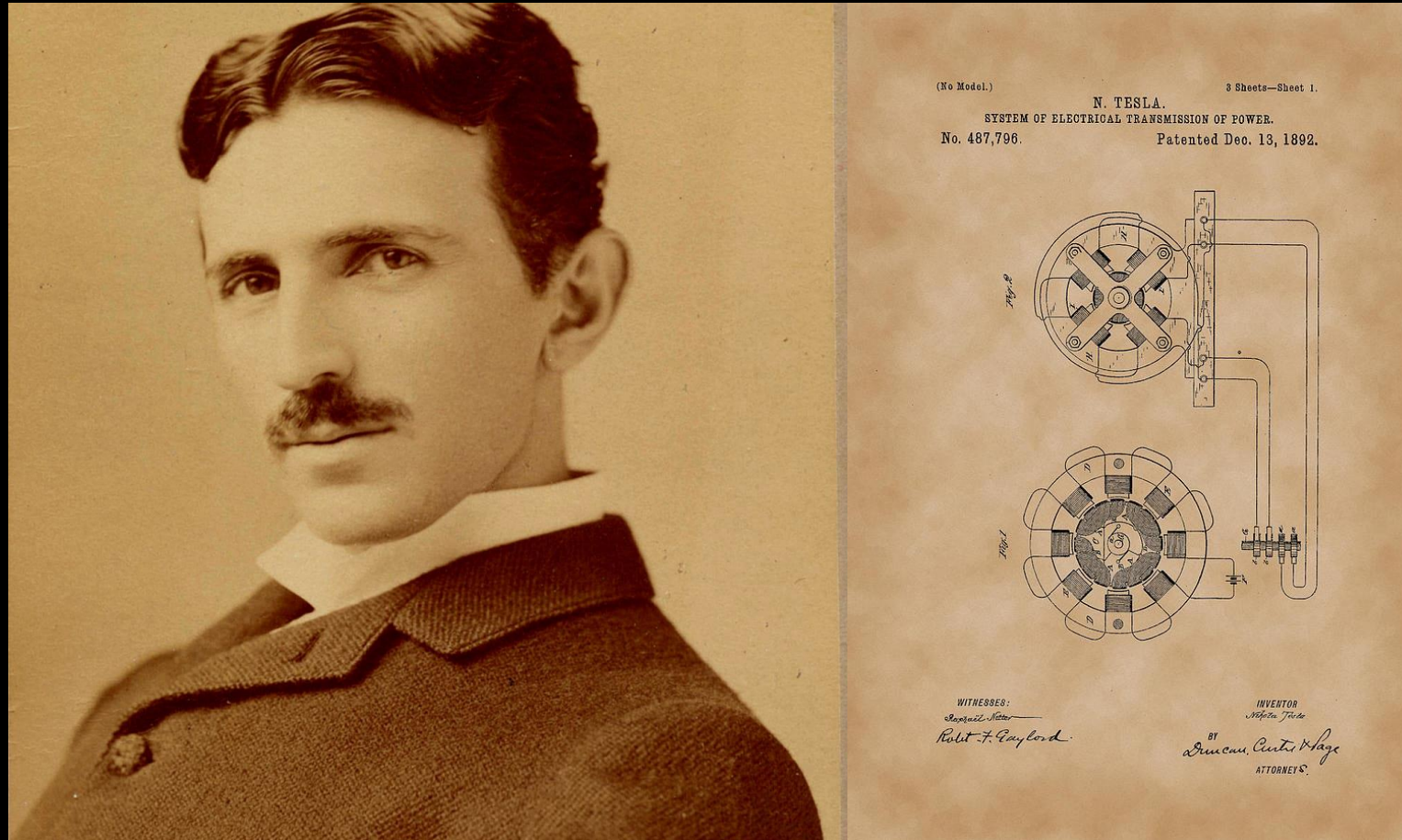


TODAY is the

130th

Anniversary of...

On December 13, 1892 Nikola Tesla patented the
”system of electrical transmission of power”



The Worst of Europe's Energy Crisis Isn't Over
A few degrees Celsius is all that stands in the way of regional blackouts.



NY creeps back to light
Could outage happen here? It's possible



Advice for Europeans: Bundle Up and Get Ready for Outages

The New York Times
POWER FAILURE BLACKS OUT NEW YORK;
THOUSANDS TRAPPED IN THE SUBWAYS;
LOOTERS AND VANDALS HIT SOME AREAS
Westchester Is Also Darkened
After Lightning Hits Line



Adirondack Daily Enterprise
The big blackout of '93
Power tower topples near Malone, leaving thousands in the dark



The Herald
Energy crisis 'could lead to power blackouts in winter'

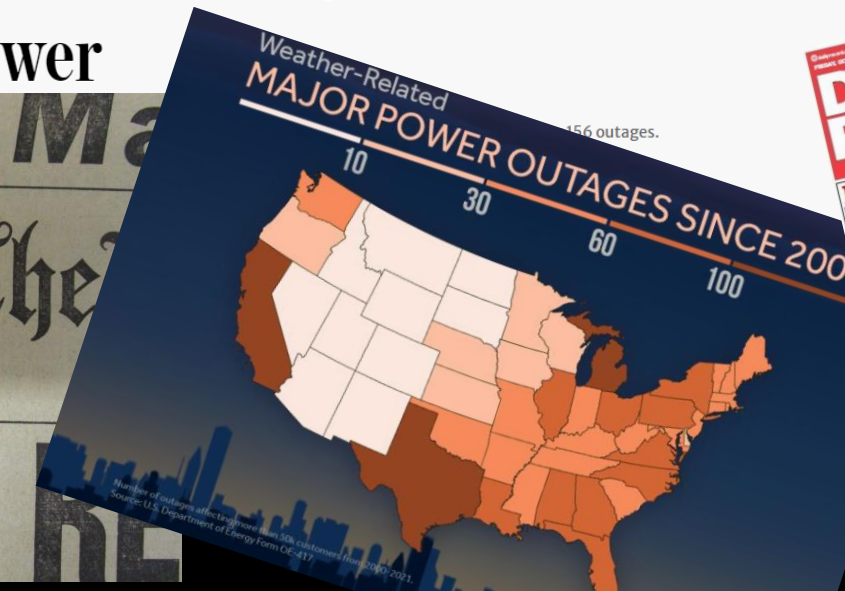


TORONTO STAR
BLACKOUT
Eves declares state of emergency and warns of rolling power outages for 'weeks to come'



Thousands of Ontarians still without power

Chicago Tribune
30 MILLION IN BLACKOUT!
N.Y. Planes, Rails, Subways Tied Up
FEDERAL STATE INVESTIGATIONS ORDERED IN GIANT POWER FAILURE



Daily Record
WIN £100k
SCOTLAND'S CHAMPION
ENERGY CRISIS BLACKOUT WARNING
Going back to the dark ages
PM refuses to act as families face 70s-style timed power cuts

Aalto University



Aalto University

Electricity market study

Niloufar Zarei, Heta Heinonen, Vittorio Casucci,
Idowu Odesanmi and Daniel Sendino



WÄRTSILÄ

Three sub- sections

1. OPERATION

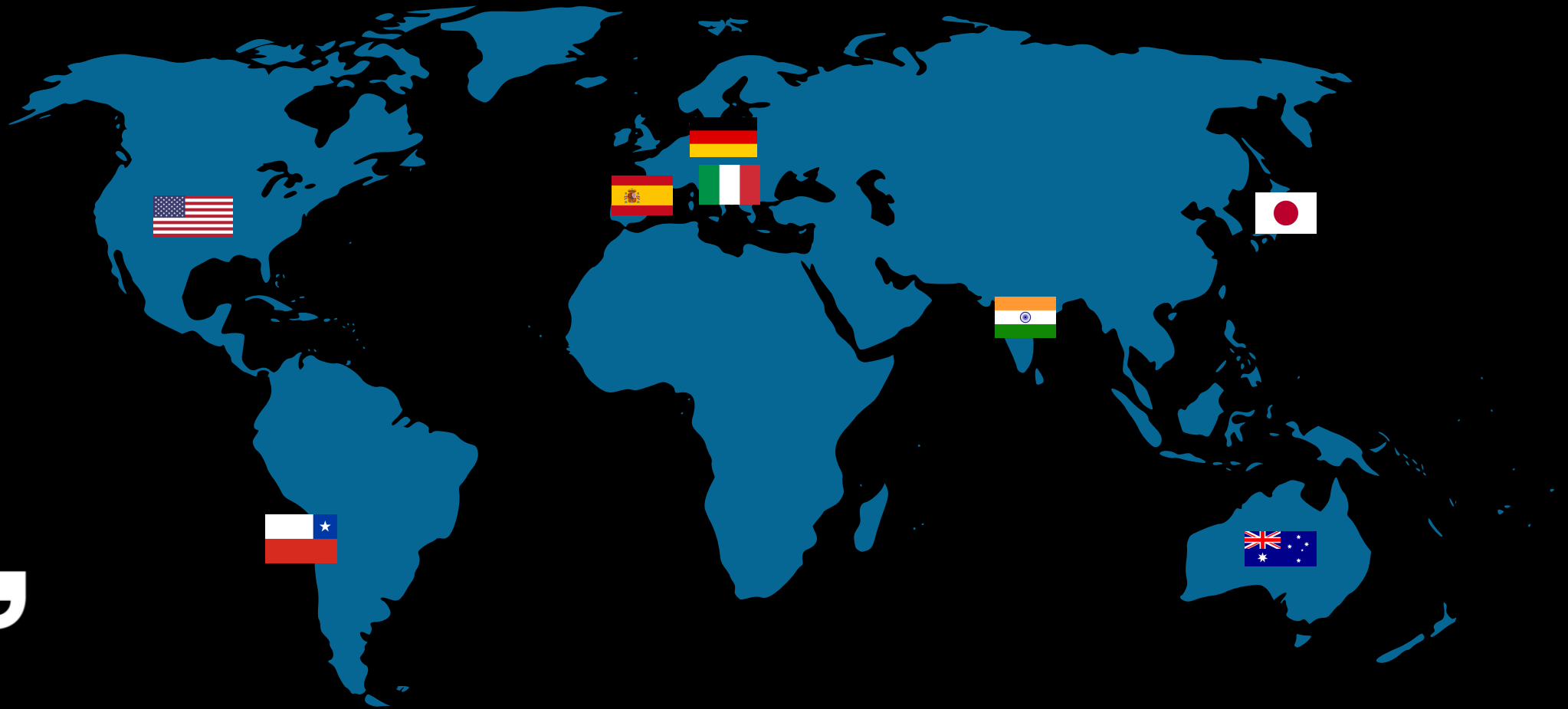
2. INVESTMENTS

3. PLANNING



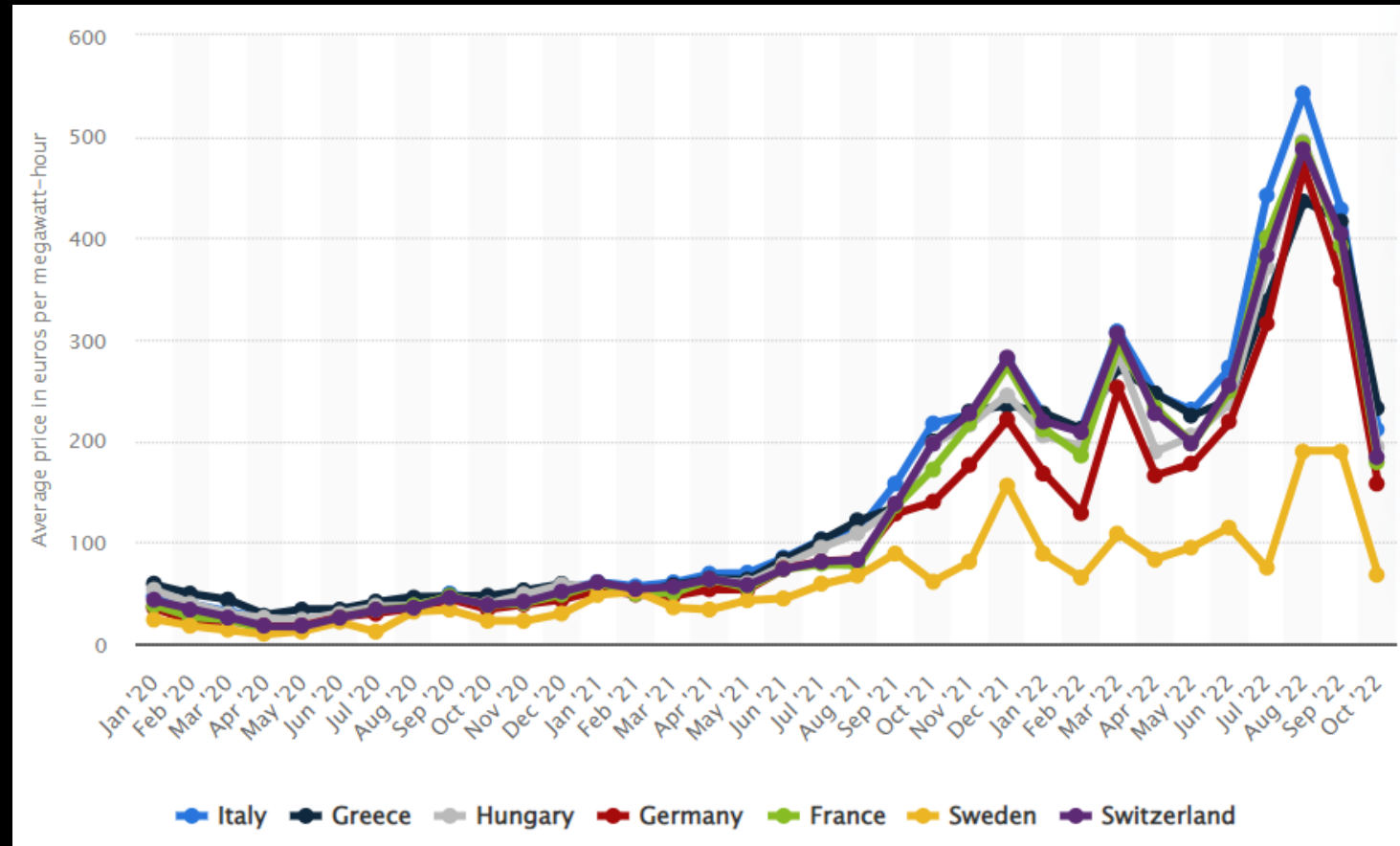
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10 jurisdictions across the world



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Average monthly electricity wholesale prices in selected countries in the European Union (EU) from January 2020 to October 2022 (in euros per megawatt-hour)



Three sub- sections

1. OPERATION

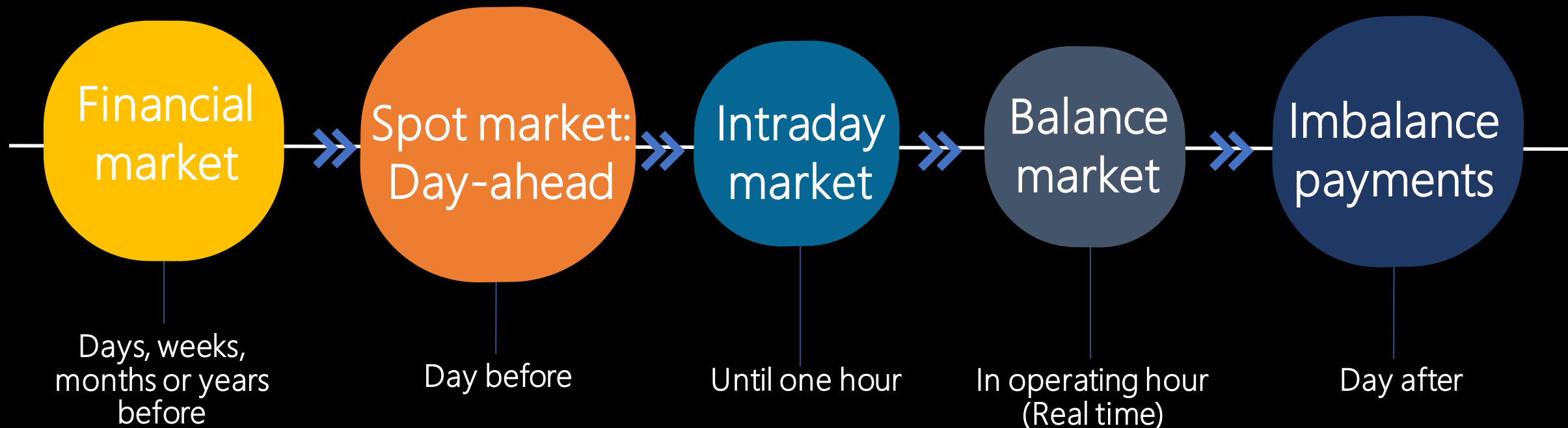
2. INVESTMENTS

3. PLANNING

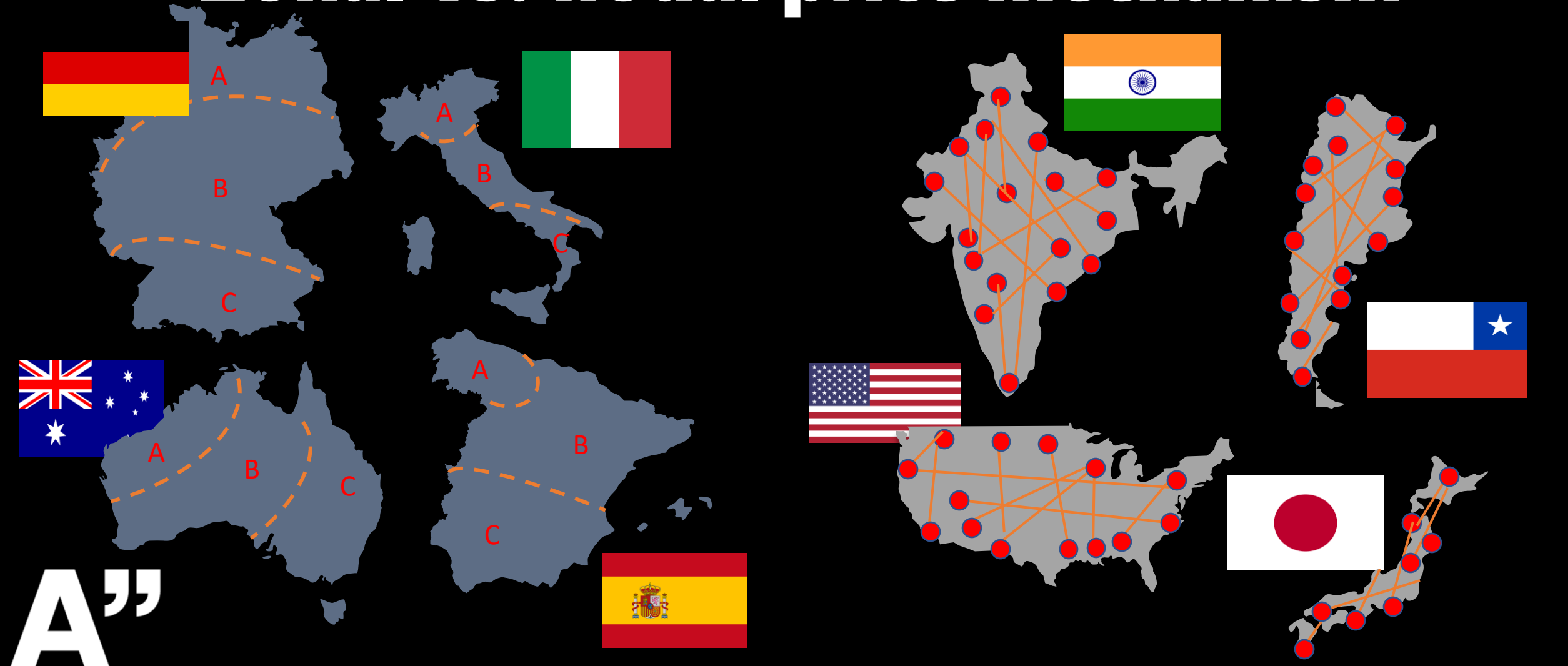


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Day-ahead & intraday **markets**



Zonal vs. nodal price mechanism



Three sub- sections

1. OPERATION

2. INVESTMENTS

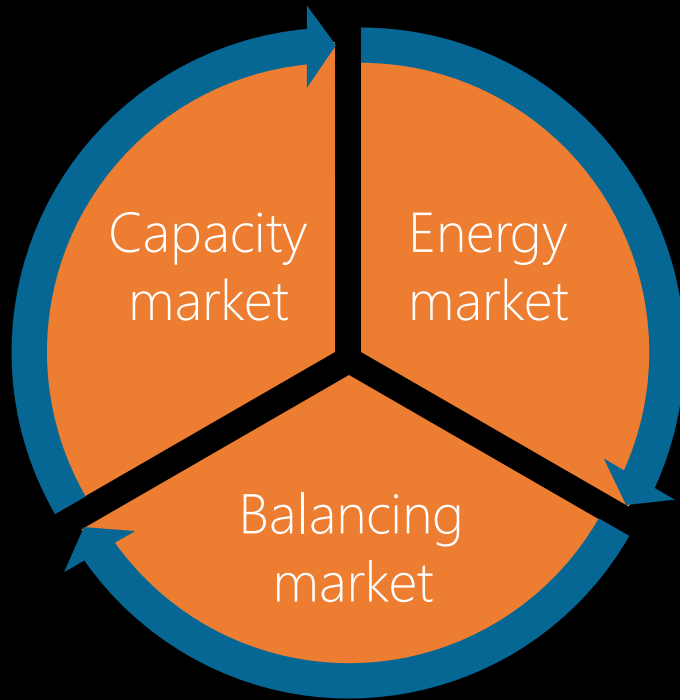
3. PLANNING



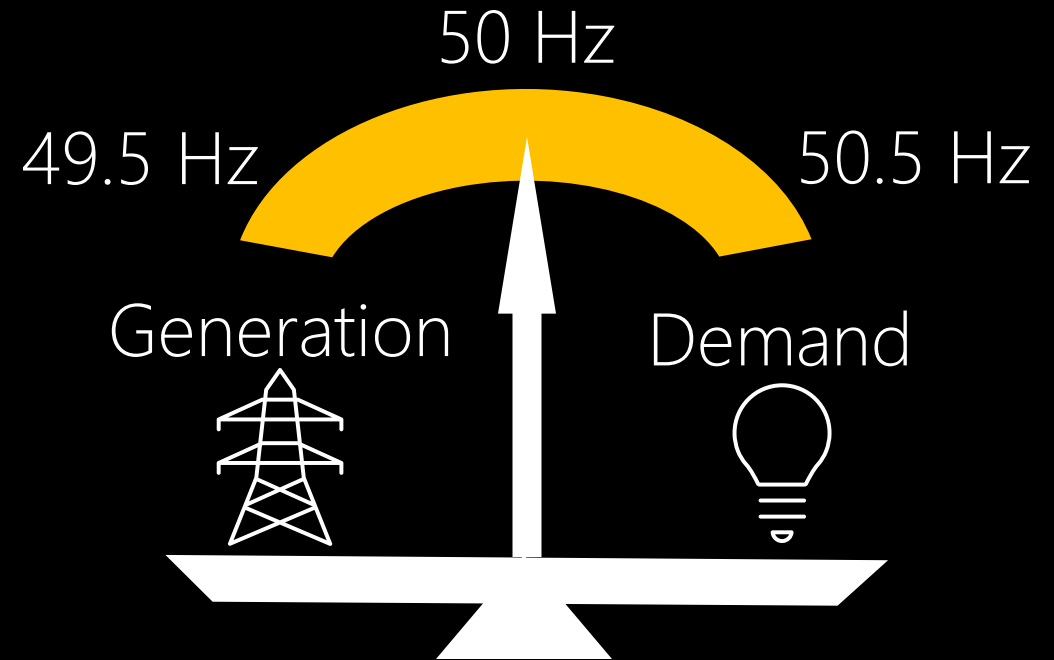
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Maintaining grid stability

- Capacity market – long-term



- Balancing market – short term

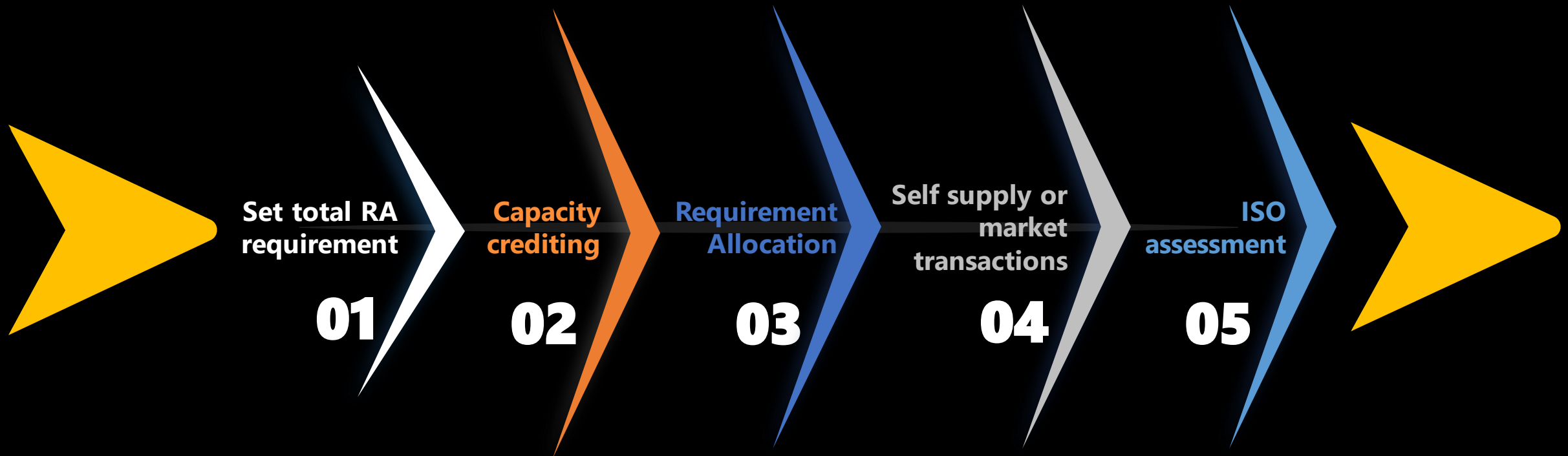


Be

aware that...

Not all jurisdictions have all these markets. For example, ERCOT does not operate a **capacity market** while PJM does

Resource Adequacy (RA) program



Three sub- sections

1. OPERATION

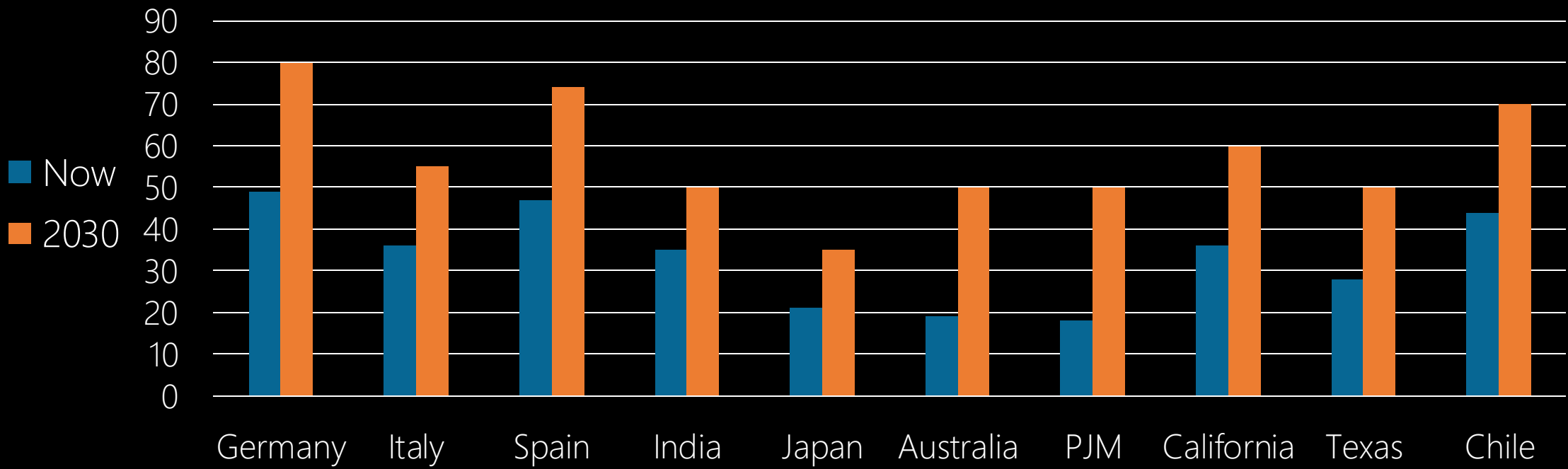
2. INVESTMENTS

3. PLANNING

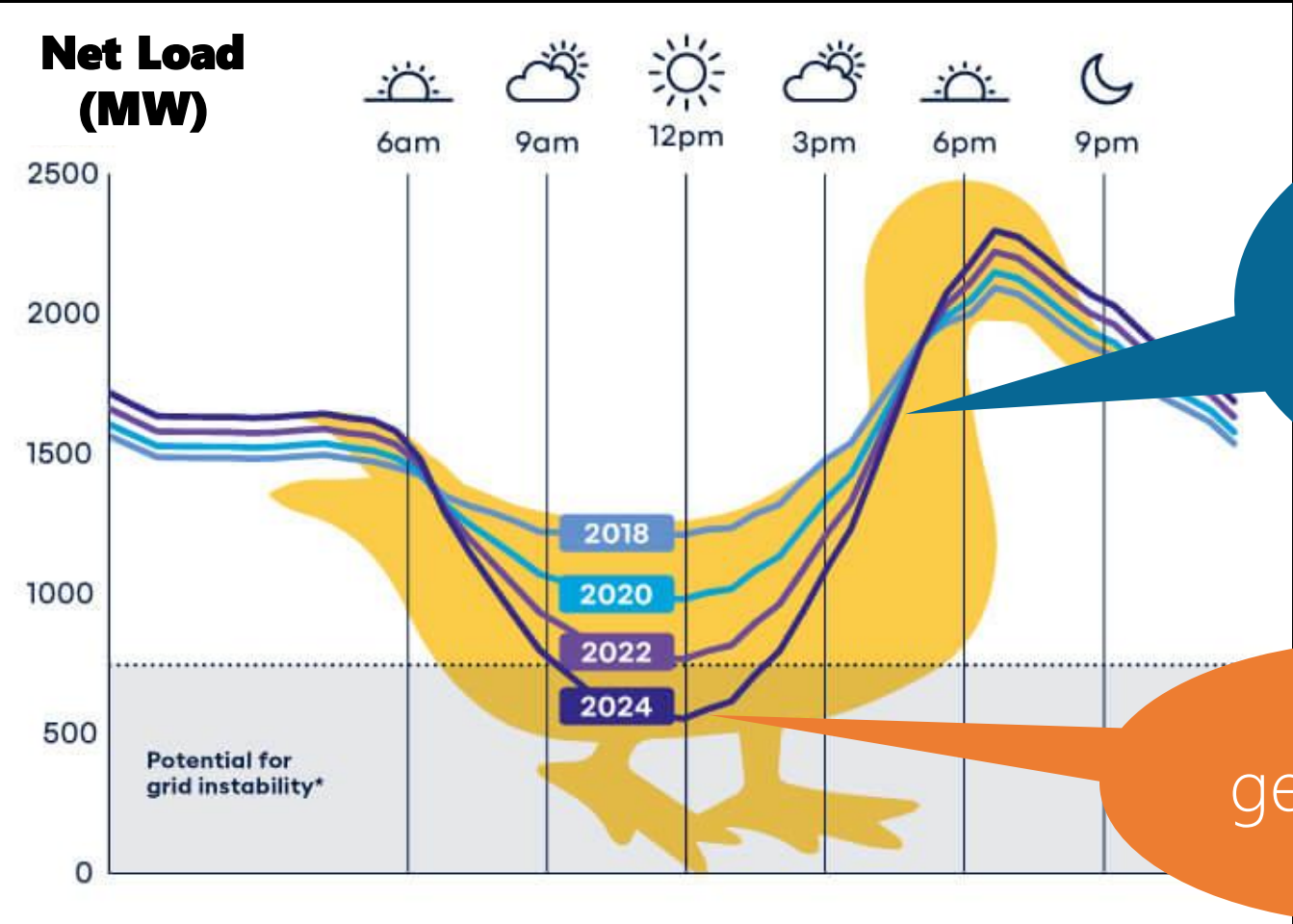


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The share of renewables



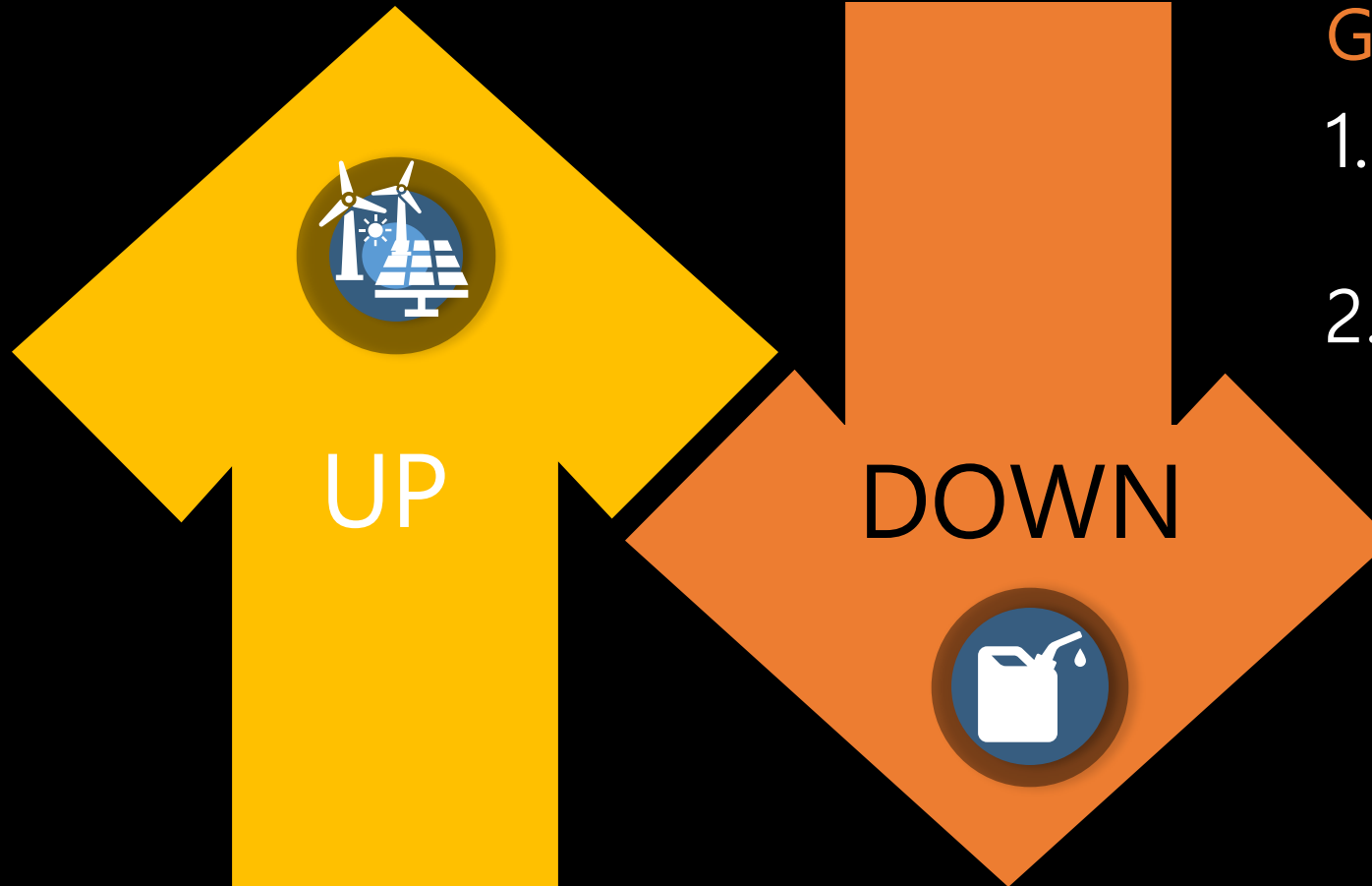
The duck curve shows overgeneration risk and steep ramping needs



CHALLENGES TO DECARBONIZE THE GRID

GRID OPERATION

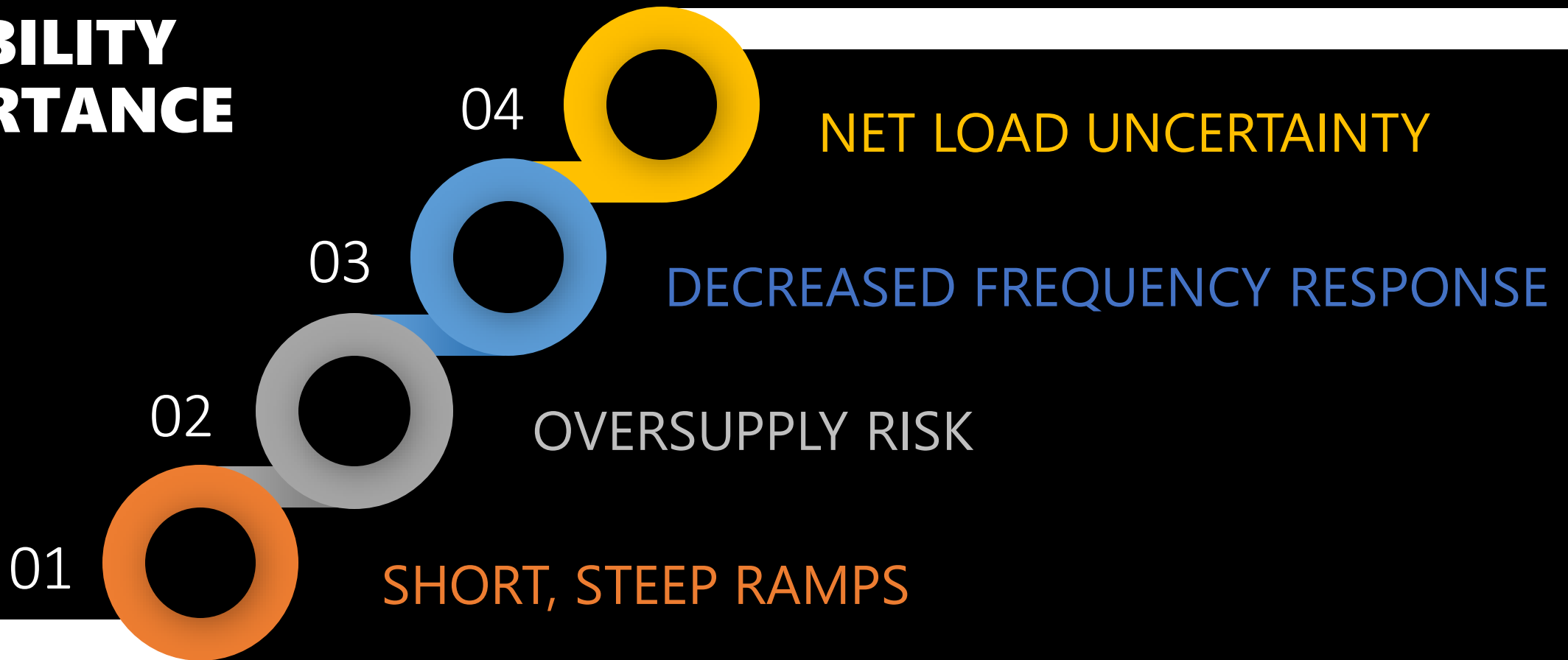
1. Handle consumer control of consumption
2. Increase share of renewables



GENERATION

1. Fossil fuel-free resources
2. Avoid overgeneration

FLEXIBILITY IMPORTANCE



A"

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Summary



Conclusions

- Electrification and renewables integration requires flexibility
- Energy-only markets with low interconnection are less resilient
- Capacity markets may not result in dispatchable generation capacity which is critical for feasible renewables integration