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Departamento de Ingeniería Eléctrica UTFSM

New ancillary services for the Chilean electricity market

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Complex Energy Systems Workshop Intelligence and Flexibility in Future Electricity Markets

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UNIVERSIDAD TECNICA
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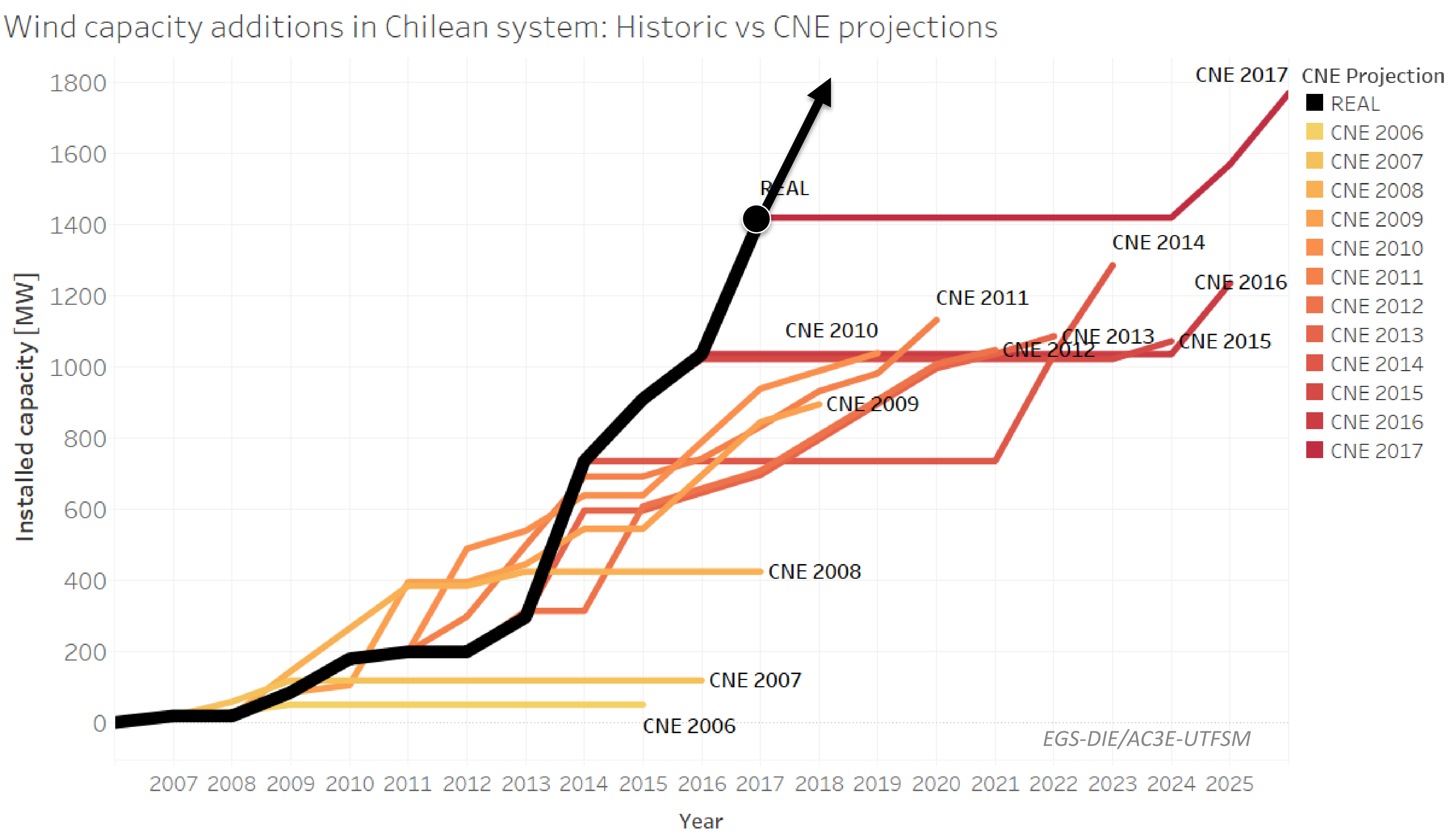
Outline

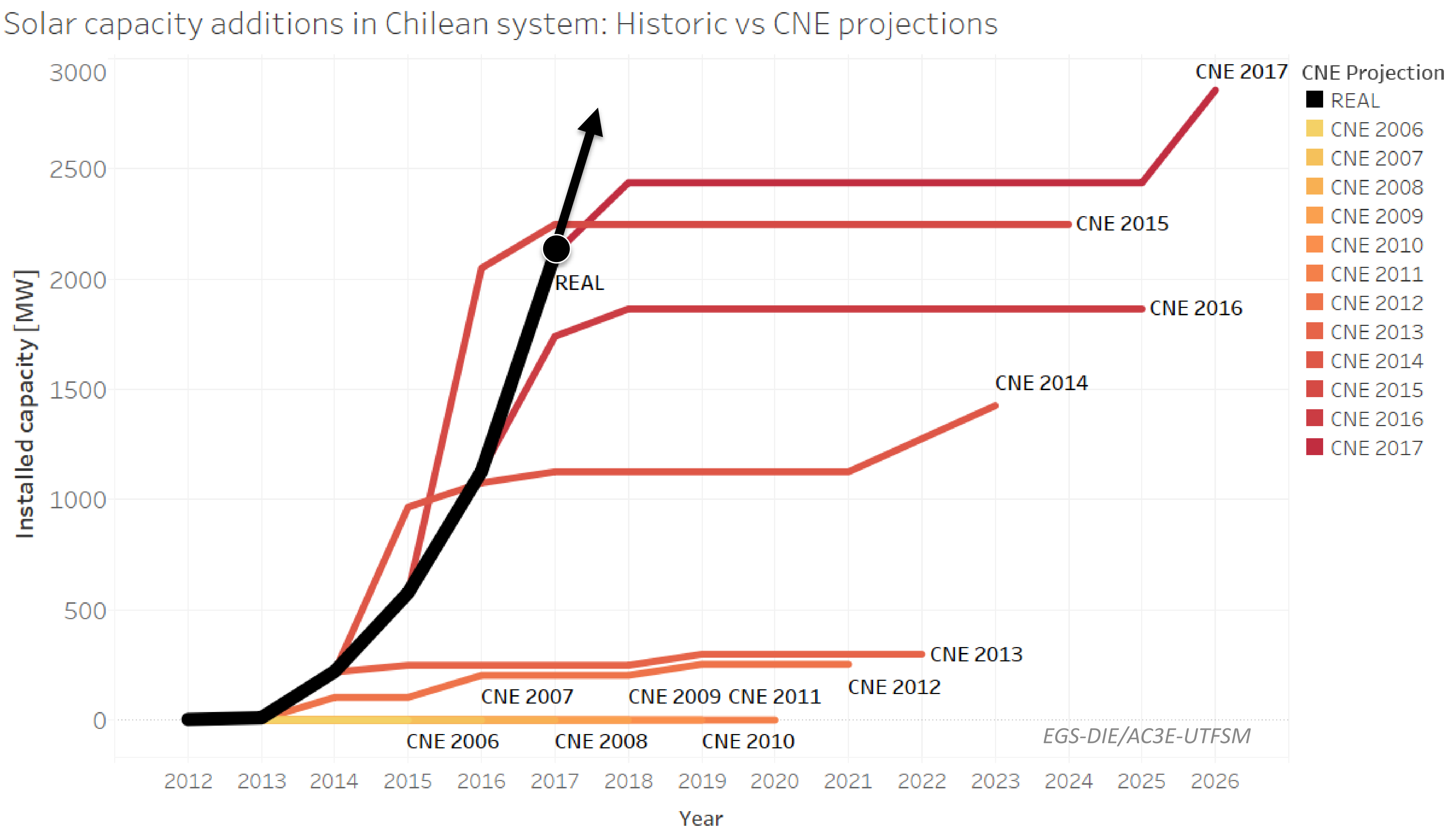
- Flexibility needs in Chilean system
- New balancing ancillary services (AS)
  - Inertial response
  - Rapid frequency control
  - Flexible ramping product
- A framework for conceptualizing new AS

THE NEED FOR FLEXIBILITY

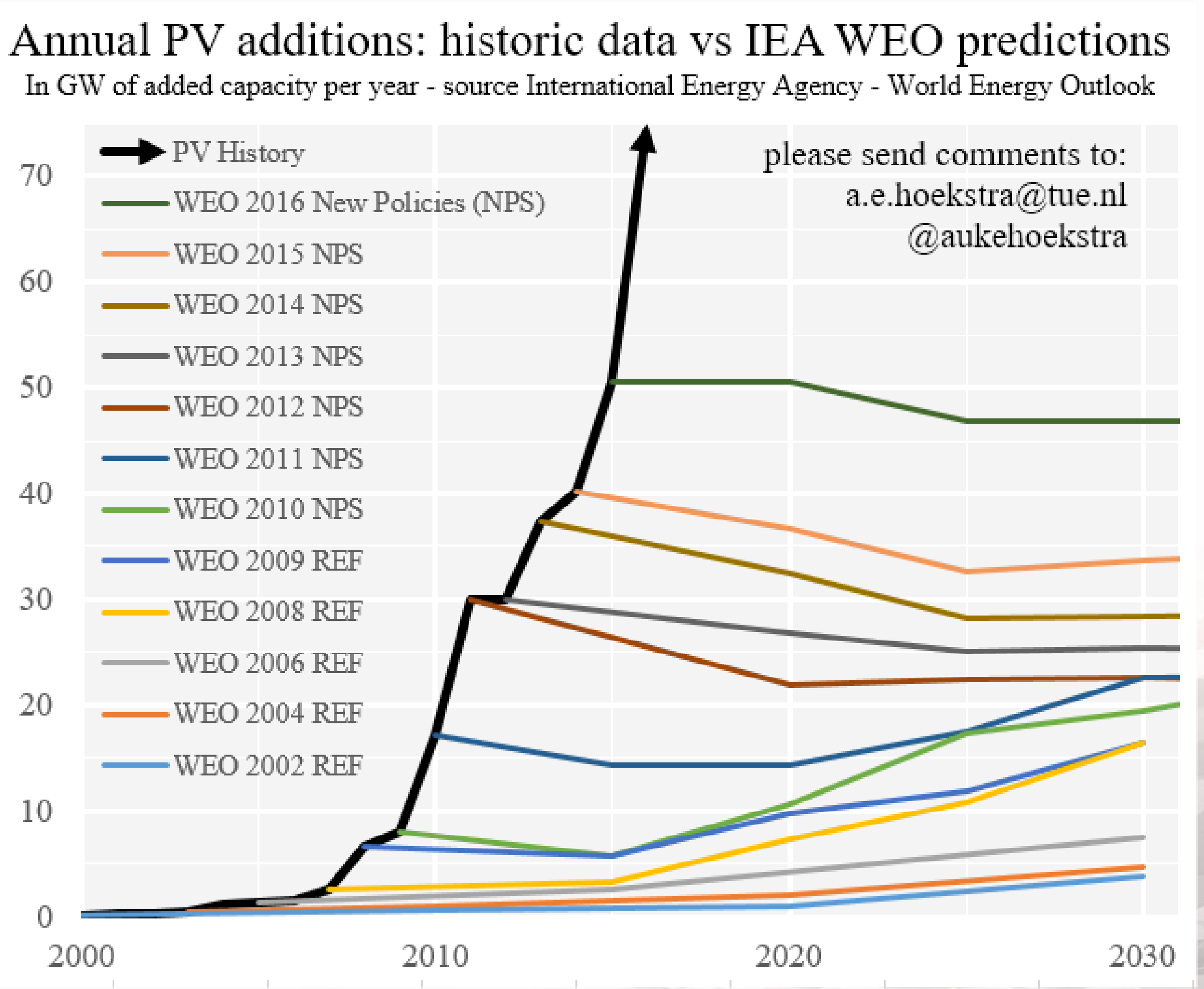
Wind power in Chile: Historic vs projections



Solar power in Chile: Historic vs projections

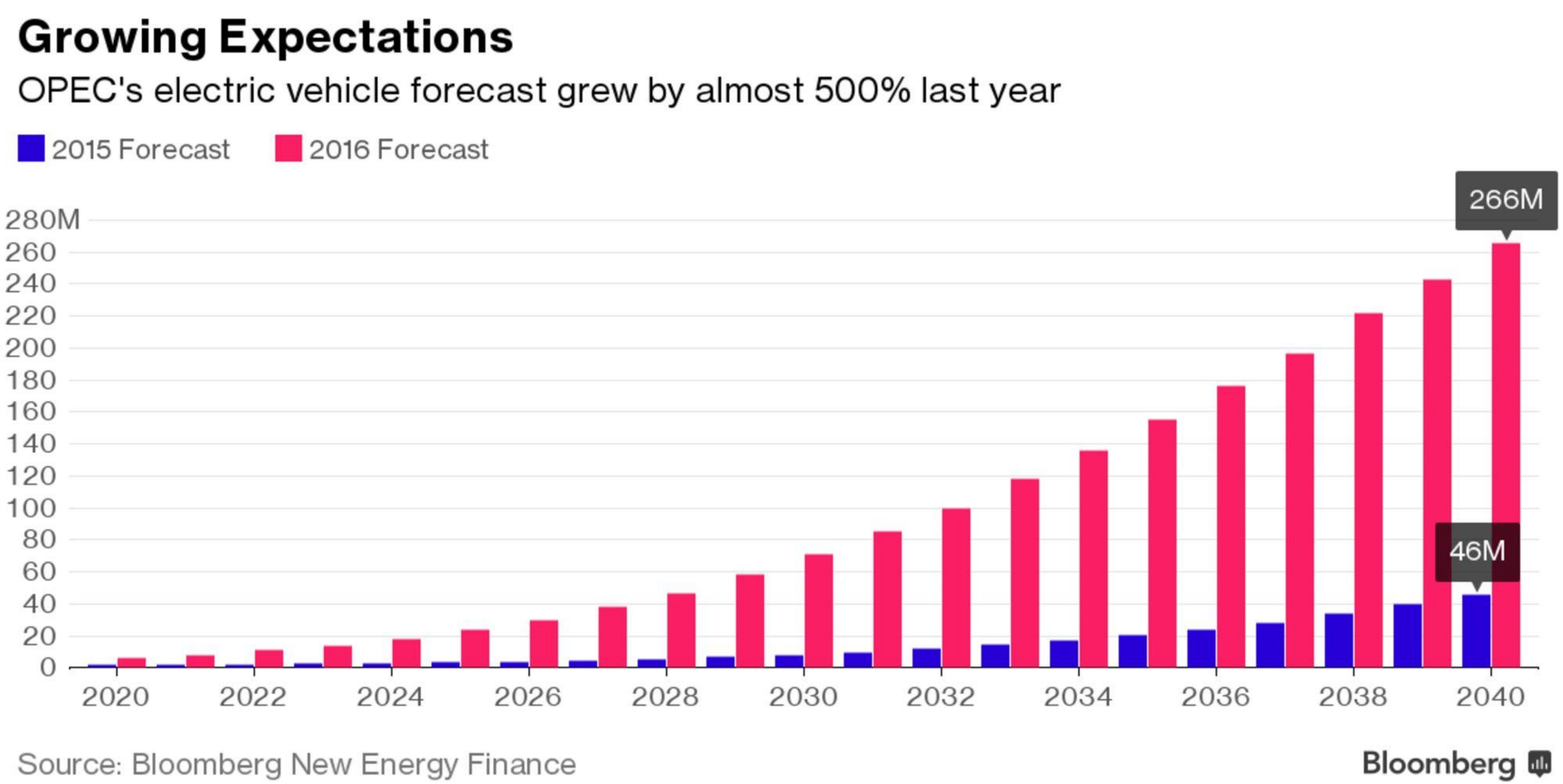


Underestimation not only in Chile



Meantime, for electric vehicles…

Everyone is revising their electric vehicle projections upward



Projection of impact of new technologies in Chile

Year	Scenario	$Energy_{net_{annual}}$ [TWh]	$P_{net_{max}}$ [GW]	$Ramp_{max_{up}}$ [MW/min]	$Ramp_{max_{down}}$ [MW/min]	$\frac{D_{max}}{D_{min}}$
2050	Base	154.3	19.9	16.4	18.0	1.29
	EV-low DG-low	164.5	22.2	40.6	20.4	1.31
	EV-low DG-high	148.9	22.2	45.0	34.7	1.54
	EV-med DG-low	182.6	26.0	94.0	73.8	1.49
	EV-med DG-high	167.1	26.0	98.4	88.1	1.74
	EV-high DG-low	208.1	31.2	168.8	148.5	1.71
	EV-high DG-high	192.5	31.2	173.2	162.8	1.99
2035	Base	121.0	15.6	12.8	14.1	1.29
	EV-low DG-low	[illegible]	[illegible]	[illegible]	14.1	[illegible]
	EV-low DG-high	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	EV-med DG-low	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	EV-med DG-high	116.2	16.5	[illegible]	[illegible]	[illegible]
	EV-high DG-low	128.3	17.2	[illegible]	[illegible]	1.30
	EV-high DG-high	119.9	17.2	31.9	21.3	1.39

35% more energy

57% more capacity

Ramping requirements may go up by many times!

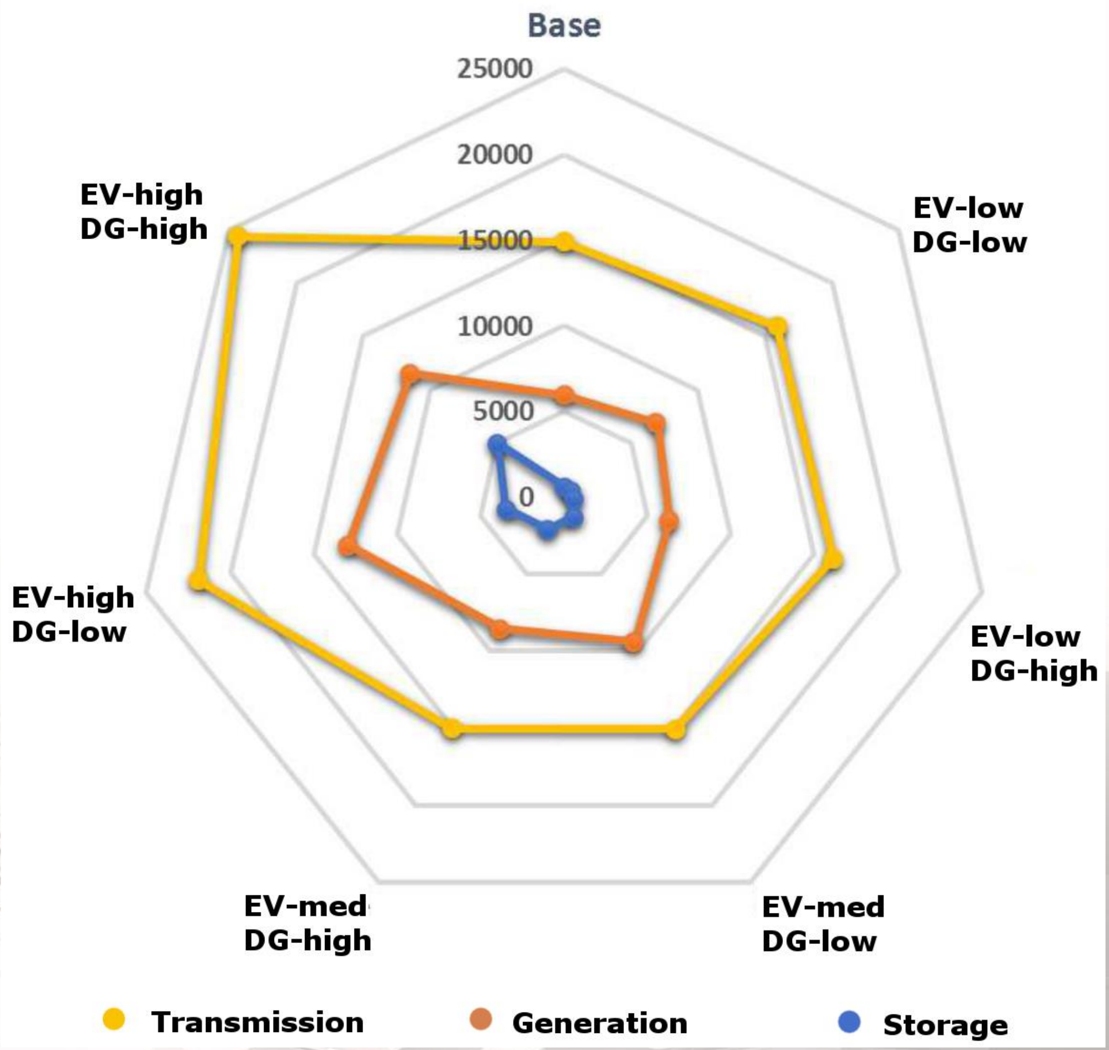
Units at minimum & cycling

Summary of projections for energy, max. annual load, and ramping needs for the Chilean SEN in 2035 y 2050, for different technology development scenarios. [Source: working paper V. Ruiz]

Storage needs in 2050

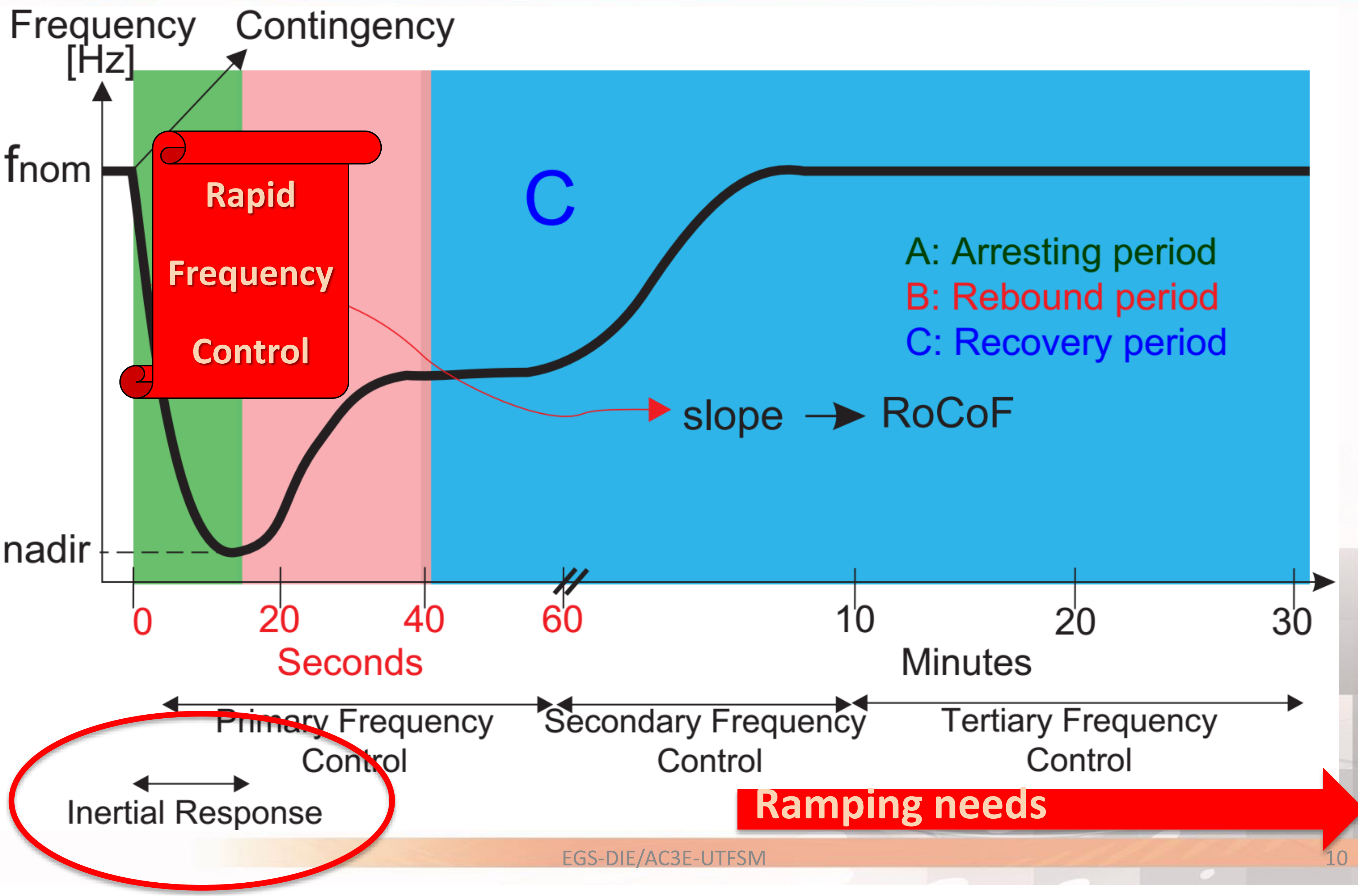
- Co-optimization of transmission, generation, and storage investments suggests a sizable amount of storage for 2050 in Chile

How to incentivize investments?



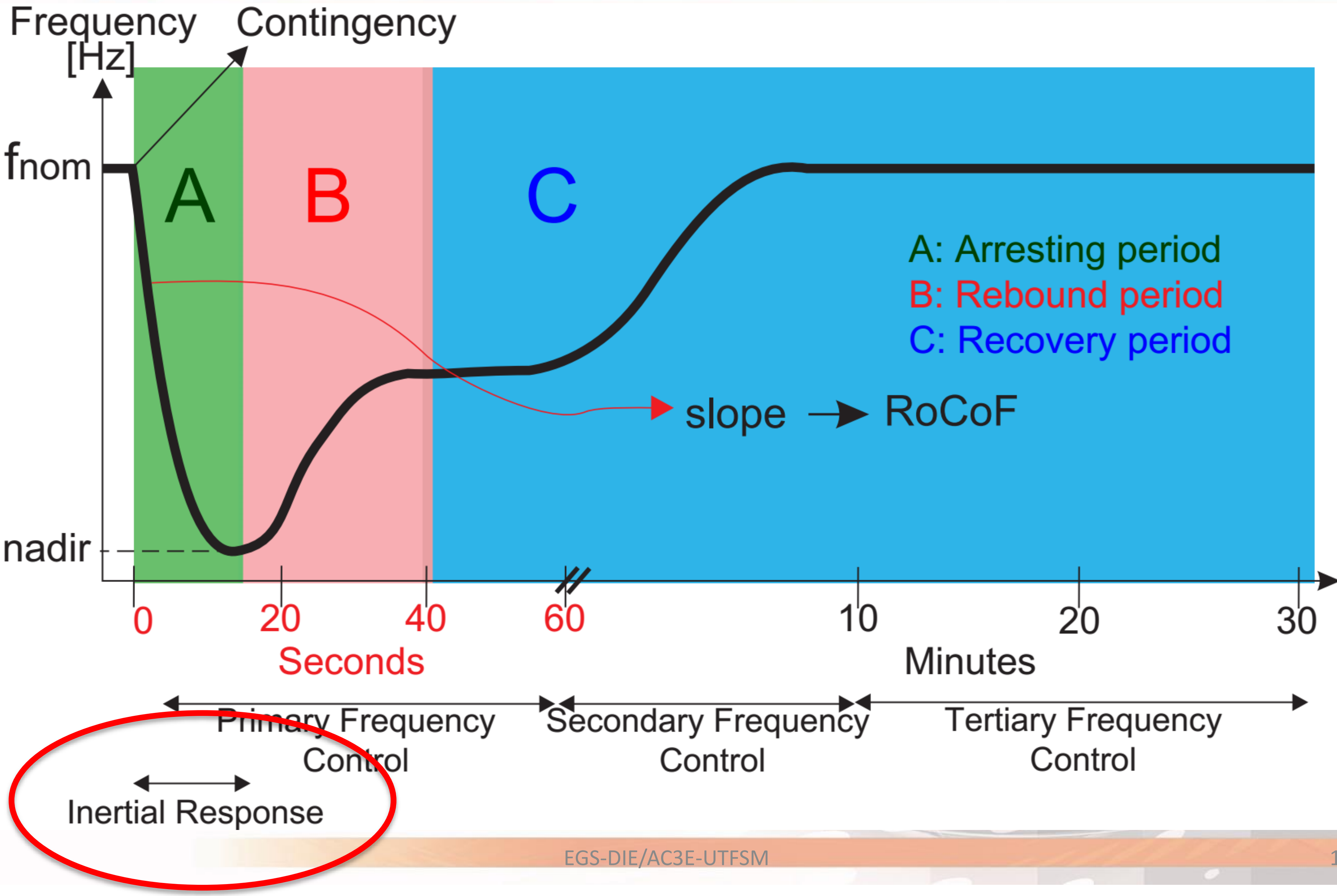
[Source: working paper V. Ruiz]

Balancing needs



INERTIAL RESPONSE

Balancing needs: Inertial response



Why?

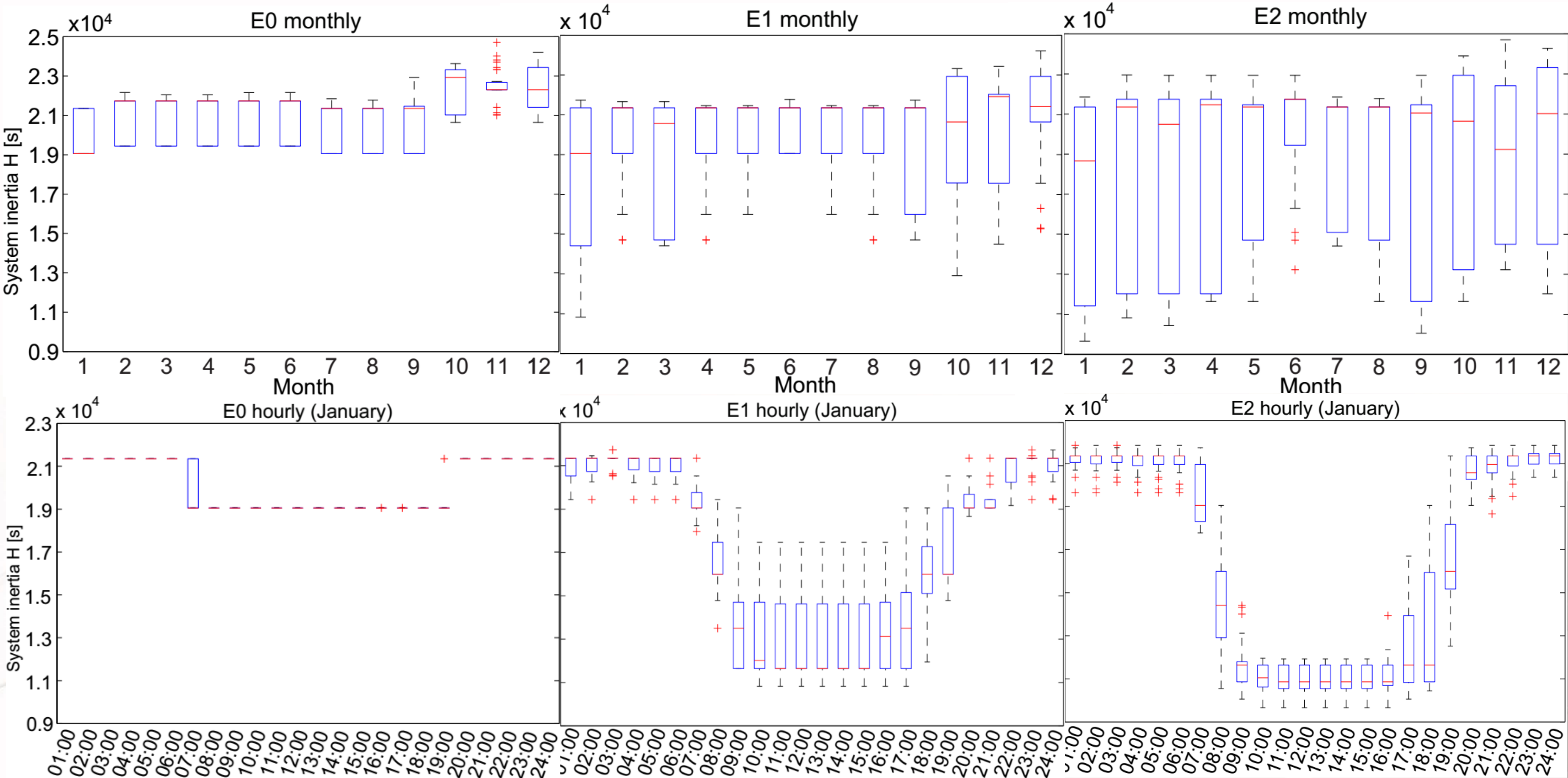
- Inverter-connected generators
  - Low inertia
  - Low-inertia generators are displacing conventional generators in the unit commitment
  - They are also displacing generators that can provide primary frequency control

Inertia v/s RES penetration

Scenario E0
RES: 725 MW installed, 10% generation

Scenario E1
RES: 1261 MW installed, 18% generation

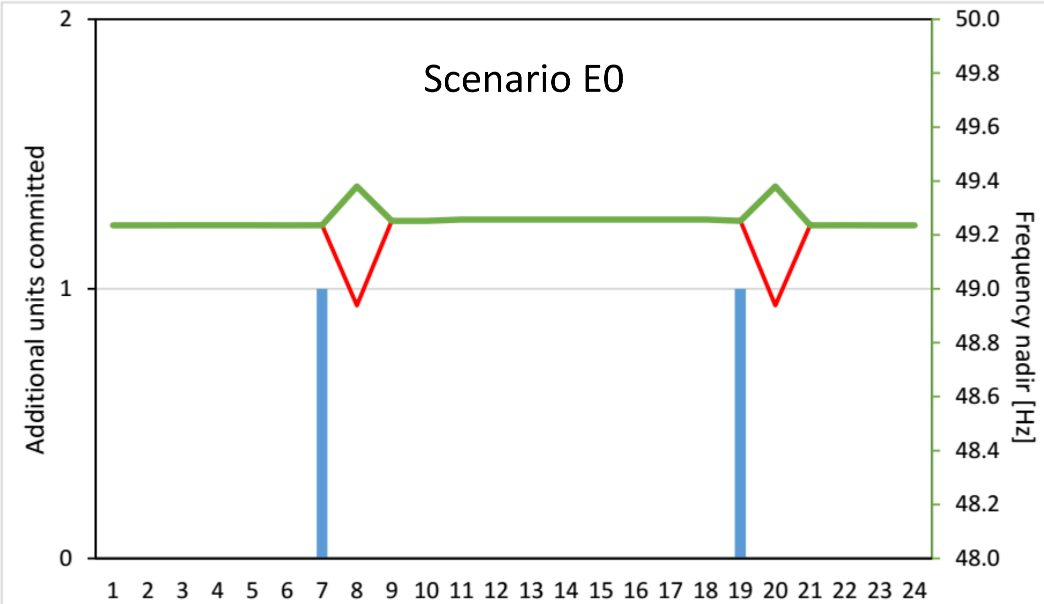
Scenario E2
RES: 1694 MW installed, 23% generation

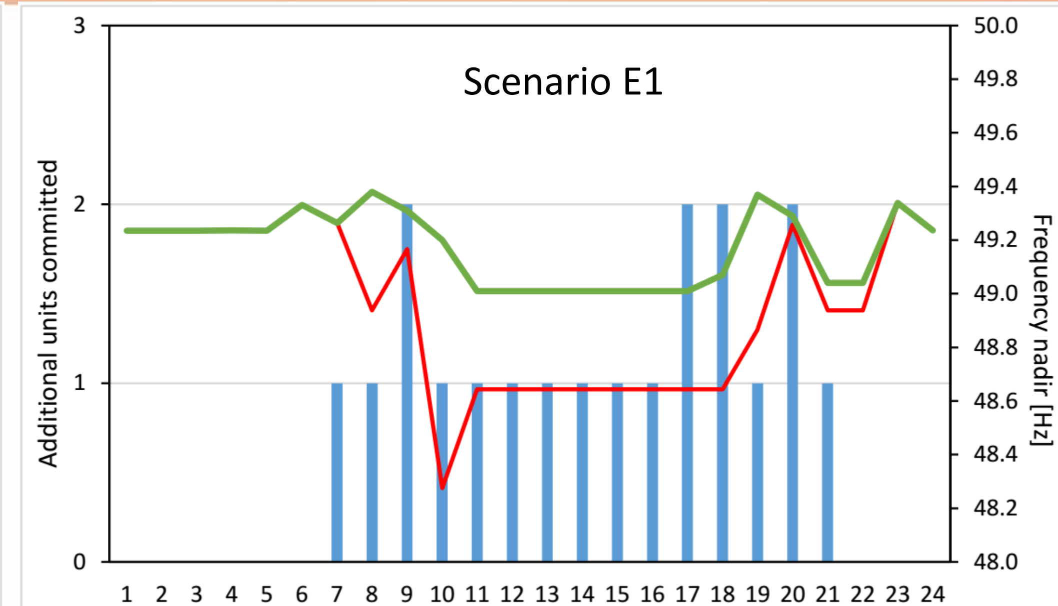


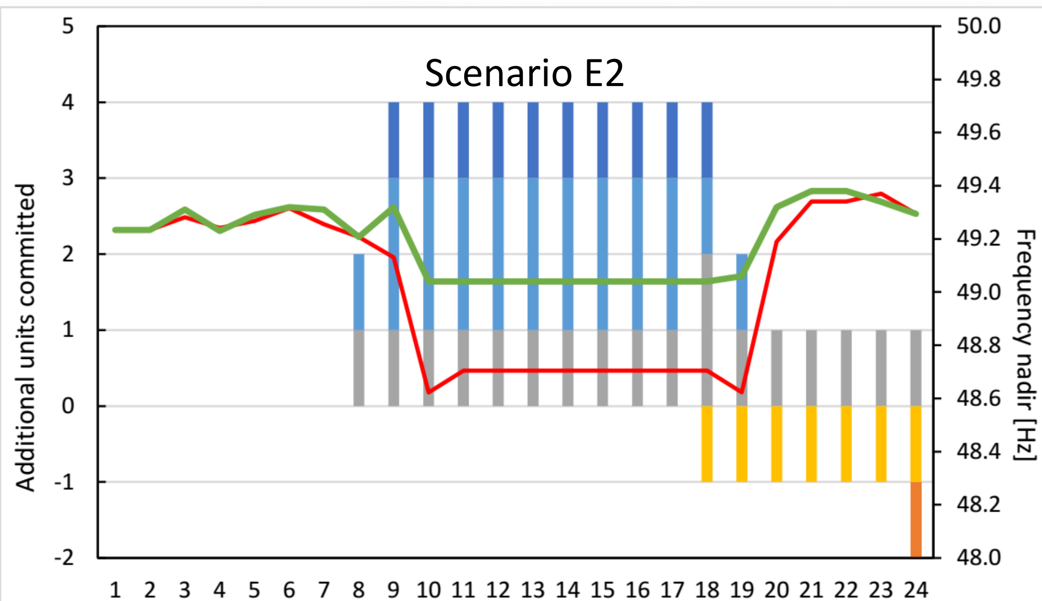
Case study: SING

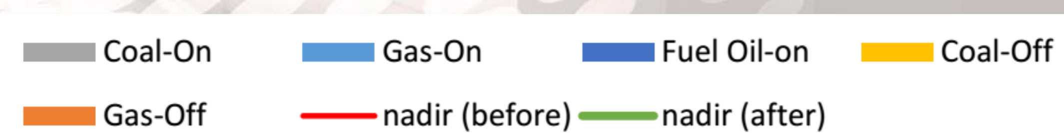
[Source: working paper M. Brito]

Need to commit additional units









[Source: working paper M. Brito]

How to provide/emulate inertial response

- Technologies that can provide it
  - Flywheels
  - Synchronous condensers
  - Synthetic inertia
    - From wind farms
    - From BESS & supercapacitors

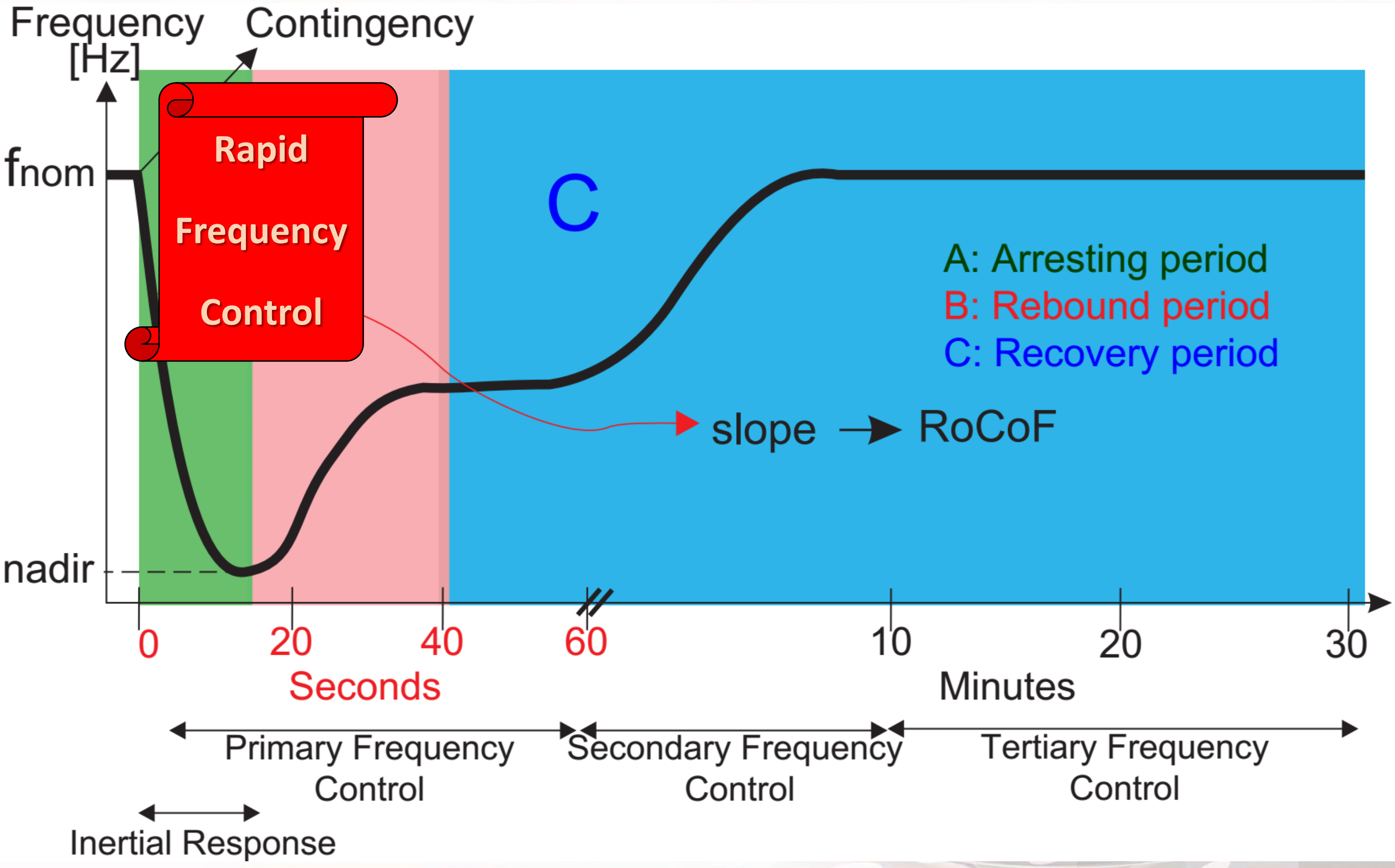
Who can provide these services at lower cost?

- But…

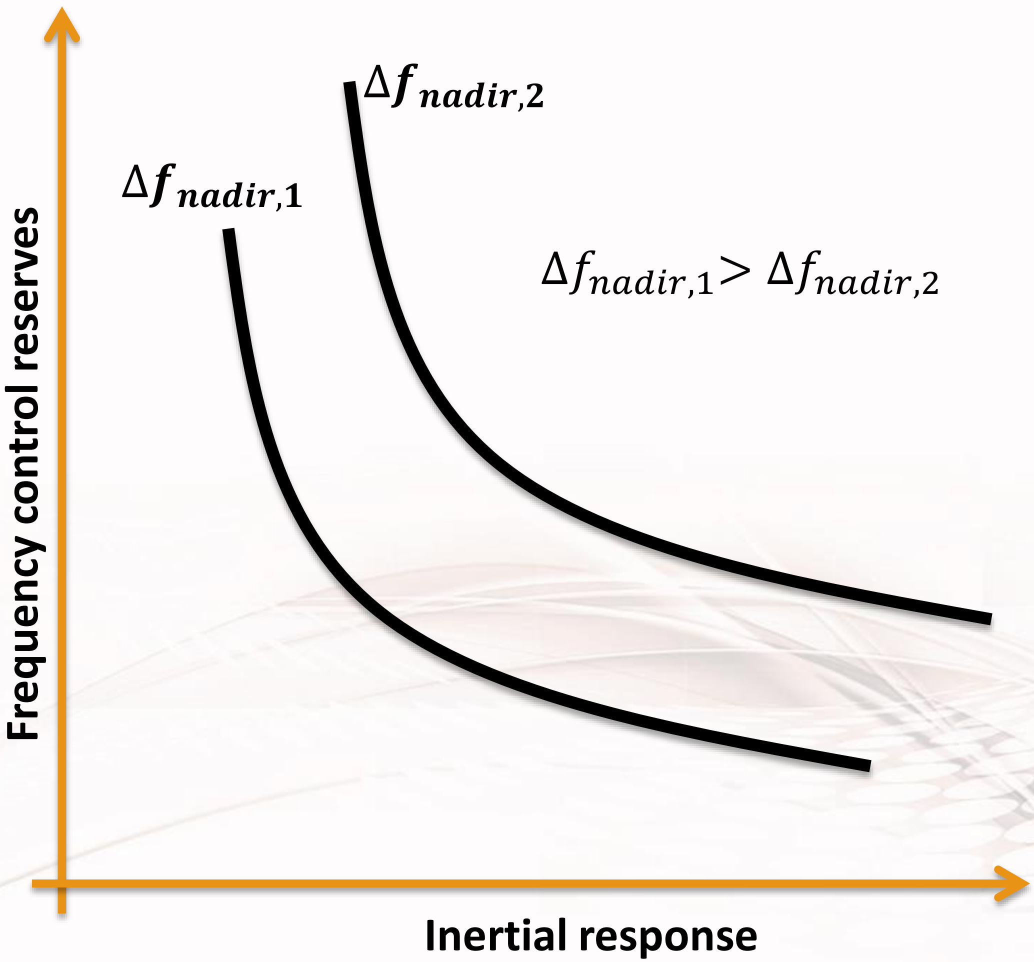
What are the incentives to provide these services?

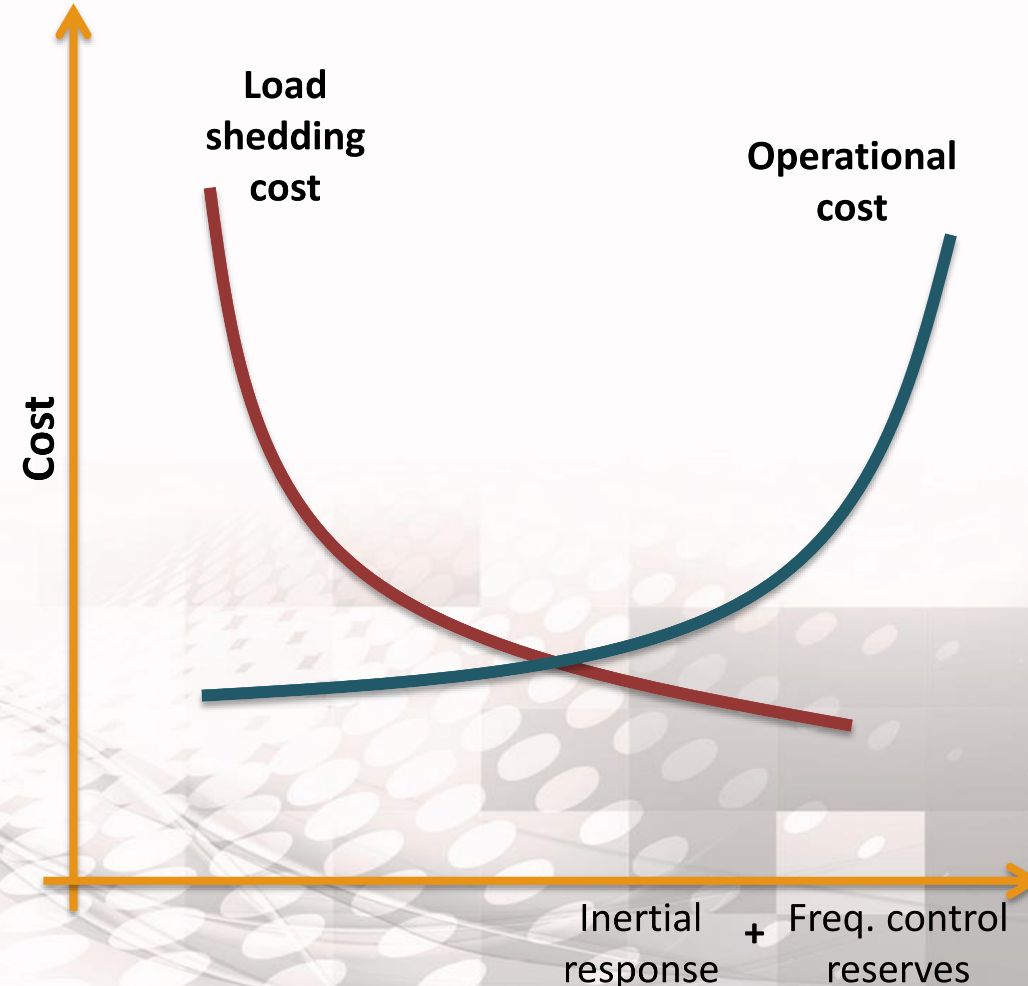
RAPID FREQUENCY CONTROL

Balancing needs: Rapid Frequency Control



Efficiency in providing frequency control services





- Technologies that can provide it
  - Bulk-energy storage
  - Distributed storage
  - Frequency-responsive demand response

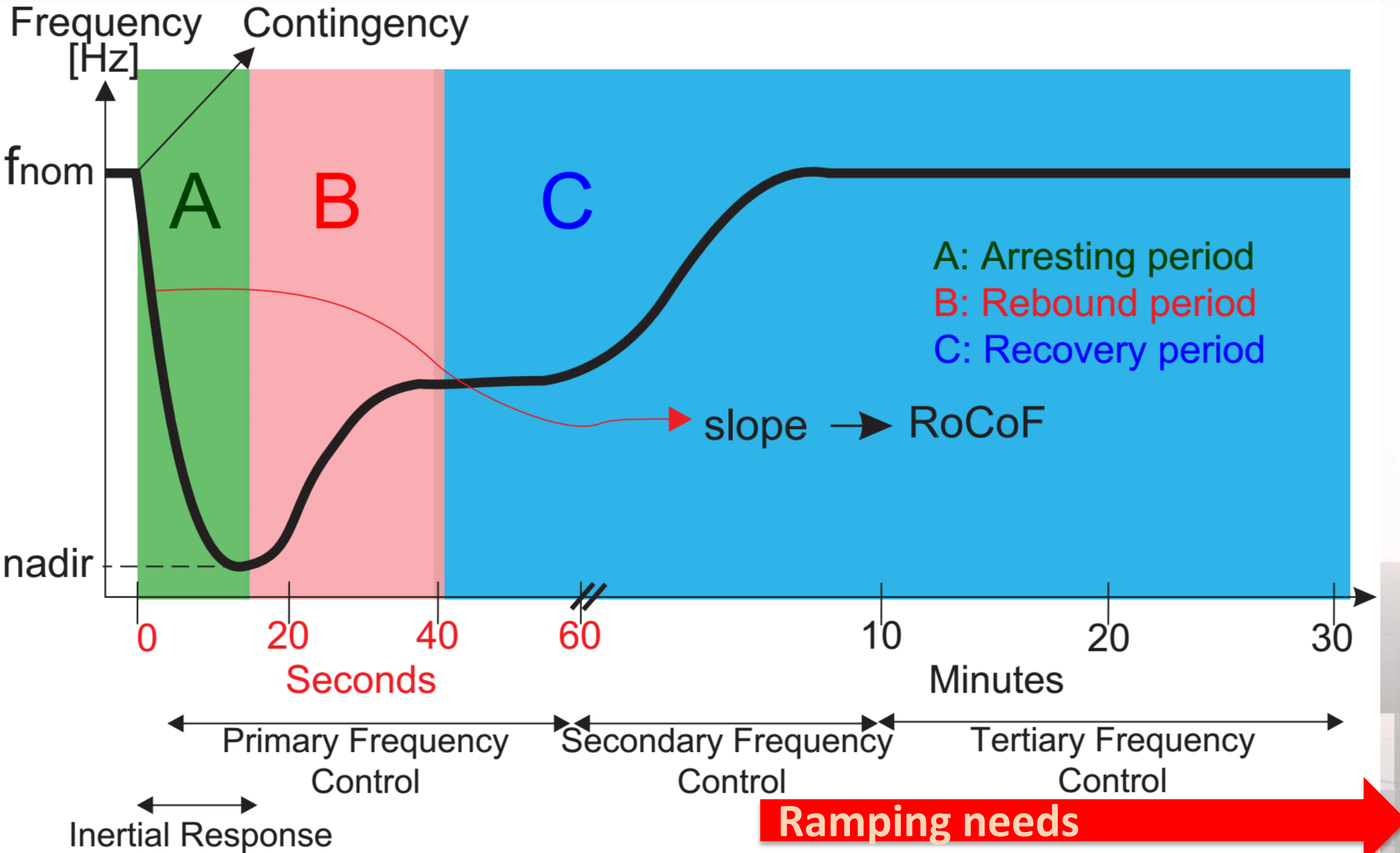
Who can provide these services at lower cost?

- But…

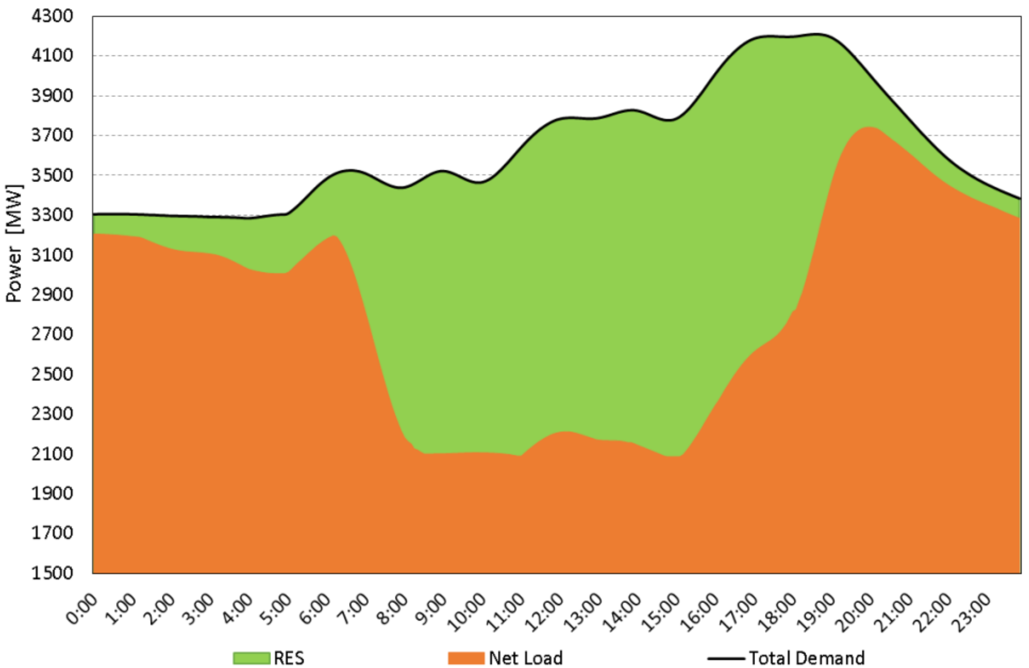
What are the incentives to provide these services?

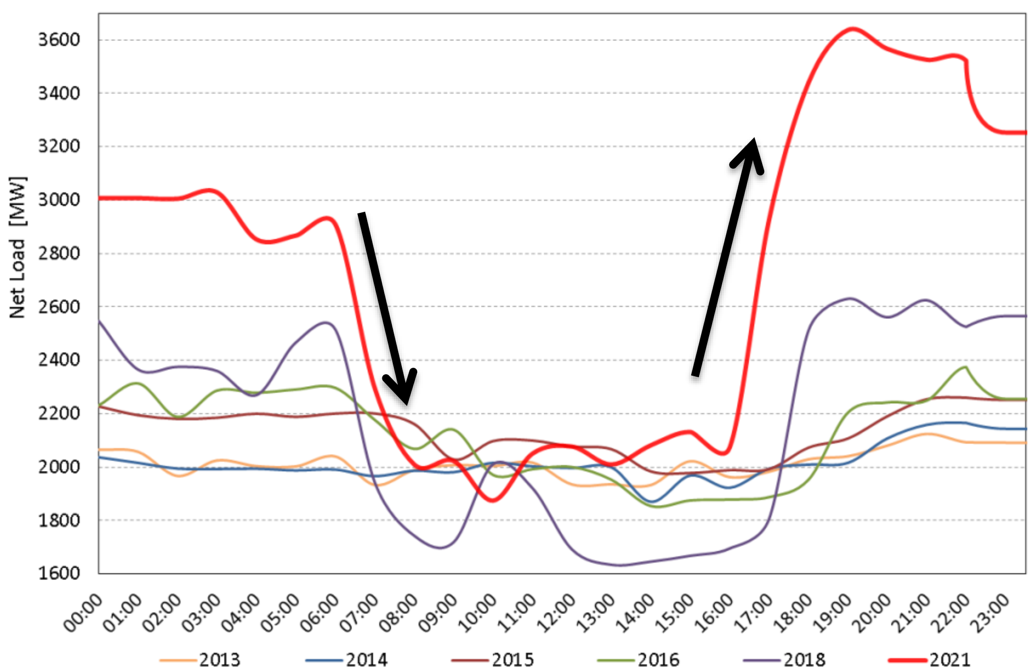
FLEXIBLE RAMPING PRODUCT

Ramping needs



Duck curve

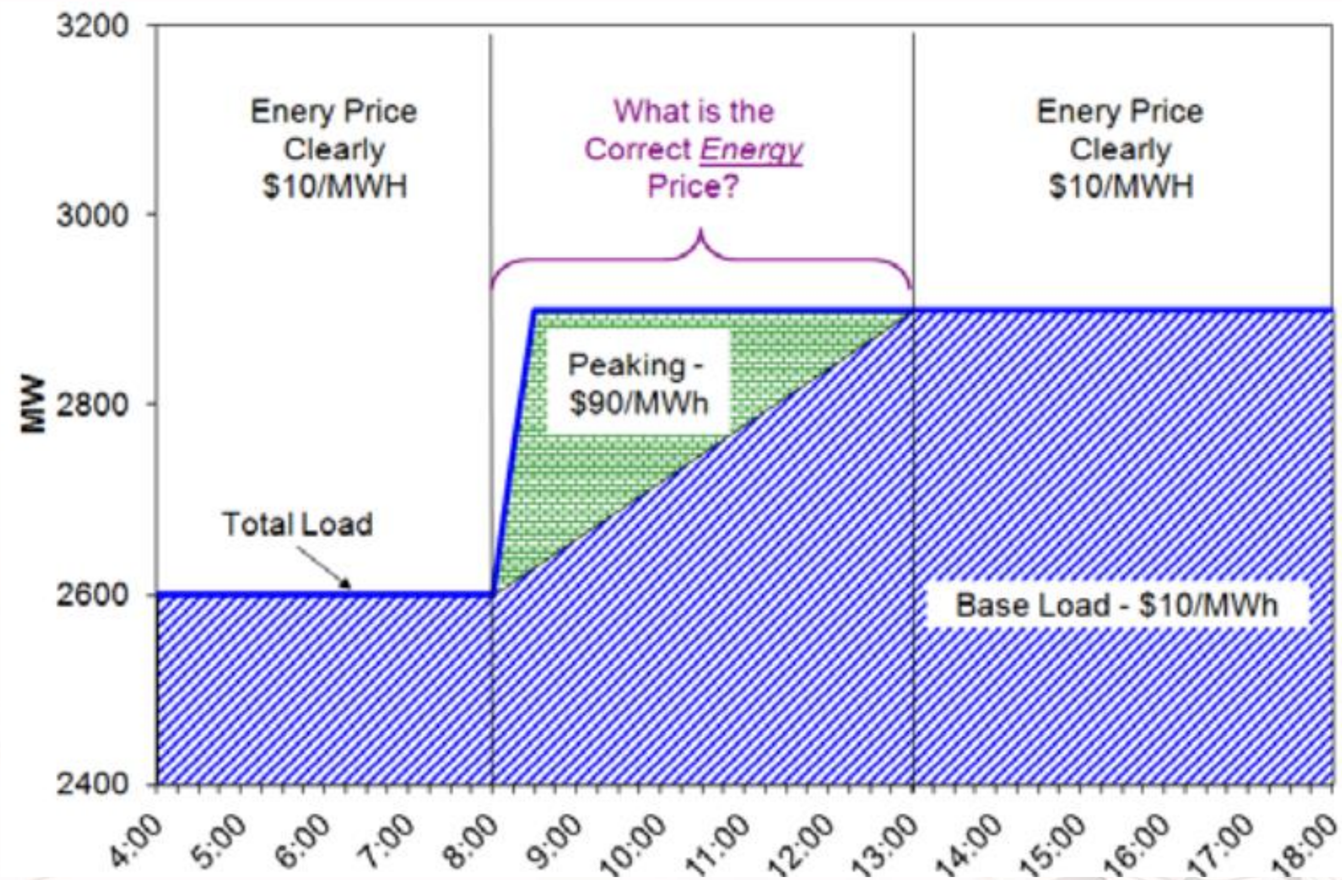




- Evolution of the net load in the SING for a typical day

[Source: working paper D. Godoy]

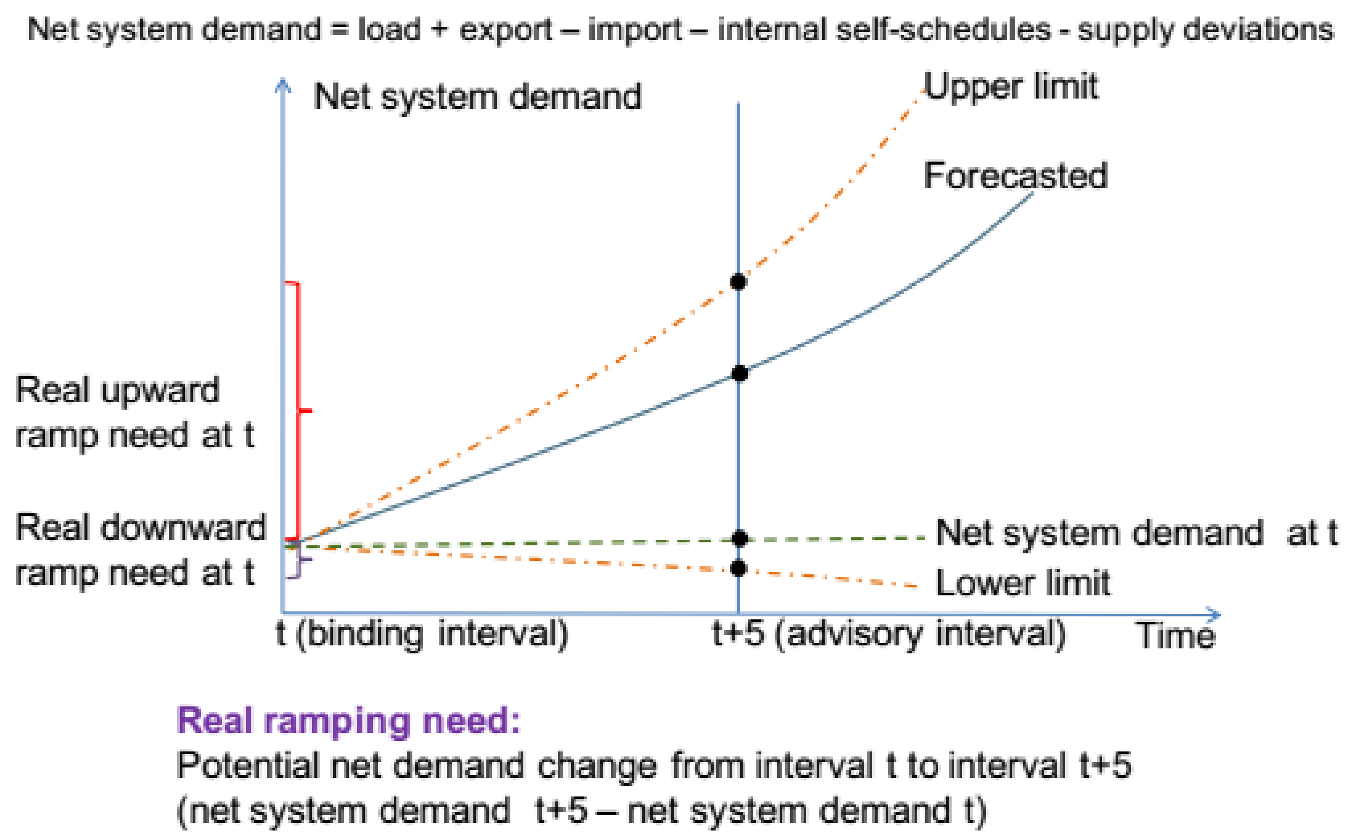
The case for a separate ramping market



[Source: Ela et al, 2012]

- Units dispatched out of merit due to ramping constraint
- Should all the energy be paid at 90 $/MWh?
- Or should the unbalance be paid separately?

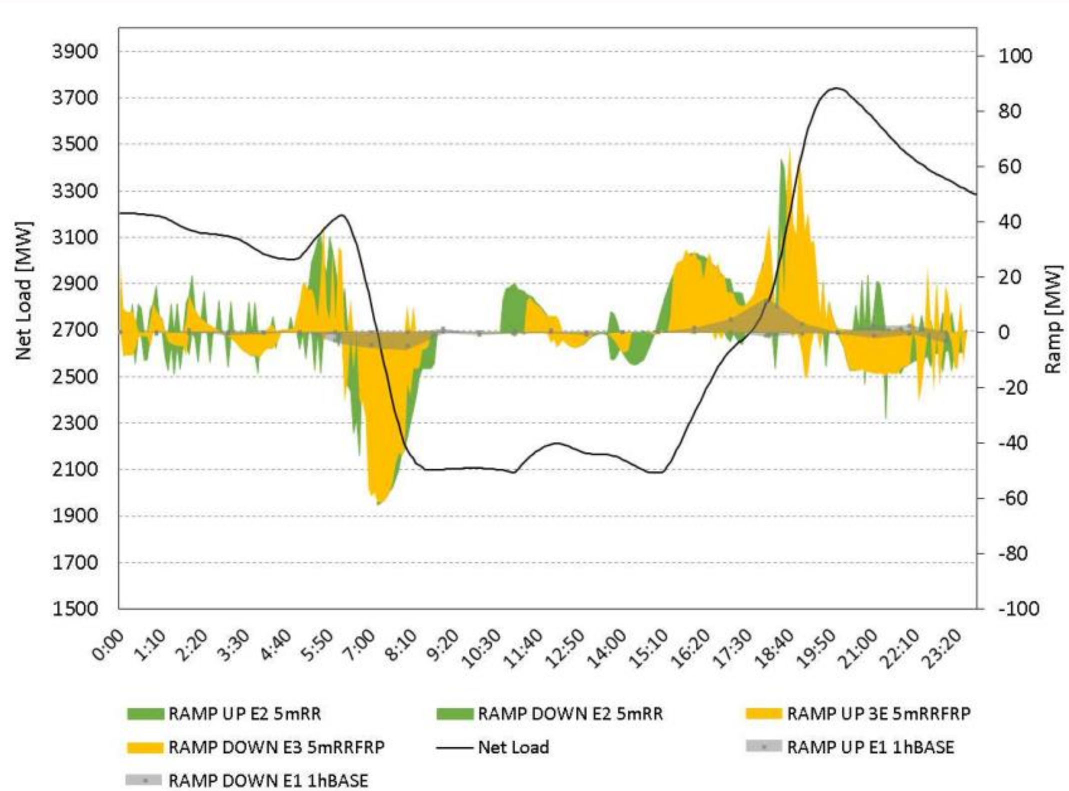
Ramping needs

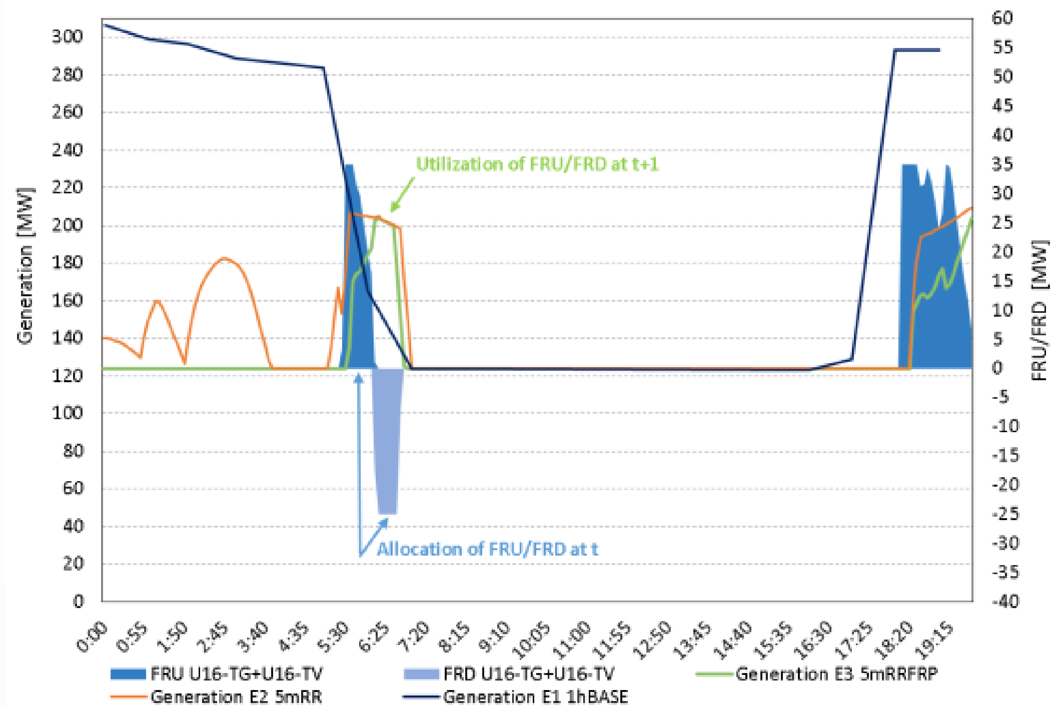


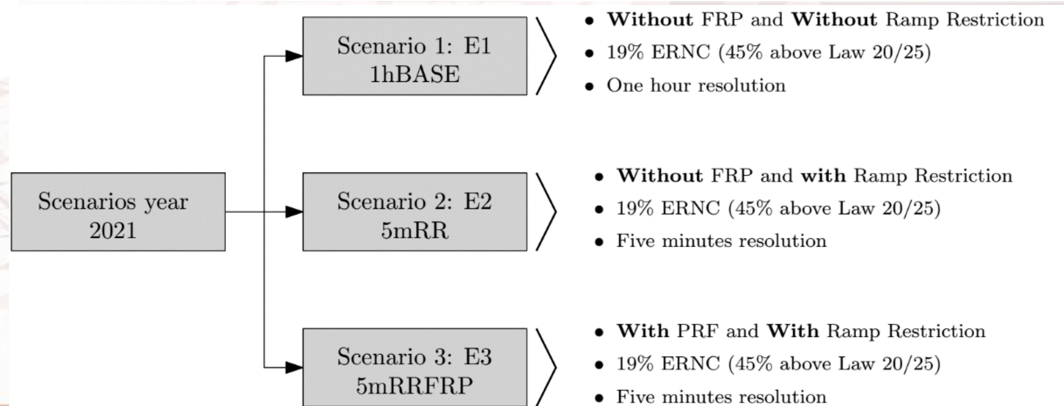
[Source: CAISO]

- Two sources of ramping needs:
  - Programmed variability
  - Uncertainty
    - Variable RES
    - Outages

Operation of a FRP in the SING



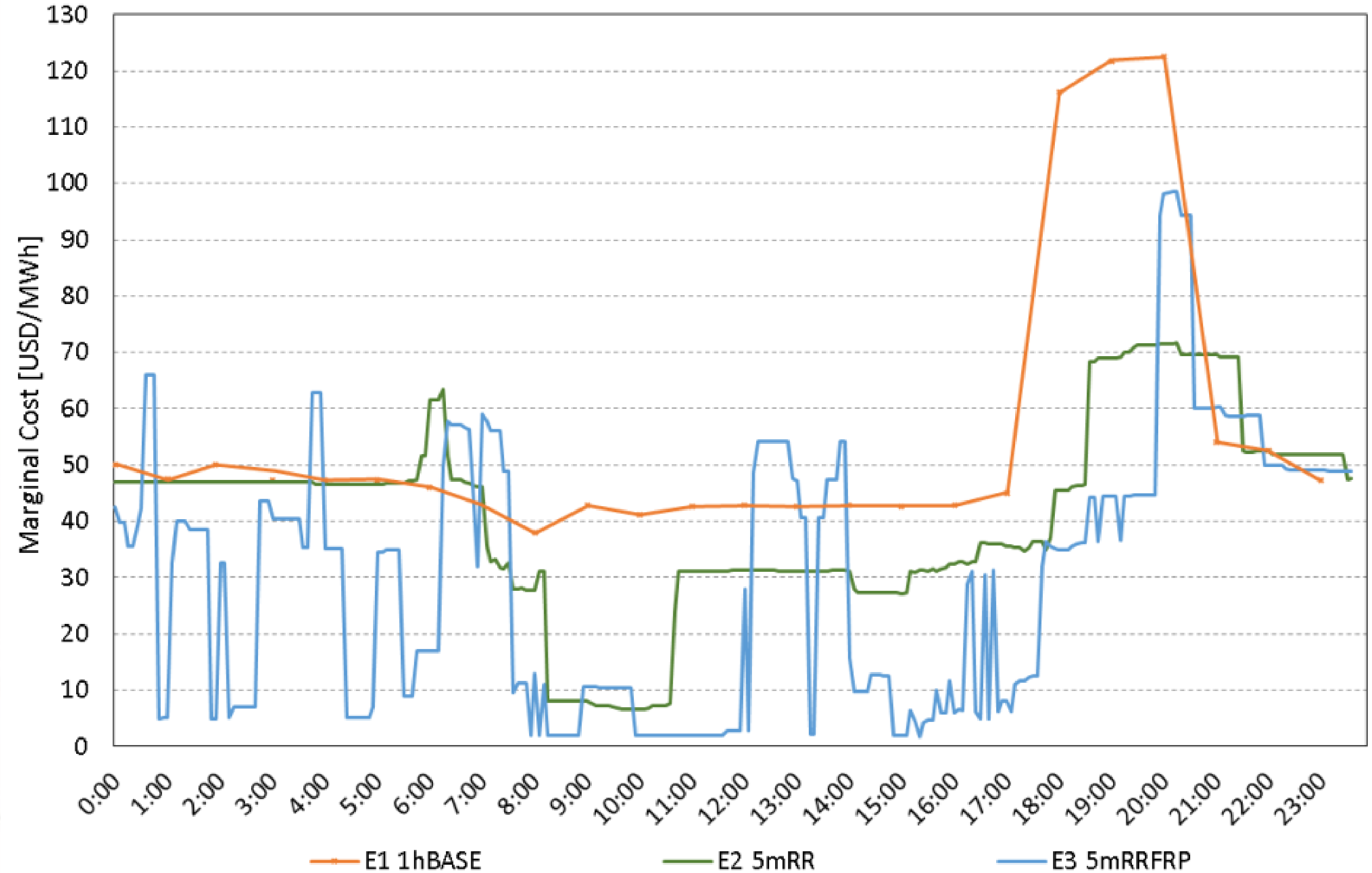




Generation and FRP allocation/utilization for generator U16

[Source: working paper D. Godoy]

Operation of a FRP in the SING



- Going from 1h to 5m dispatch and including ramping constraints allows a more efficient allocation of ramping resources
- Avg. price reduction of 44% by using FRP

[Source: working paper D. Godoy]

A FRAMEWORK FOR NEW ANCILLARY SERVICES

Solutions need to tackle different aspects

Hardware

- New technologies
- New applications of existing technology

Software

- Monitoring, control, decision-making
- Skills and knowledge for handling technology

Orgware

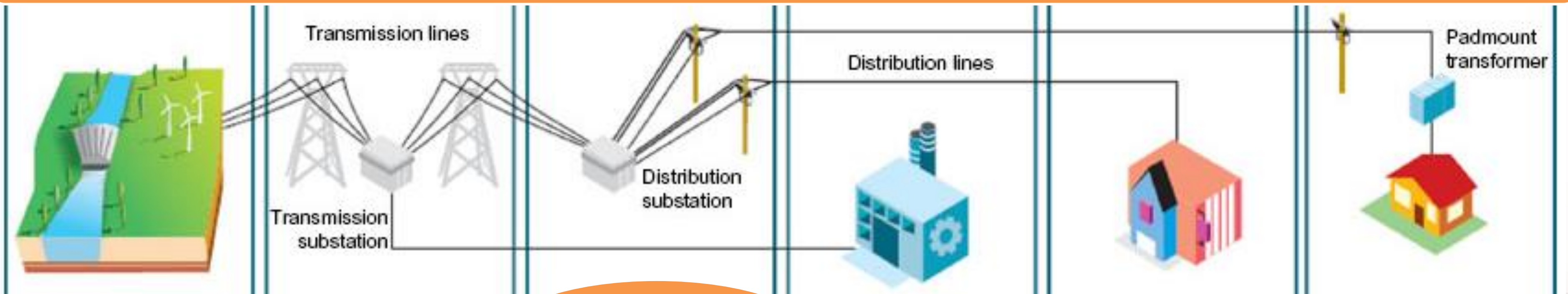
- Regulation
- Incentives for creating and using the technology

A N C I L L A R Y   S E R V I C E S

Hardware

Enabling technologies

- Information and communication technology
- Power electronics
- Renewable and distributed generation
- Energy storage



Applications

- Solar
- Wind
- WAMS
- Dist. grid management
- DR
- DG
- Smart houses
- Marine
- FACTS
- DLR
- DSM
- BESS
- Smart metering
- EVs
- Geoth.
- HVDC
- SPS
- Dist. energy storage
- Microgrids
- Mini-hydro

Software

- How to monitor and control all the different resources?
- Handling big data
- Estimation of balancing requirements
  - How much is needed?
- More complex decision models
  - Hierarchical decision making or co-optimization?
  - Need to internalize risk
  - Modeling of many different technologies
- Bigger optimization problems
  - Need for more granularity
  - Need for parallelization
- New decision variables
  - Emerging technologies
  - Consumer-driven decision variables
- More complex objective functions
  - Multiple objectives
  - Stochastic optimization
- More complicated constraints
  - Network constraints
  - AC instead of DC OPF?

Orgware

Quantification

Operation

Ancillary services

Certification & verification

Remuneration

Conclusions

- We are quite bad at predicting technology development
- All the drivers (costs, environmental concern, societal pressure, changes in consumer roles) point in the same direction
  - Disruptives technologies such as wind & solar power and EVs will likely be adopted faster than projected today

Conclusions

- Changes not only in energy consumption, but in capacity and flexibility requirements
- Increasing penetration of inverter-connected generators calls for procuring more inertia and providing faster frequency control
- It is a good idea to decouple the energy and flexibility markets
- Solutions require not only the technology, but also the software and regulatory framework to work

References

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