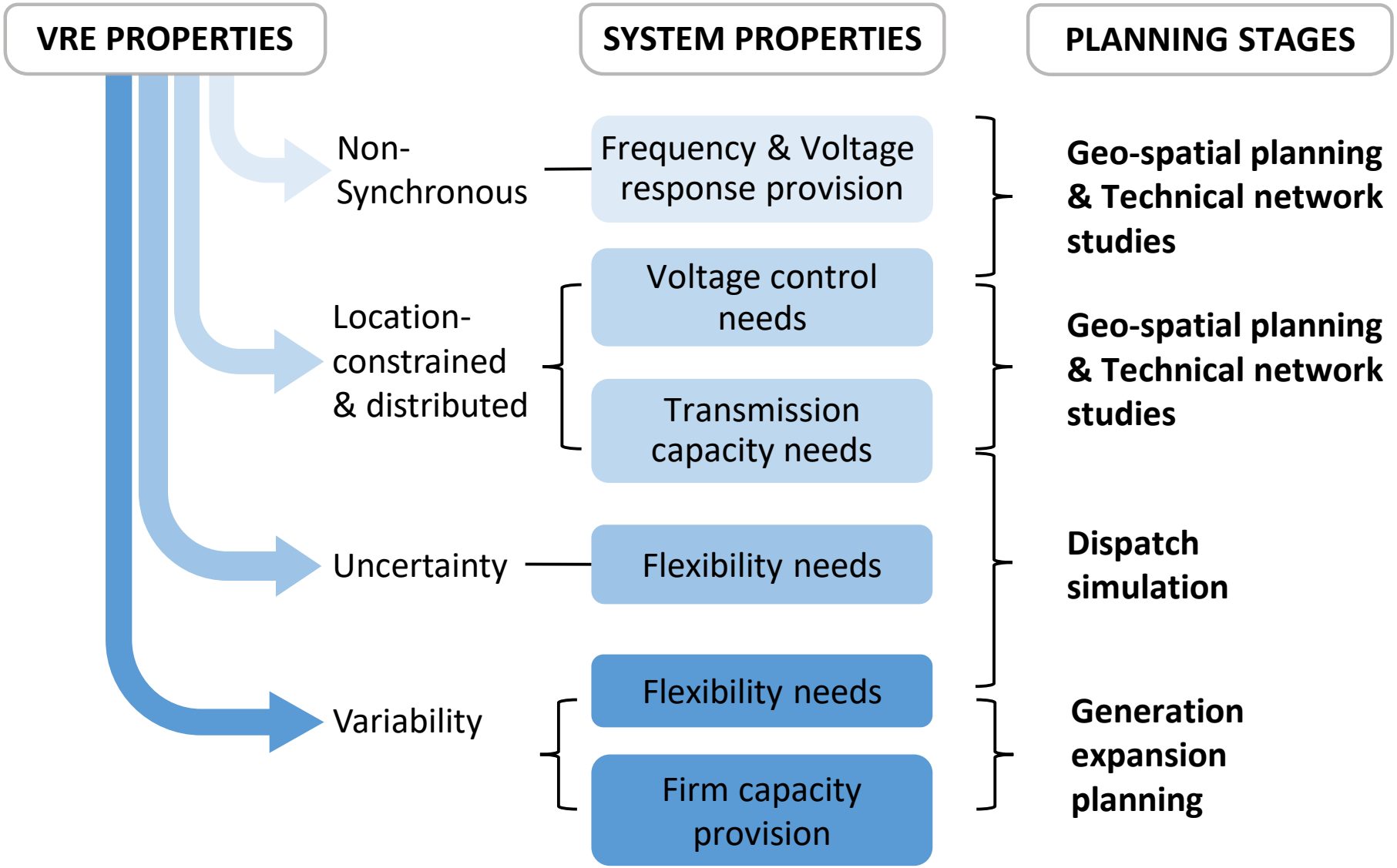
Tools for different stages



Source: IRENA (2017), Planning for the Renewable Future: Long-term modelling and tools to expand variable renewable power in emerging economies