IRENA

International Renewable Energy Agency

Power sector modelling and analysis for higher levels of RE

Asami Miketa

March 31, 2017, Bangkok, Thailand

Agenda

- Power sector planning: Four focus areas
- How do planning processes link with each other?
- VRE in the planning process
- Grid integration studies
- Conclusions

IRENA team

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MESSAGE

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Global Atlas

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PLEXOS

Francisco G

Power Factory

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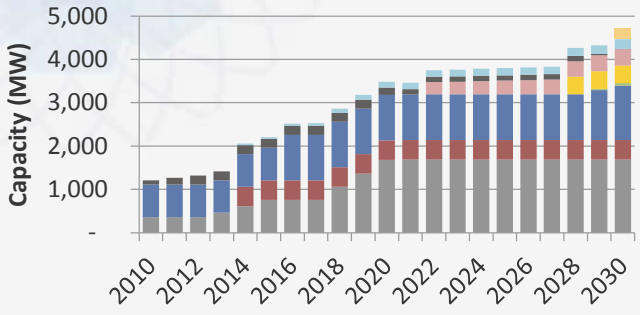
Power sector planning:
Four focus areas for techno-economic analysis

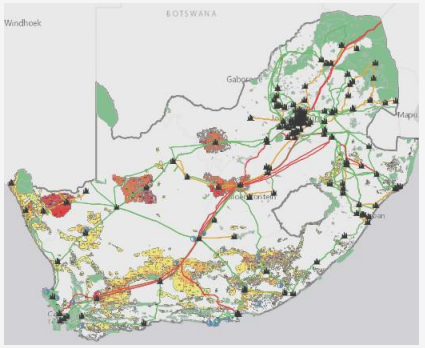


Generation expansion planning

- Ministry of Energy
- Planning agency
- Utility

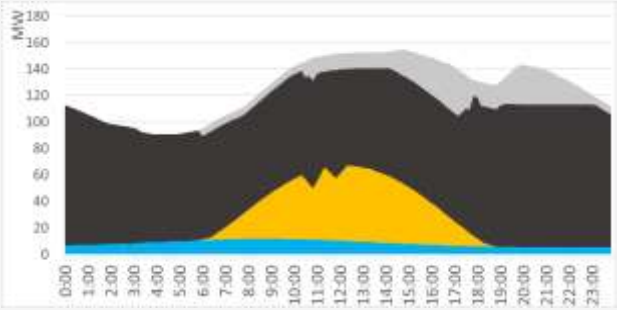
Geo-spatial planning

- Government planning office
- Planning agency
- Utility
- TSO



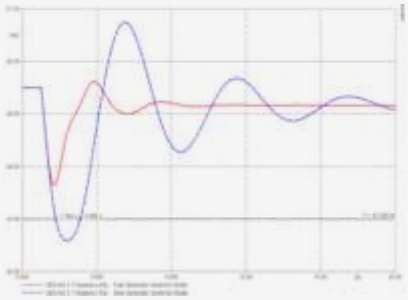
Dispatch simulation

- Utility
- Regulators
- TSO

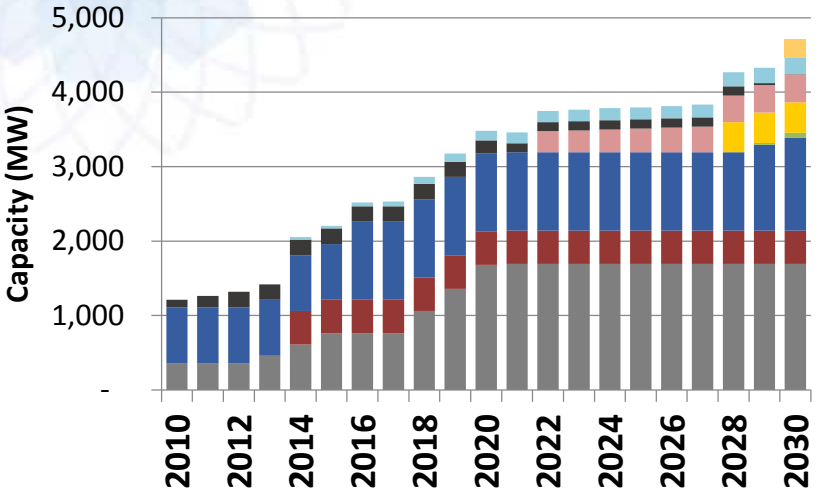


Technical network studies

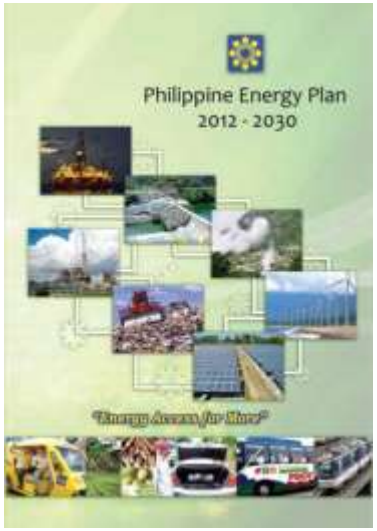
- TSO
- Regulator
- Project developer



1. Generation expansion planning



- Future energy mix and investment path
- Compliance with long-term energy policy goals
- Political consensus making
- Linked often with non-power sector planning



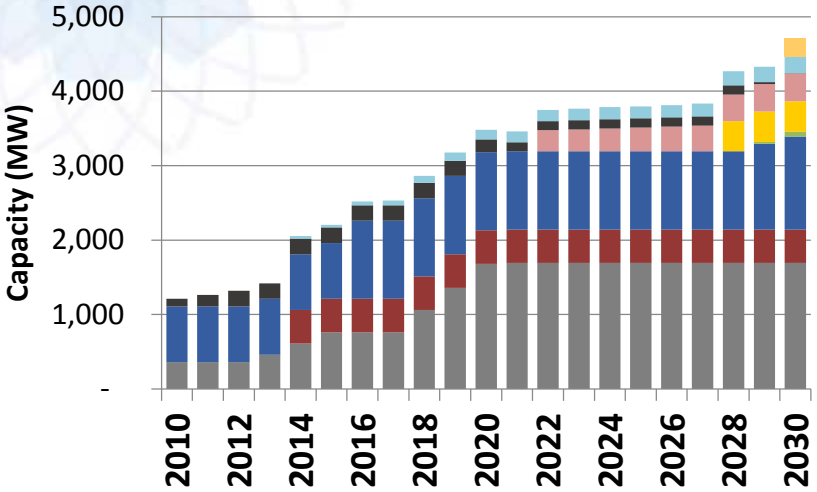
Department of Energy

Regulatory commission

Utility

Specialized agency

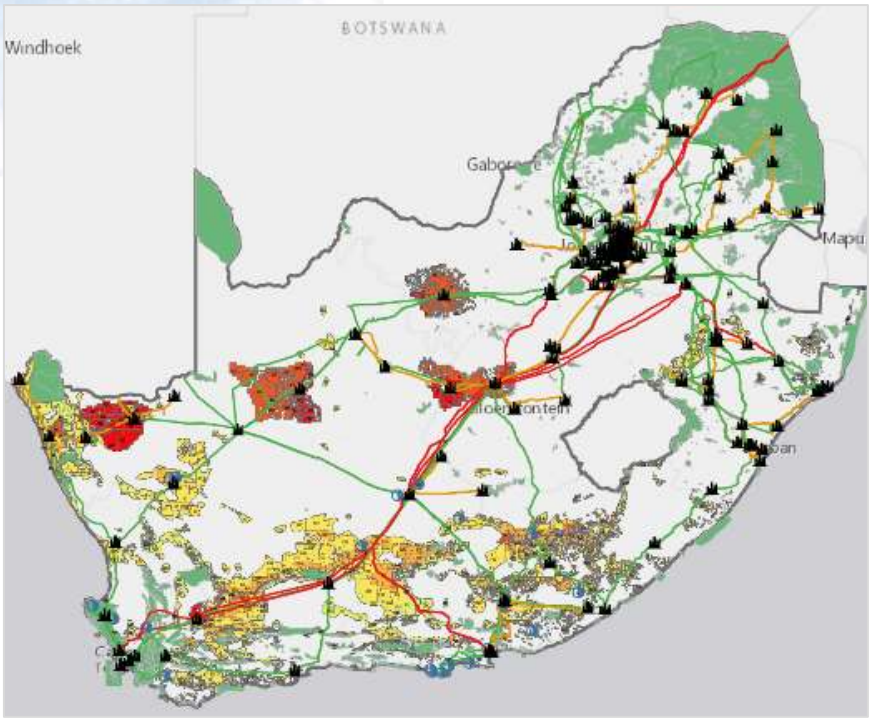
1. Generation expansion planning: Tools



Generation expansion models, long-term energy planning models

- Long-term planning horizon (20-40 years ahead)
- Capacity build up with time steps of 1-5 years
- **Co-optimization of investment, dispatch, and transmission**
  - Limited time resolution (simplified representation of dispatch)
  - Limited spatial resolution (simplified representation of power flow)

2. Geo-spatial planning



- Generation siting and long-term transmission development needs
- High-level screening scenarios for transmission network development
- Zone identification for investment promotion

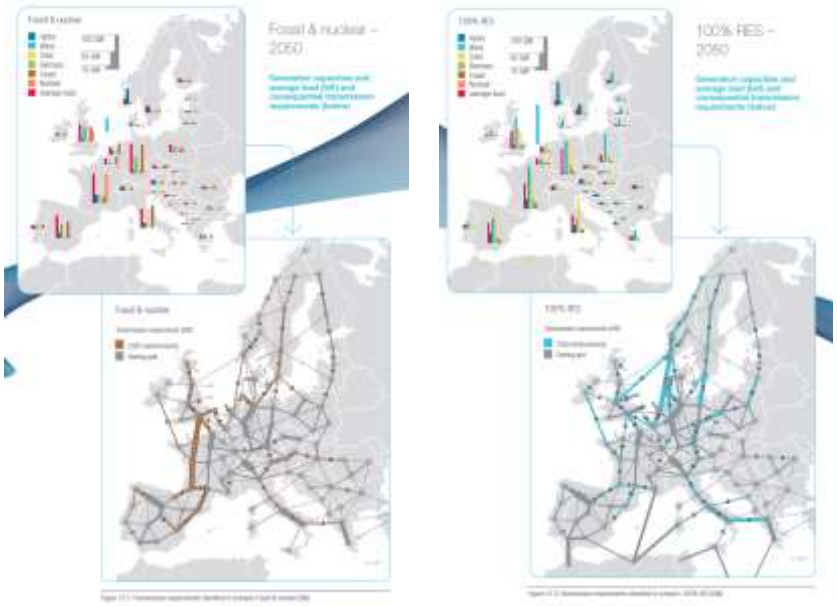
Tools:
Geographical Information System (GIS), Maps

2. Geo-spatial planning

Inputs to other planning steps

- Co-optimization with generation expansion
- A part of technical network studies

Modular Development Plan of the Pan-European Transmission System 2050 (E-highway by ENTSO-E)



Fossil&Nuclear scenario

100% RES scenario

No-regret investment

Energy generation scenarios given

↓

Geo-spatial information

↓

Optimal power flow

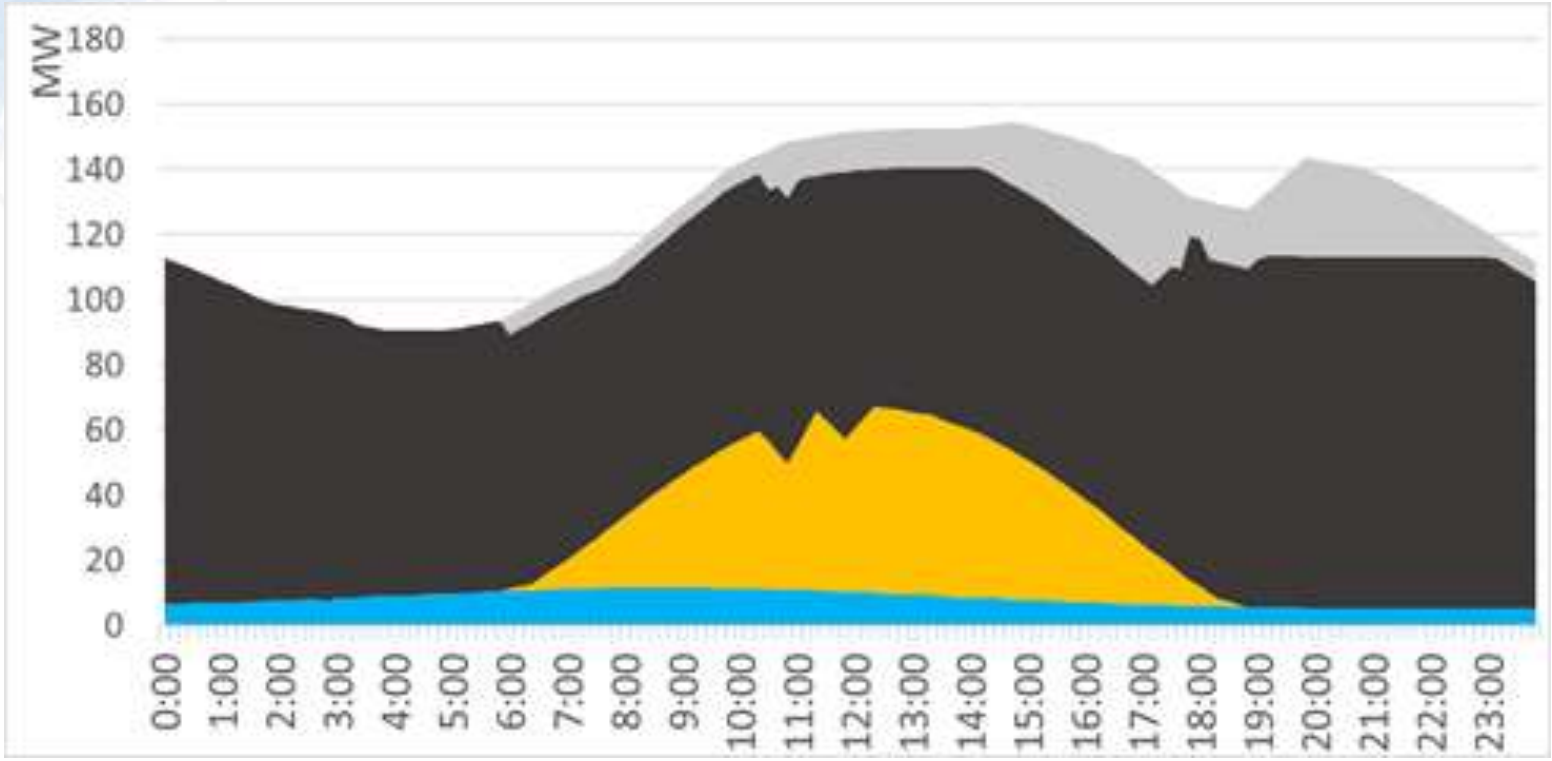
↓

Grid enhancement needs to 2030 plan

↓

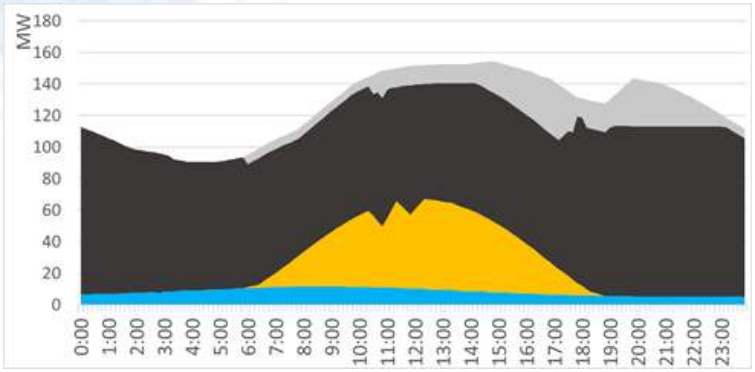
Check for voltage and stability problem

3. Dispatch simulation



- Fuel and operation cost calculation
- Maintenance scheduling
- Economic power flow
- Market and regulation design
- VRE integration study

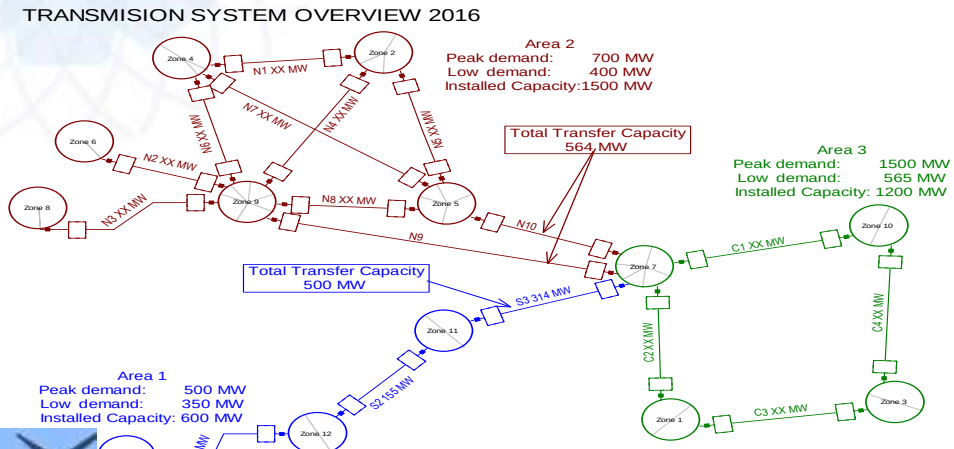
3. Dispatch simulation: Tools



Production cost models, Unit commitment and economic dispatch models, Operational power system models, Market models

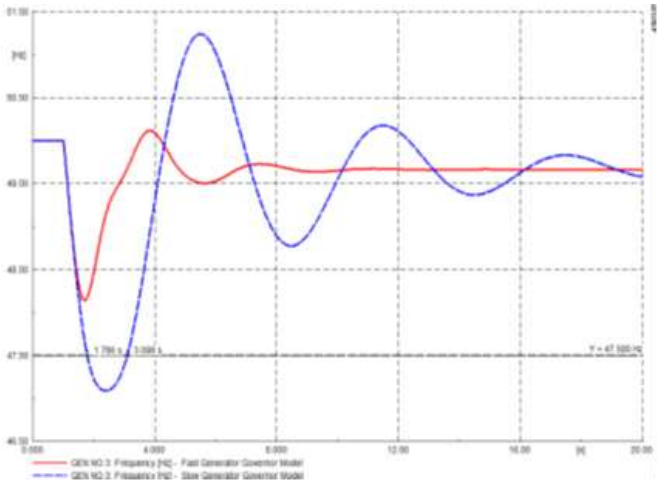
- Near to semi-long time horizon (several months to 20 years ahead)
- Used also for real-time operation decision making
- Capacity build up is often outside the scope
- Sub-hourly to hourly simulation for a period of up to a few years
- Network constraints are often taken into account

4. Technical network studies



Load flow analysis

- Simulate power flow of a given network under a challenging situation
- Identify network enhancement needs
- VRE integration study

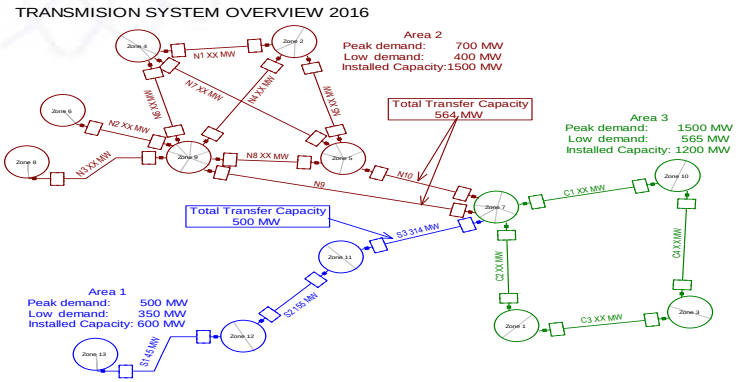


Stability assessment

- Simulation of frequency and voltage response in a network to a contingency event
- VRE integration study

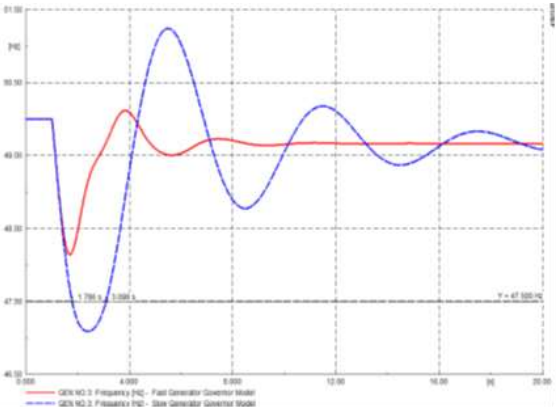
4. Technical network studies: Tools

Static network models



- Network topology and dispatch decision are given
- Real-time to semi-long time horizon (up to 20 years ahead)
- Snap shot analysis

Dynamic network models



- Detailed network description is given
- Real-time to near term (up to a few years ahead)
- Dynamic analysis following a contingency event (mill-second to a few minutes)

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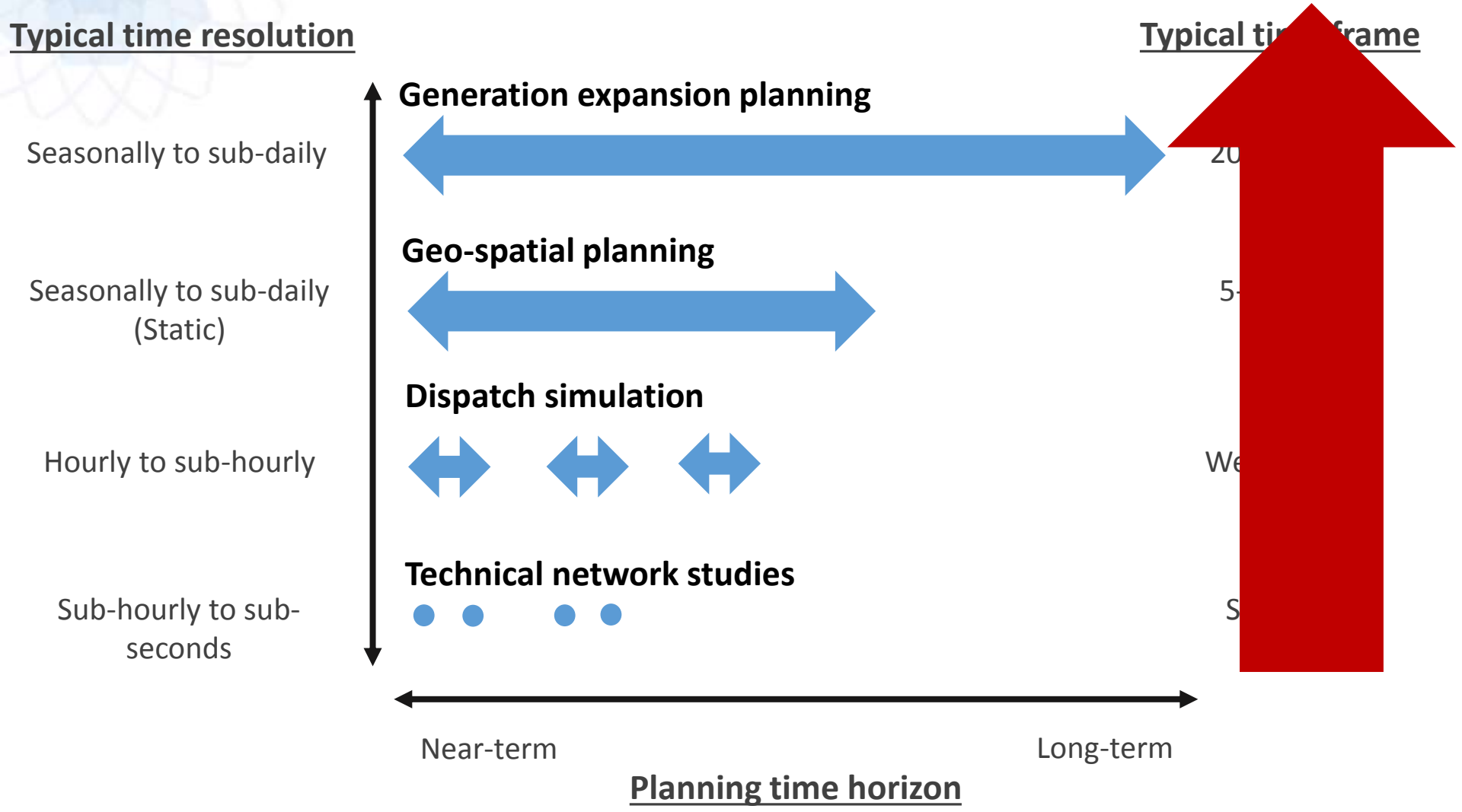
Time dimensions of power sector planning



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

Modelling software – indicative coverage

MESSAGE

MARKAL/TIMES

PLEXOS-LT

BALMOREL

Quantum GIS

ArcGIS

NEPLAN

PLEXOS-ST

Power Factory

Grid-View

PSSE

OPT-GEN

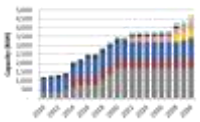
WASP

GT-MAX

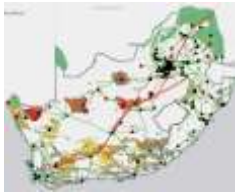
SDPP

WASP

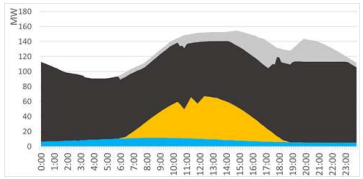
GT-Max



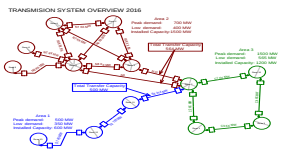
Cap expansion



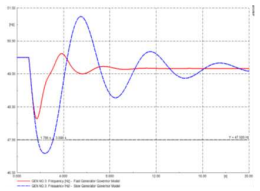
Geo-spatial



Dispatch

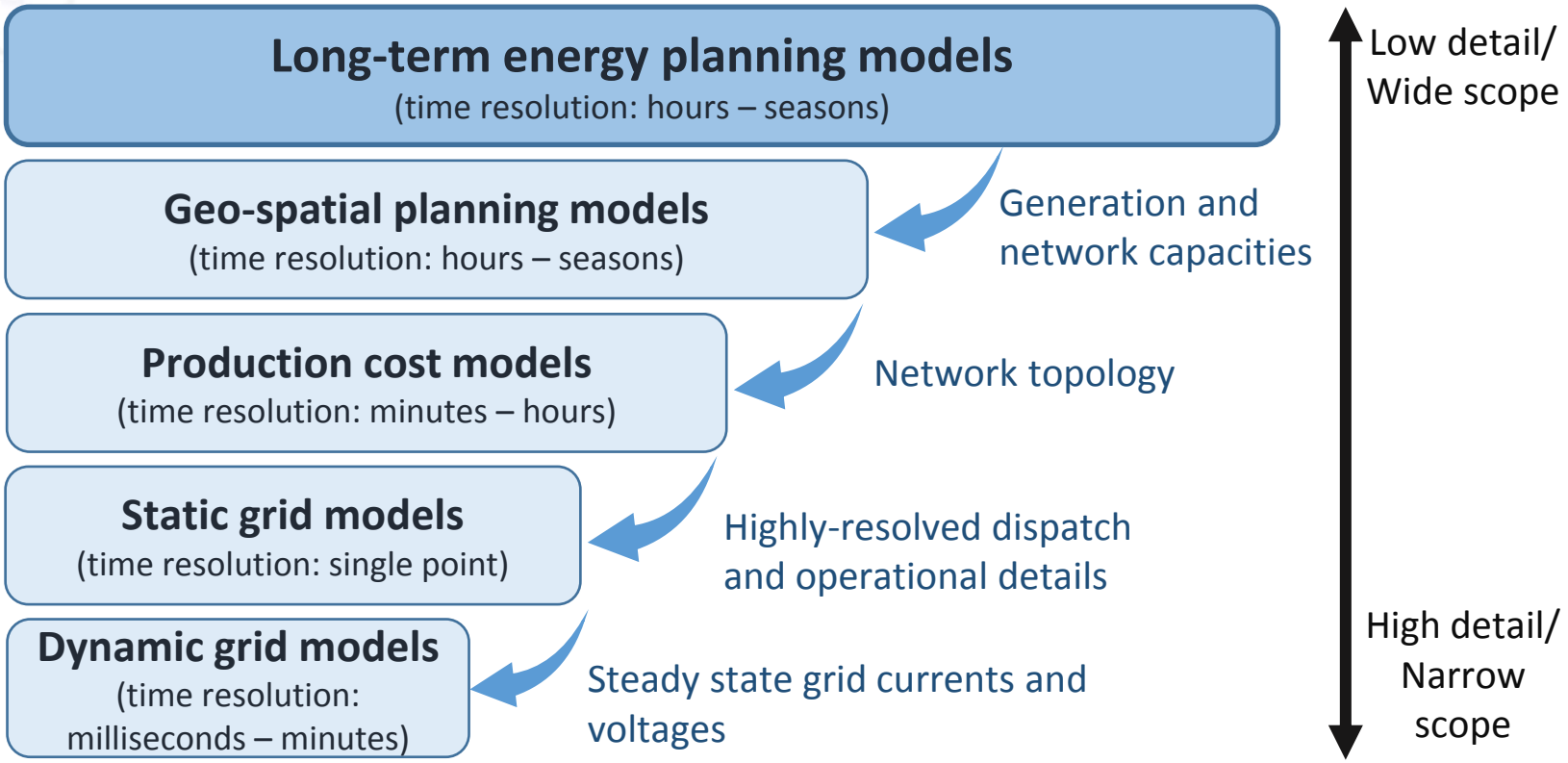


Static



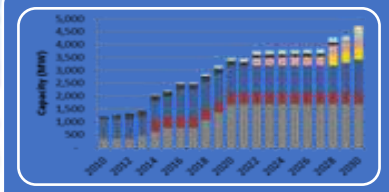
Dynamic

Planning tools



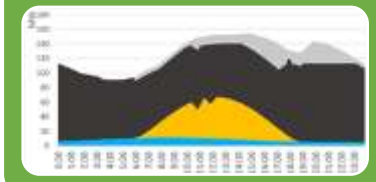
Source: IRENA (2017), Planning for the Renewable Future: Long-term modelling and tools to expand variable renewable power in emerging economies

Typical data requirements

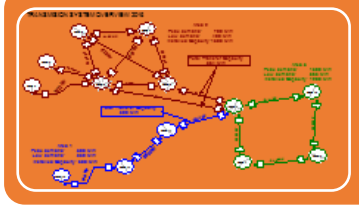


Demand, demand profile
Technology costs, technology operational characteristics, fuel prices, resource availability

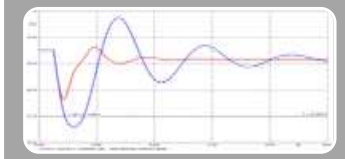
Meteorological information
Site specific demand profile



Capacity mix, network topology
Detailed load profile and technology characteristics



Detailed network topology, and technical characteristics
Demand at each node
Operational procedure and technical regulation



Protection system settings
Units providing primary/governor control

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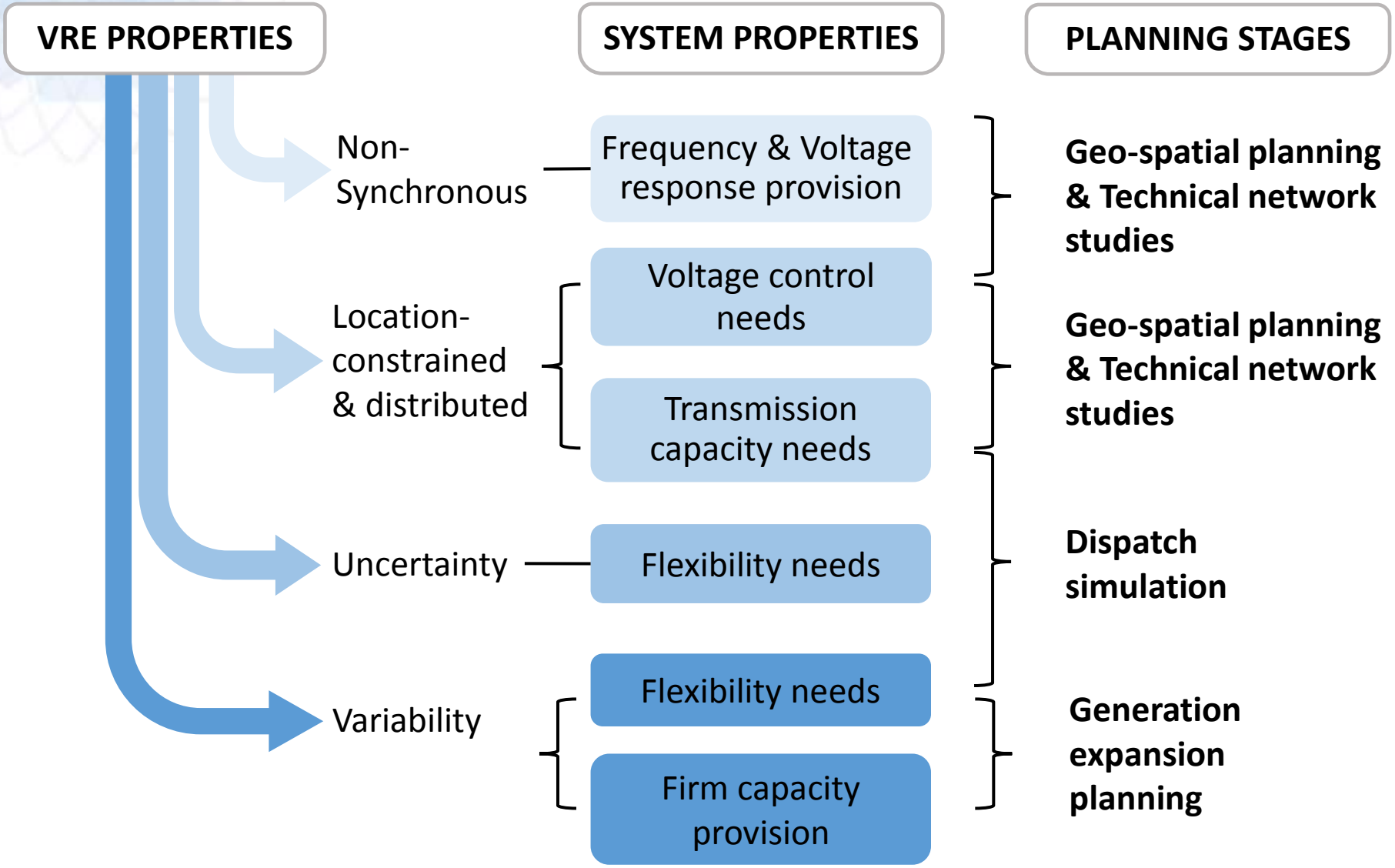
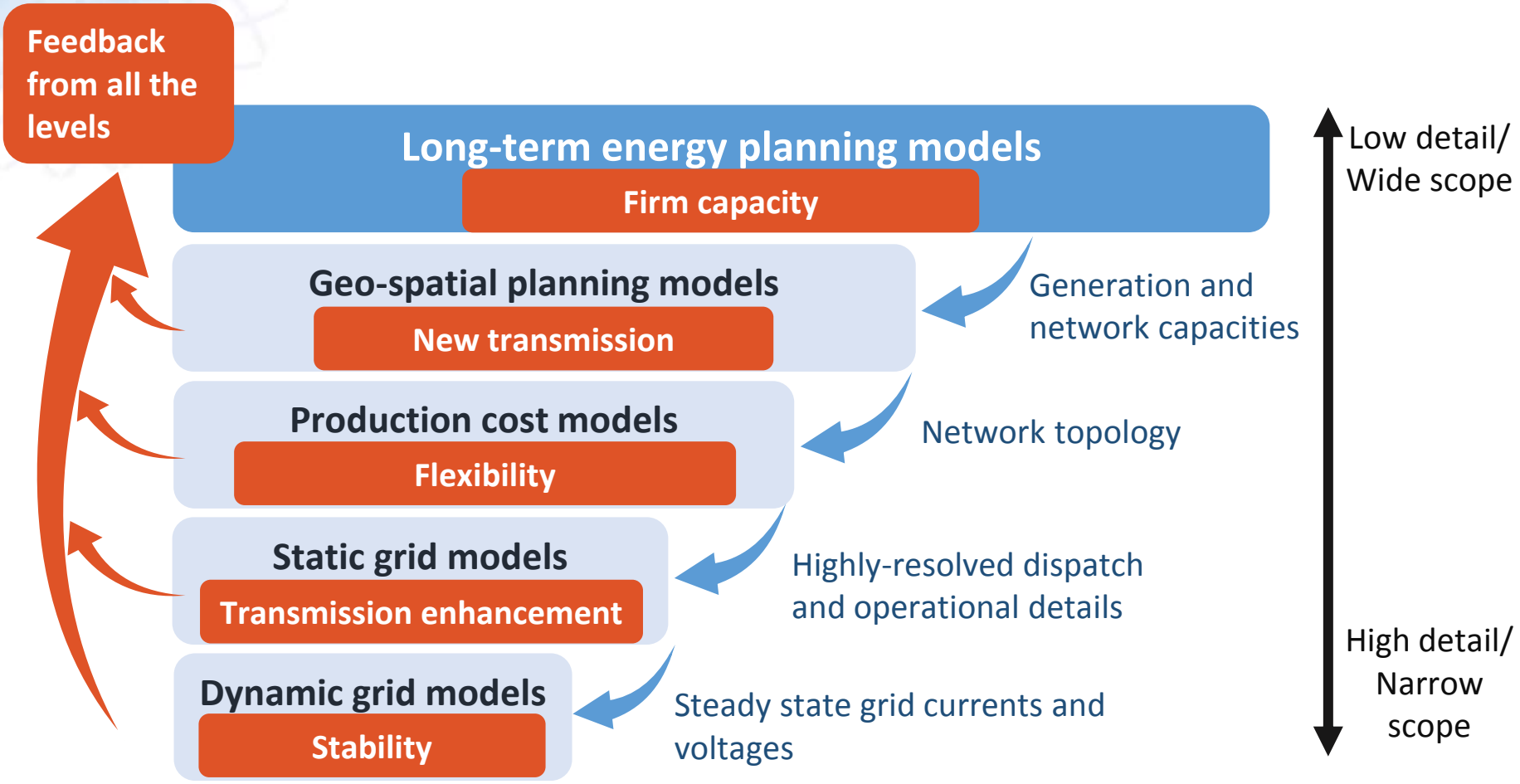
VRE in the planning process



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

With variable renewable energy...



Key elements of the subsequent steps can be pre-analyzed in a simplified manner

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

Two methodological guides from IRENA

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International Renewable Energy Agency

Long-term energy planning models
(time resolution: hours – seasons)

Geo-spatial planning models
(time resolution: hours – seasons)

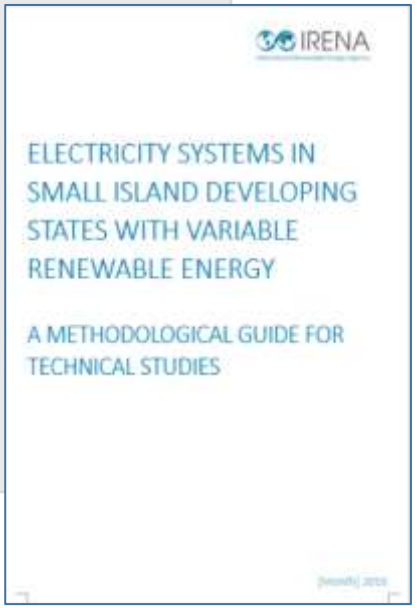
Defining long-term capacity mix and transmission infrastructure

Production cost models
(time resolution: minutes – hours)

Static grid models
(time resolution: single point)

Dynamic grid models
(time resolution: milliseconds – minutes)

Grid integration studies for a given capacity and transmission infrastructure



Grid integration studies – IRENA experience

Purpose

Limits to the secure and reliable integration of VRE in to the existing grid

Network expansion measures and operational strategies to permit more VRE

Technical requirements for the connection of RE technologies to the electricity grid

Operability

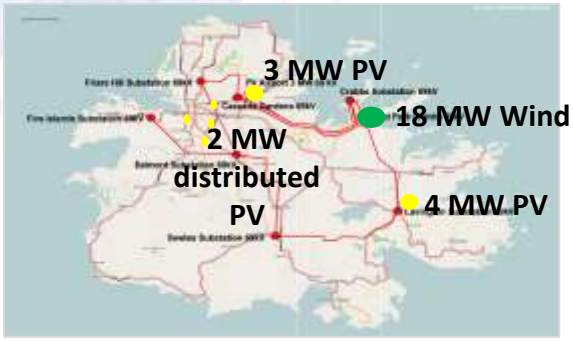
Frequency

Spinning reserve requirement
More ramping
Reduces system inertia

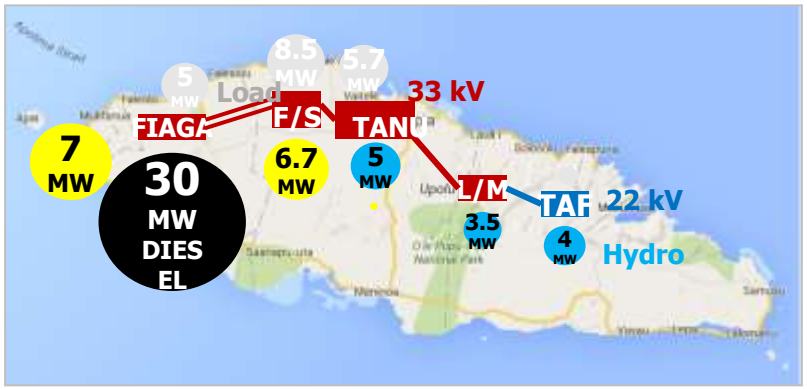
Voltage

Enhanced reactive power support

Grid integration studies – IRENA experience



Antigua



Samoa

Palau, Dominican Republic, Panama, etc

Focus on grid stability analysis and expanding to grid operation planning

- Solutions for the integration challenges are known. How much VRE can be deployed is economic question rather than technical question.
- Implementation of solutions is a matter of careful planning, understanding the implications for each particular system.
- Mistakes in long-term planning results in more expensive near-term solutions

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Conclusion

It is important to do it right from the beginning!

How?

- Improve long-term energy planning modeling methodologies by incorporating key VRE features
- Coordinated planning across planning bodies

IRENA's country support programme offers country specific planning support

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