SYSTEM PLANNING WITH SOLAR ENERGY

FEBRUARY 4, 2019

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ESMAP
Energy Sector Management Assistance Program

Outline

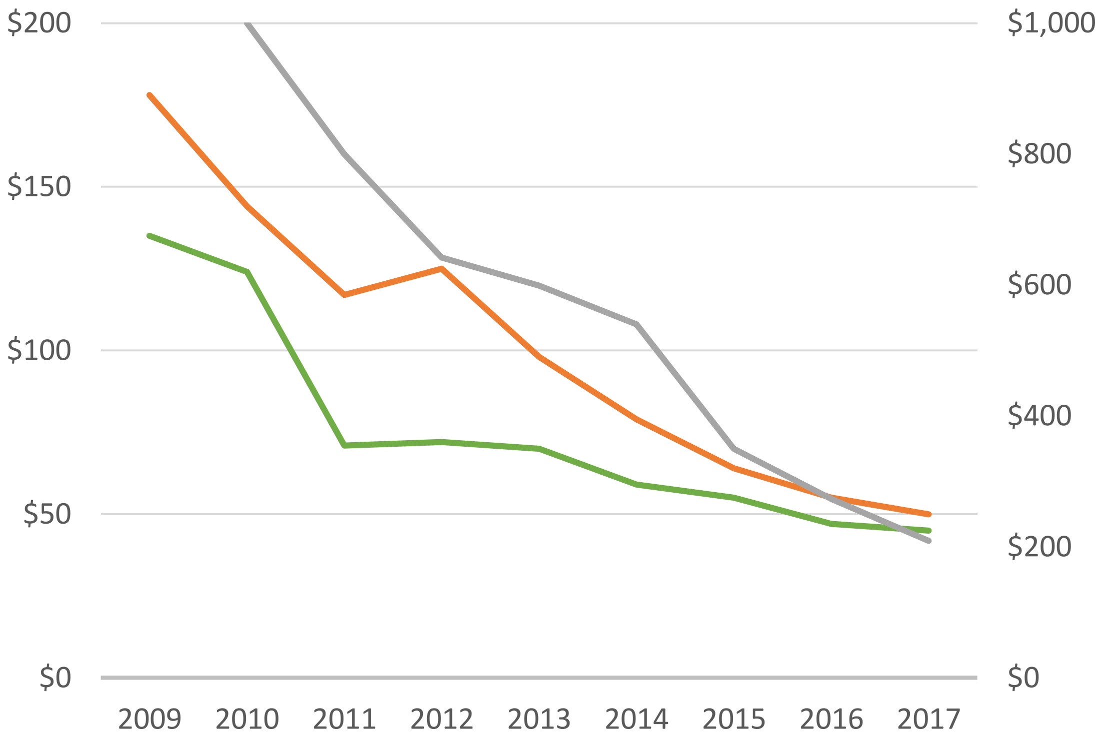
- ✓ Race between cost and value with high shares of renewables.
- ✓ Importance of planning to “get it right” with the renewable amount.
- ✓ Ingredients of planning with renewables.
- ✓ Evolution of planning models.

Solar PV Boom

- ✓ Costs of solar PV below USD 1/Wp.
- ✓ High capacity to displace fossil fuel generation (high economic savings, high CO_2 emissions reductions).
- ✓ Short deployment period.
- ✓ Easy to install and maintain.
- ✓ Modularity.
- ✓ Some project risks can be mitigated (e.g., WBG financial solutions).

Wind, solar and battery costs plummet

Levelized cost of wind and solar ($/MWh)



Lithium-ion battery pack costs ($/KWh)

Total cost declines

Solar $/MWh -72%

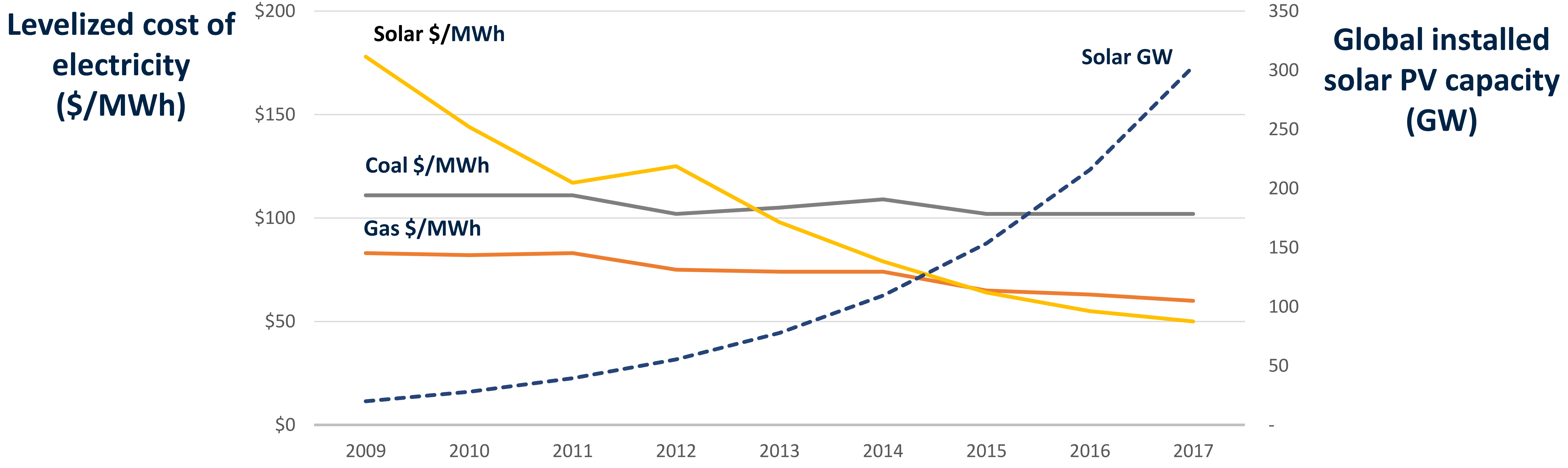
Wind $/MWh -67%

Li-ion packs $/KWh -79%

Data Source: Wind and solar levelized costs from Lazard. Battery pack costs from Bloomberg New Energy Finance

The mental model

A race to beat fossil fuels on cost…



Data Source: Lazard (2017), Levelized Cost of Energy 2017, https://www.lazard.com/perspective/levelized-cost-of-energy-2017/.

A flawed model?

Marginal value of PV decreases: PV is worth as much as the fuel being saved, and at high PV capacities, most of the fuel has already been displaced.

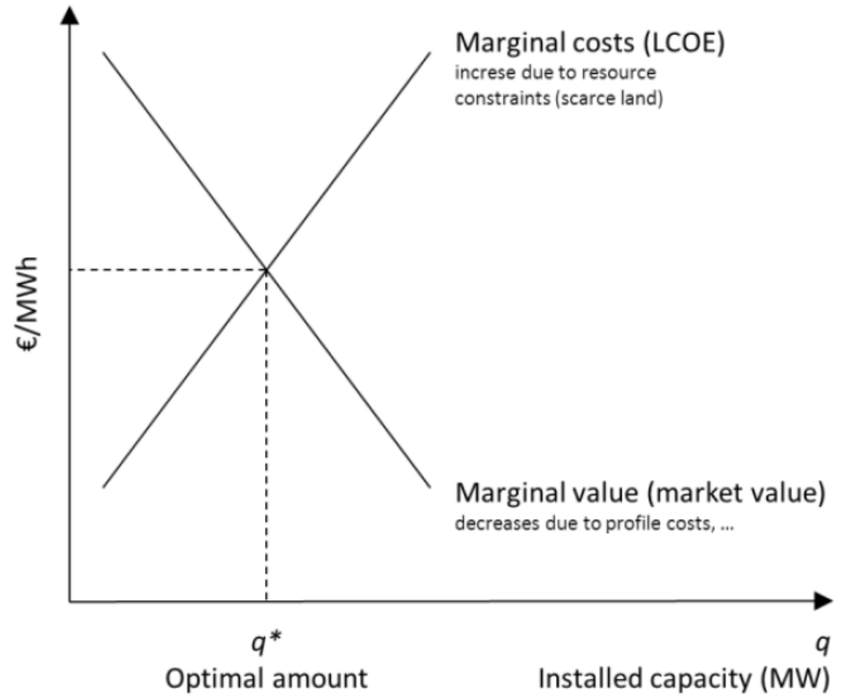
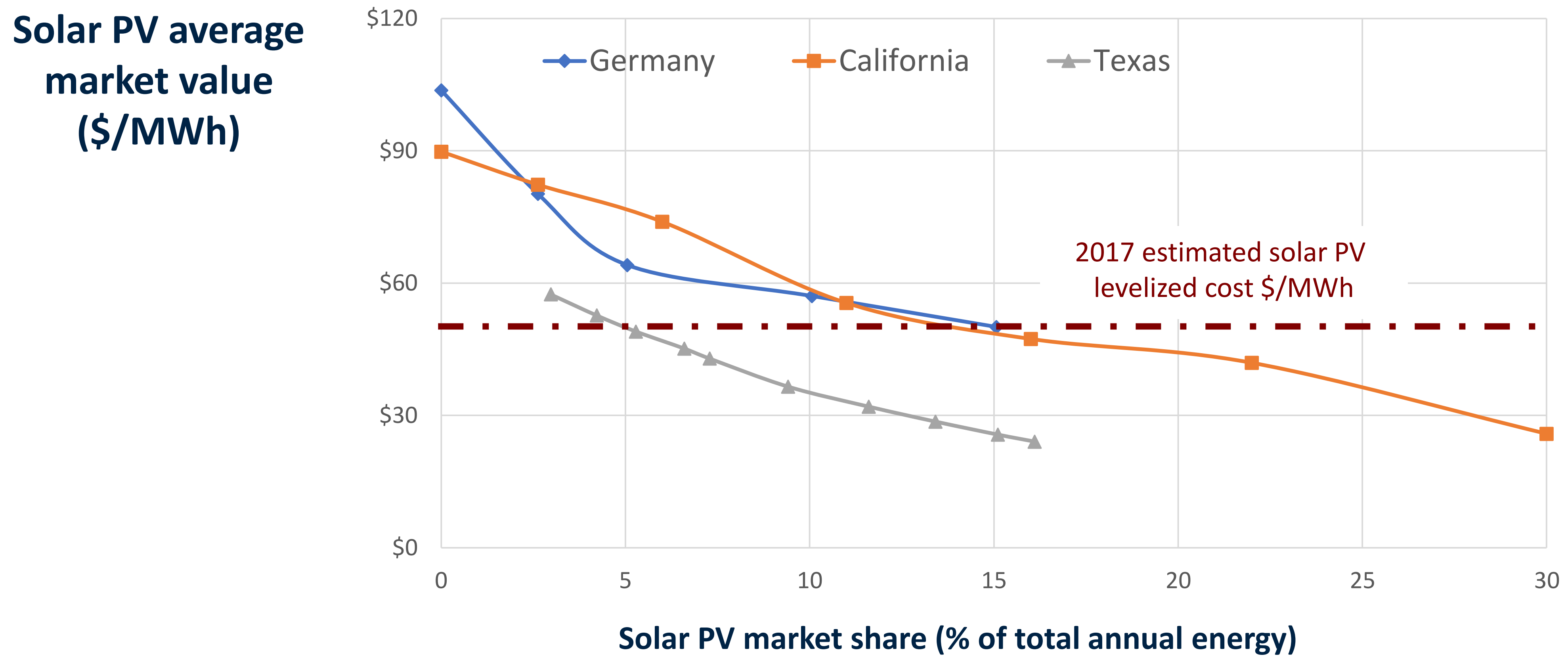


Figure 3. The intersection of long-term marginal costs (LCOE) and the market value gives the optimal amount of VRE (Hirth 2012b).

A race against declining value

...technology cost has to decline faster than the decline in value



Germany (Hirth, 2013)

California (Mills & Wiser, 2012)

MIT Future of Solar Study (2015)

Data Source: Sivaram & Kann (2016), Solar needs a more ambitious cost target, *Nature Energy* Vol. 1 (April 2016).

How can we preserve the value with large shares of PV?

GREATER FLEXIBILITY

- ✓ Energy storage
- ✓ Demand response
- ✓ Interconnections
- ✓ Power plant flexibility

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SOUND PLANNING

- ✓ What is the “right” amount of solar that we can deploy?
- ✓ When should new solar auctions be planned?
- ✓ How much solar can be exported/imported?
- ✓ How resource profile matches up with other renewables?
- ✓ How much battery capacity do we need to install?

Why is "planning" important?

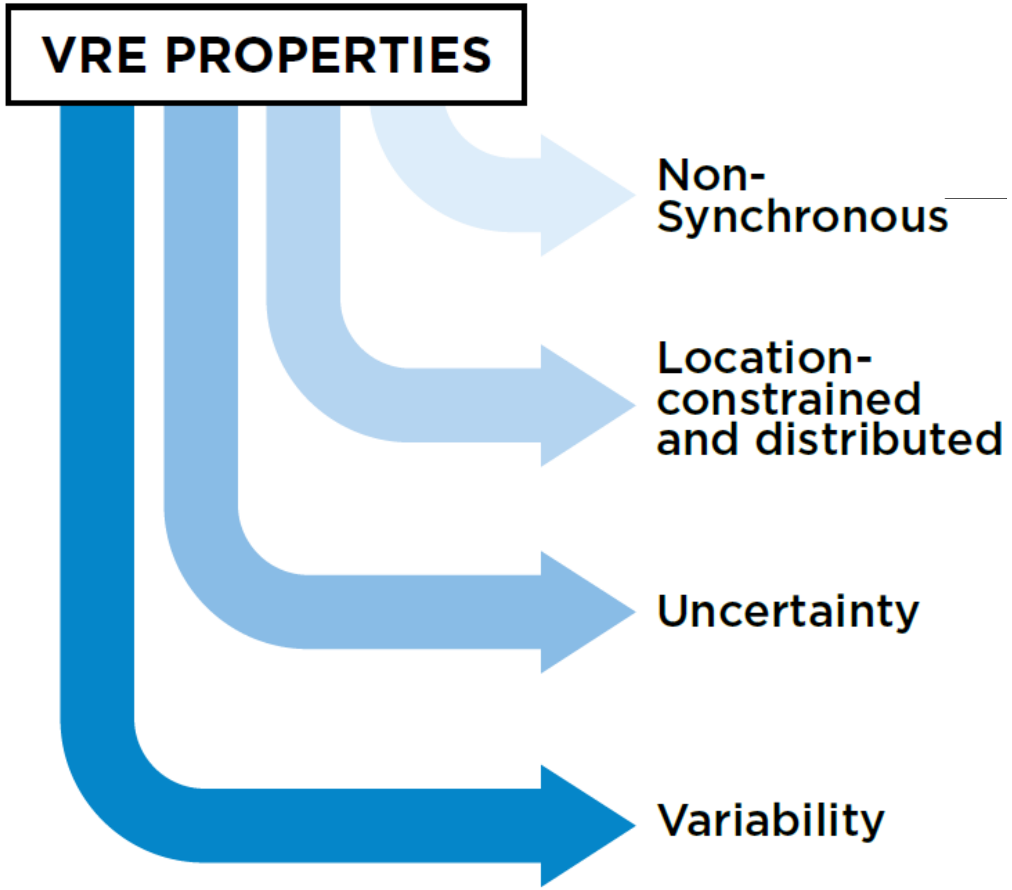
Systematic framework to assess:

- ✓ How much?
- ✓ Where (mapping)?
- ✓ When?
- ✓ How?

1. meet future electricity demand
2. minimize cost to consumers, c$/kWh
3. guarantee the stable operation of the system
4. comply with environmental standards

Planning for VRE

Key links between variable renewable energy, power system properties and planning



Source: "Planning for the Renewable Future", IRENA (2017)

Planning for VRE

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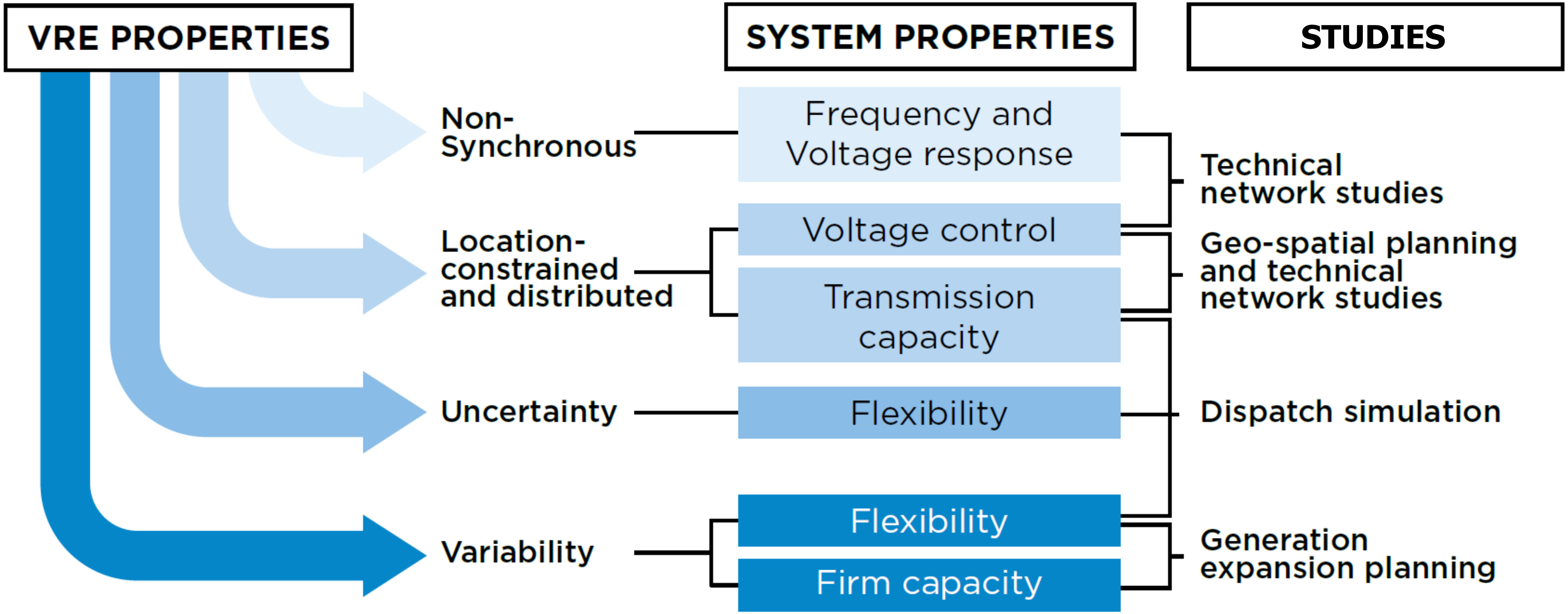
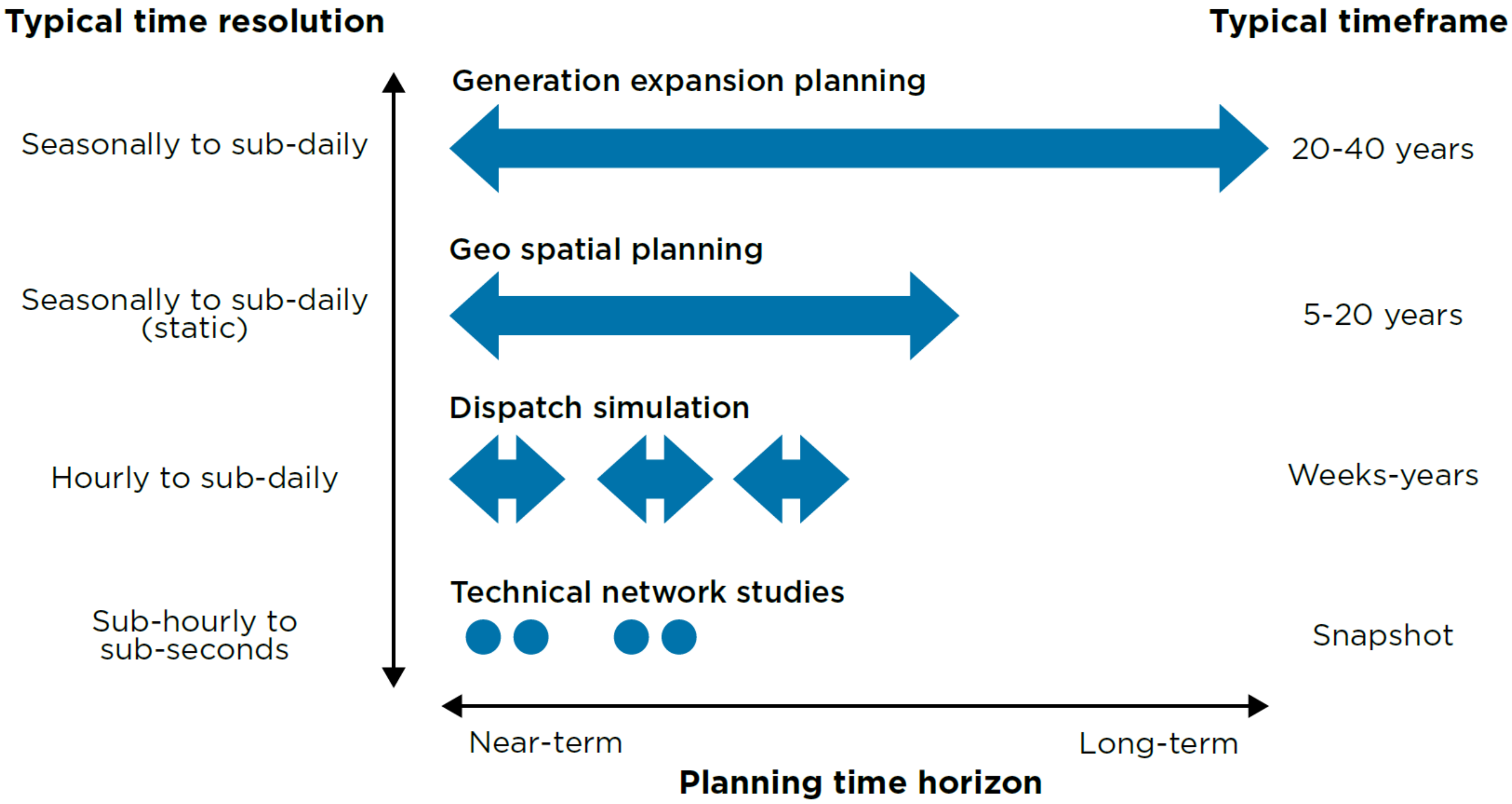


Source: "Planning for the Renewable Future", IRENA (2017)

Planning for VRE

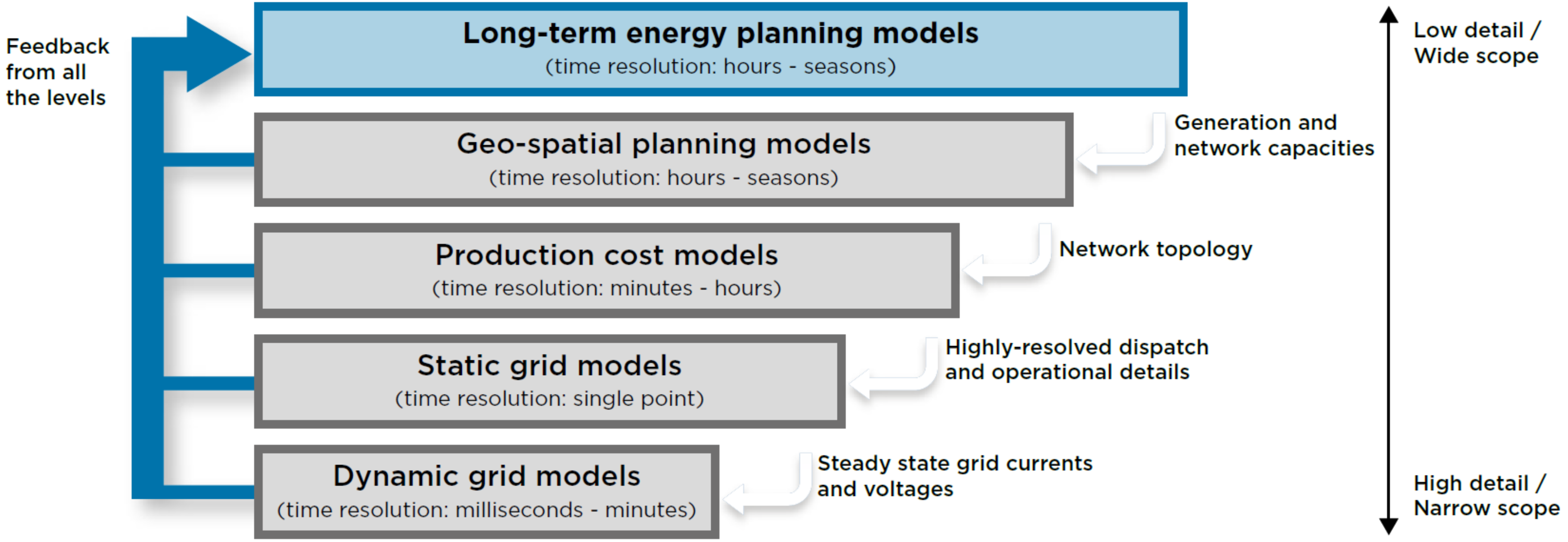
Transition planning components and time horizon



Source: “Planning for the Renewable Future”, IRENA (2017)

Planning for VRE

Tools and analyses for energy system planning with feedback



Source: "Planning for the Renewable Future", IRENA (2017)

Latest trends in long-term energy planning

Planning models have been in constant evolution to adapt to new challenges (e.g., hydro uncertainty, renewable intermittency, optimize storage):

- 1970's – Screening curves: Originally planning analyses were solely based on economics.
- 1990's – Dynamic programming: to reflect **hydro uncertainty** in planning analyses with low-time resolution (blocks).
- 2010 – Hourly resolution: planning models with dispatch constraints, accounting for **hourly variability** of renewables and reserve needs to optimize thermal capacity.
- 2016 – Joint optimization of renewables and thermal capacity to estimate optimal penetration levels.
- 2018 – Integrated planning: with renewables, batteries, hydro and network constraints (large dimensionality!)

Where is the limit?

Long-term planning models are limited by their **dimensionality** and **computational capacity**

"Short blanket theorem"

... and usually two or more blankets are needed.

Typical inputs and outputs in models for VRE planning

input

- wind resource historical hourly availability
- solar resource historical hourly availability
- demand historical hourly data & growth expectation
- topology and thermal limits of the transmission lines
- fixed and variable cost of generating technologies
- flexibility options available (hydro, storage, DSM, etc)

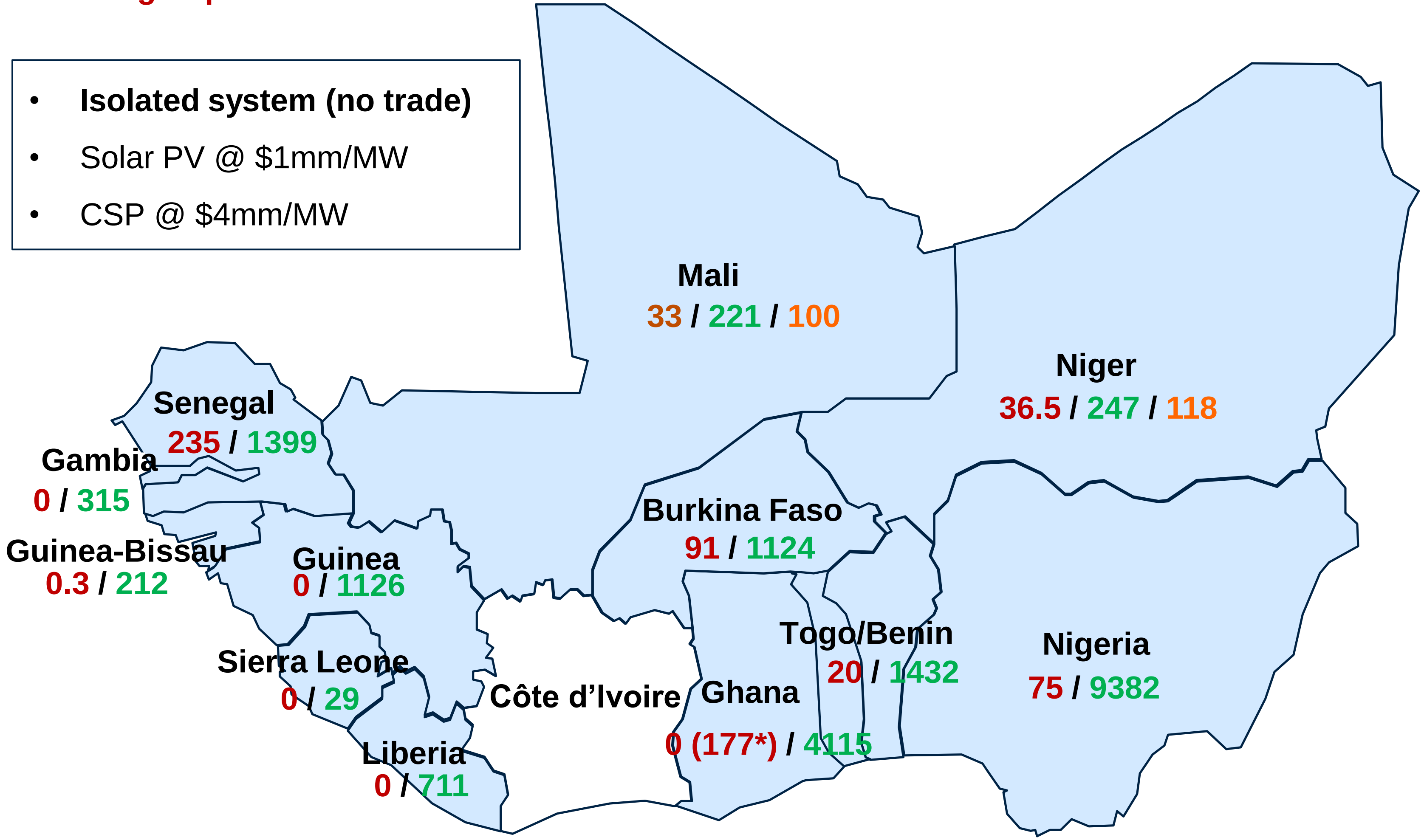
output

- optimal generation investments
- capacity factor of individual technologies
- energy contribution of individual technologies
- system carbon emissions
- wholesale prices
- energy traded among zones

Example: regional planning in WAPP

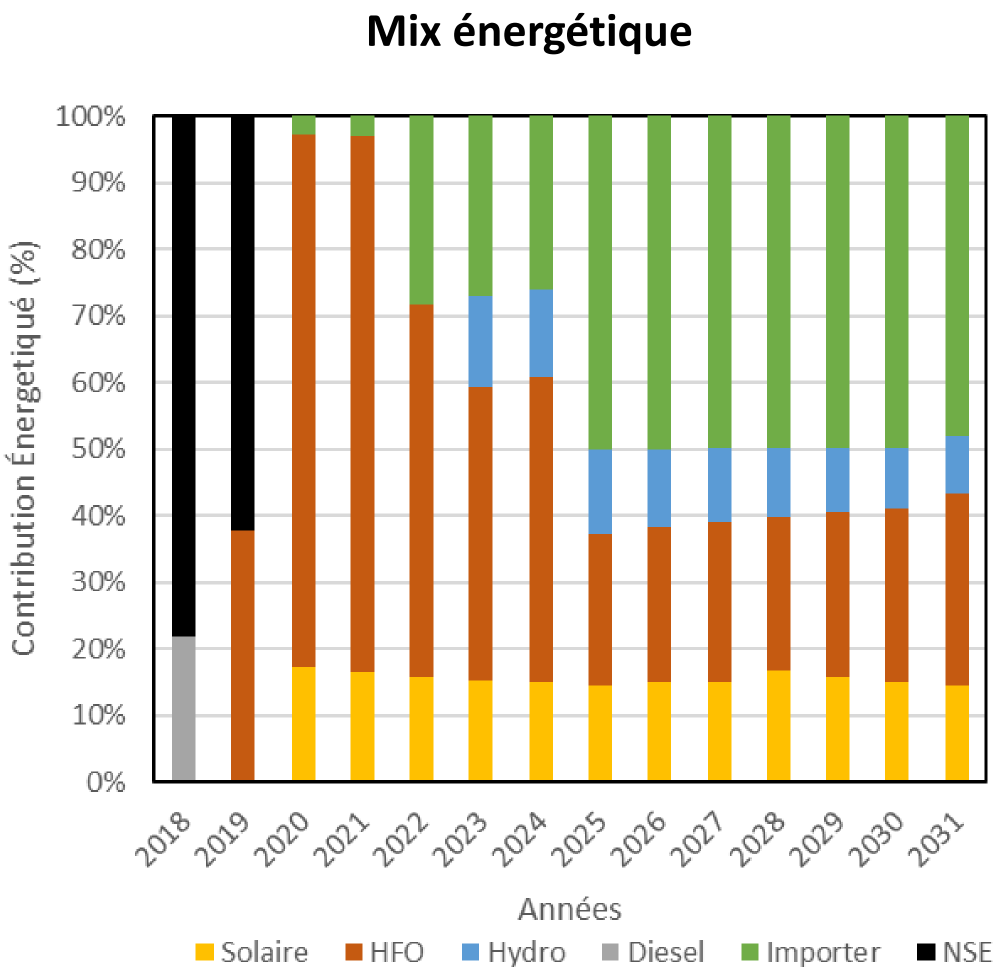
PV existing or planned / PV new / CSP new

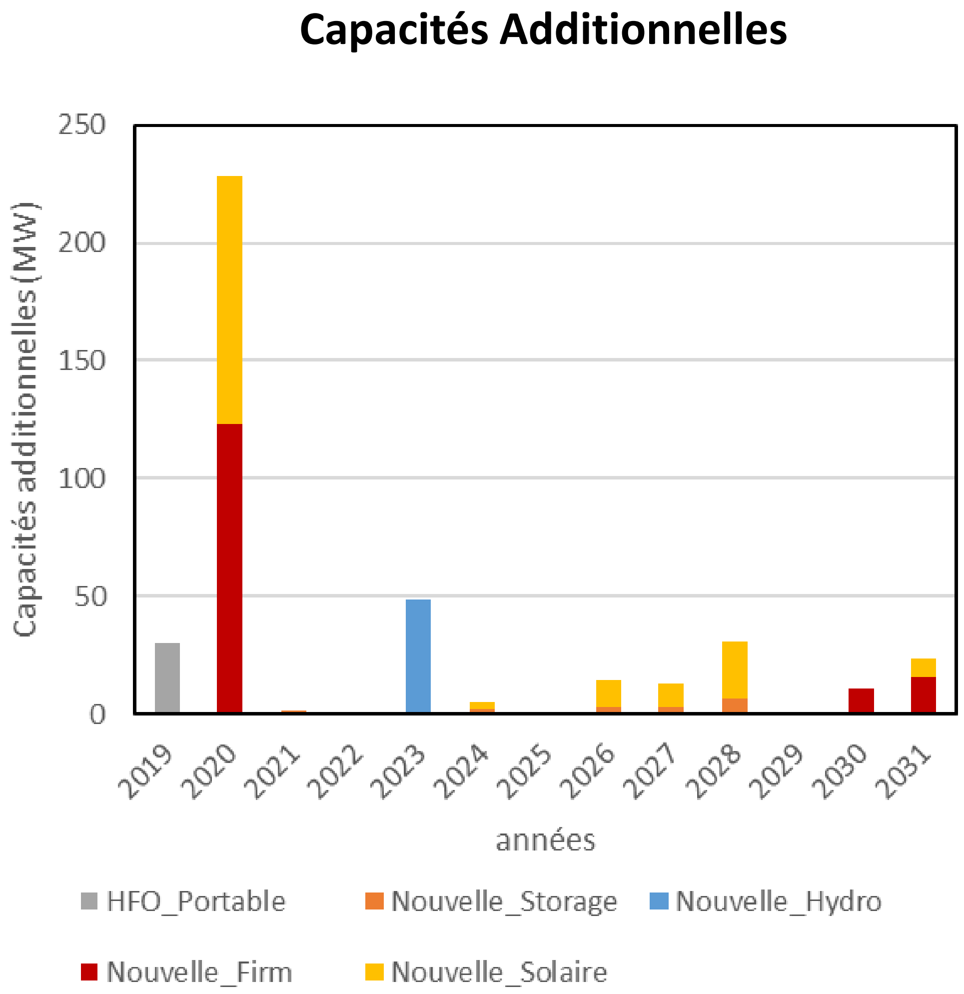
- **Isolated system (no trade)**
- Solar PV @ $1mm/MW
- CSP @ $4mm/MW



Total solar capacity deployed by 2030: 21,421 MW (20,931 MW new).
CSP in Mali and Niger.

Example: solar planning with battery storage





Conclusions

- ✓ It is not only about the **cost** of a technology, it is also about the **value** that it brings.
- ✓ Long-term planning is important to install the "right" amount of solar (and other technologies) and **minimize the cost paid by consumers**.
- ✓ Different planning tools can address different aspects of **grid integration**.
- ✓ Solar, storage and other new technologies bring new challenges to planning (variability and uncertainty), but **models are evolving** to address these challenges.

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