Short-Term Flexibility

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Technical Brochure by WG C5.27
Tutorial, CIGRE e-Session, 3 September 2020

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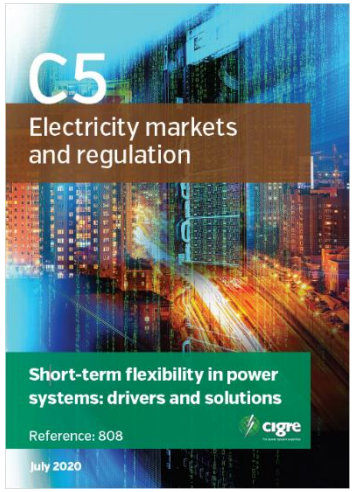
Background

- Tutorial was based on the work of Working Group C5.27 under Study Committee C5, Markets and Regulation
- WG started in 2018 and finished recently
- 25 members from all continents
- Technical Brochure 808:
  - ✓ **Short-term flexibility in power systems: drivers and solutions**

- Note: TB also includes overview over US and EU research within the relevant area



Link to pdf

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Introduction

Is this definition useful?

- Flexibility, many definitions
  - ✓ **IEA: the ability to <u>respond</u> in a <u>timely</u> manner to <u>variations</u> in electricity <u>supply</u> and <u>demand</u>**

Flexibility for the grid / congestion management: *out of scope*

- Short term
  - ✓ **Instantaneous, < 5 min, < 15 min, < 12 hours**

Longer term flex (Dunkelflaute, elfstedentochtscenario, seasonal flex: *out of scope*

- Drivers
- Providers
- Arrangements

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Definitions: capacity and flexibility

- **Capacity**: is the ability (or option) to deliver or offtake (sell or buy) electrical energy

- **Flexibility**: is the ability to use/exploit capacity with few limitations
  - ✓ **Flexibility is a *characteristic* of capacity**
  - ✓ **Flexibility has many different time dimensions**
    - Example: A battery has short-term flexibility, but no longer term flexibility

Flexibility is not a separate commodity

One can't carve out a "flexibility market"

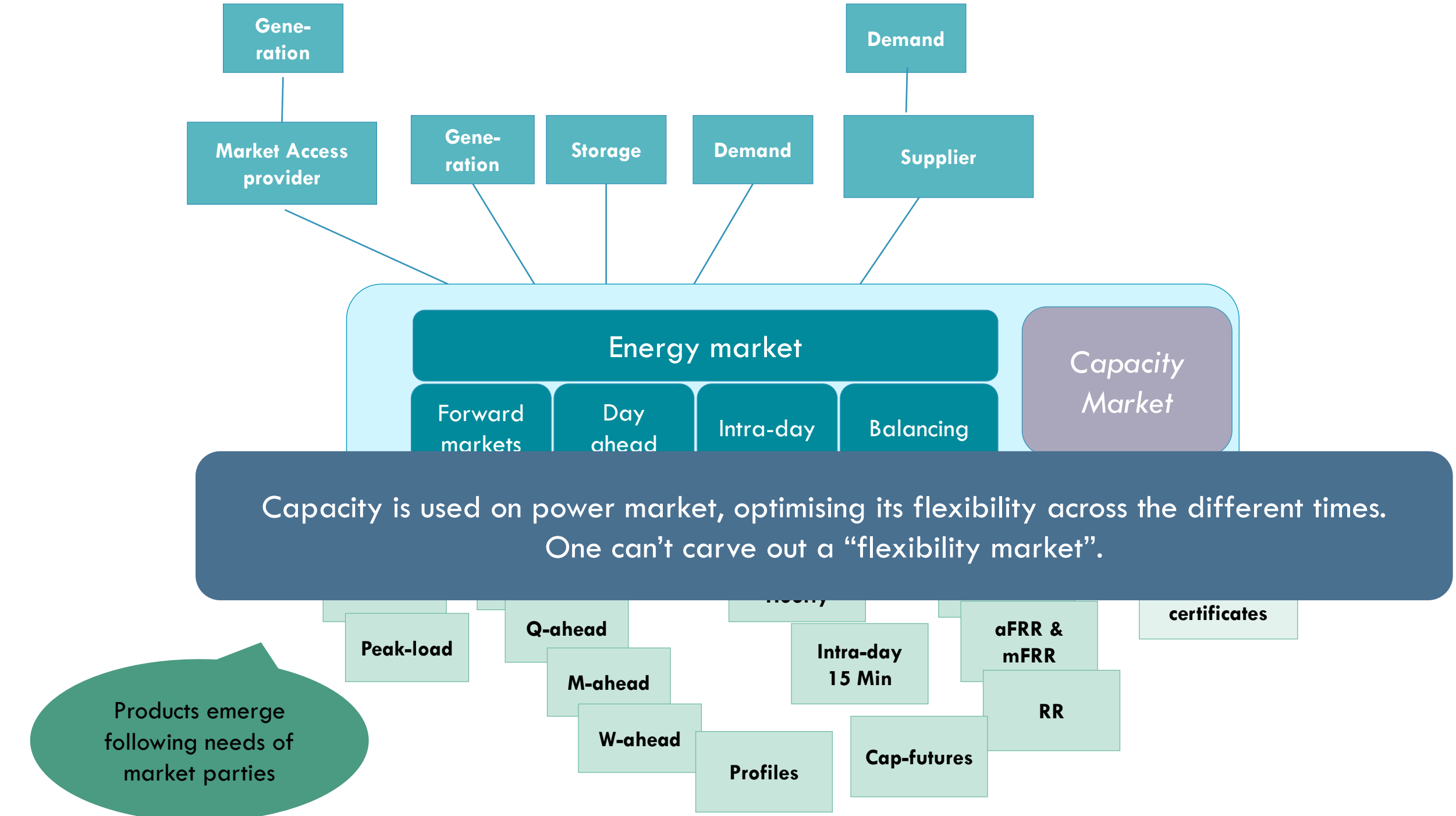
Capacity is used on power market, optimising its flexibility across the different times

Reliability = adequacy + security
no need to discuss flexibility!

NERC definitions:

- **Adequacy**: is the ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

- **Operating reliability (security):** is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system components.


Gene-ration
Demand
Market Access provider
Gene-ration
Storage
Demand
Supplier
Energy market
Capacity Market
Forward markets
Day ahead
Intra-day
Balancing
Capacity is used on power market, optimising its flexibility across the different times.
One can't carve out a "flexibility market".
Peak-load
Q-ahead
M-ahead
W-ahead
Profiles
Intra-day 15 Min
Cap-futures
aFRR & mFRR
RR
certificates
Products emerge following needs of market parties

Increasing share of RES: decreasing activation of operating reserves & increasing use of intraday market

Graph: Volumes in the activated reserve markets (green) versus intraday market (red) in Germany
Source: Statkraft

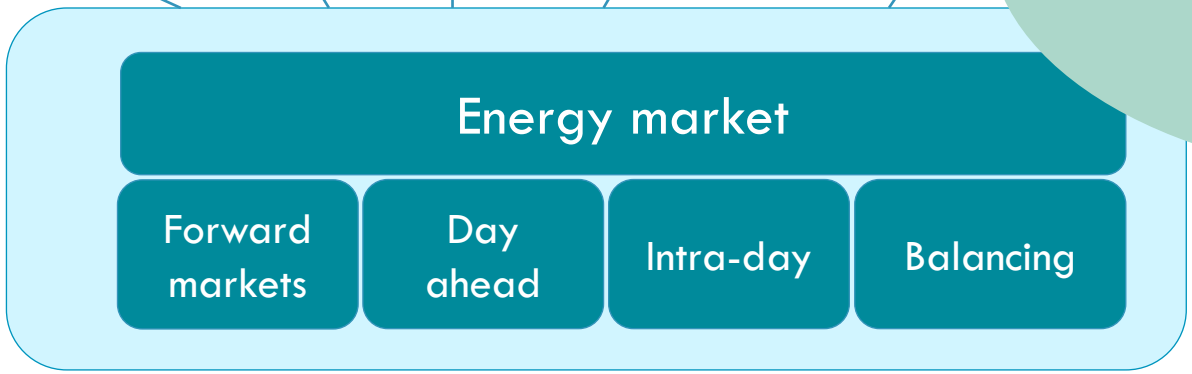
- If that “classical” paradigm remains valid,
- - and why wouldn’t it? -
- then there is no stacking of revenues from providing grid support!

- “Grid connected market party” (consumer/prosumer/generator/storage) is at the centre
- He owns its flexible capacity and decides on its use (self-dispatch)
- Market signals are leading. Congestion management should be reimbursed without distorting the market.

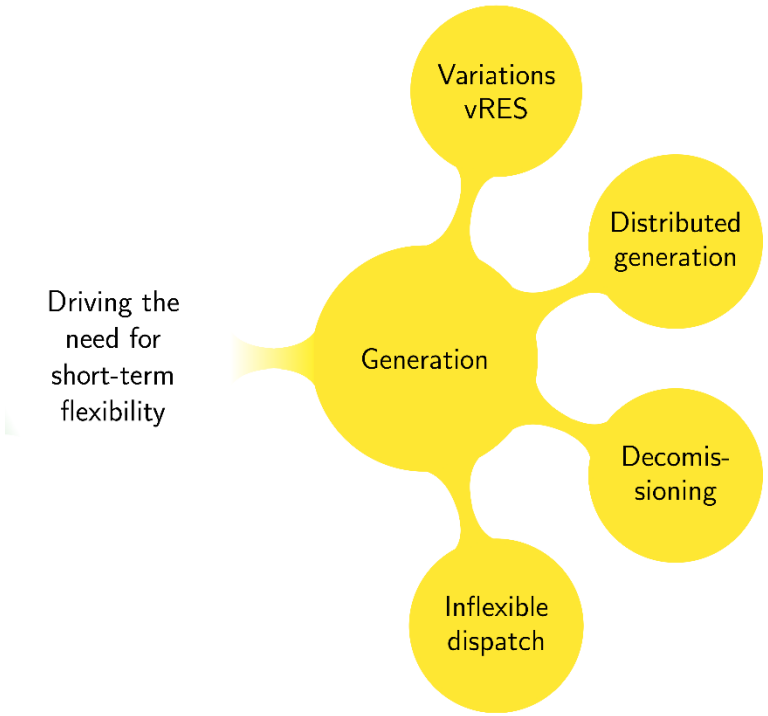
The grid (operated by TSOs and DSOs) facilitates the market.

DSOs/TSOs need to manage congestions (in a coordinated way) and thus interact with generation, demand & storage.

Congestion management (sometimes called flexibility market) is not a market. Congestion costs are transmission costs.



Is more flexibility needed, and how will it be provided?



Driving the need for short-term flexibility

Variations wind & solar power

Distributed generation and storage (siting, grid connection, behind-the-meter)

Decomissioning of conventional generation (merit order)

Inflexible dispatch of power plants (economical, technical and environmental limitations, provision of reserves, combined heat and power, habits, full exposure to price signals)

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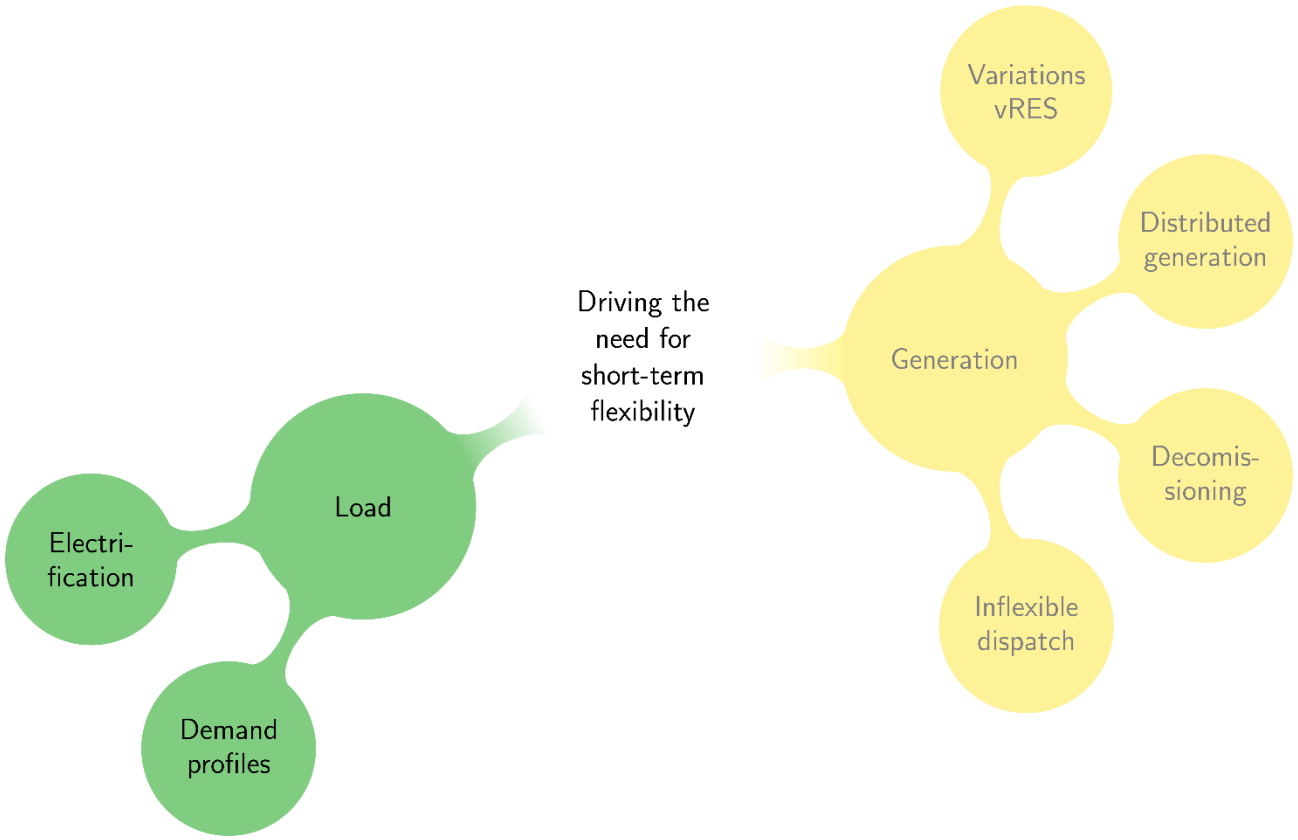

Driving the need for short-term flexibility

Demand varies

Electrification of transport and industry processes

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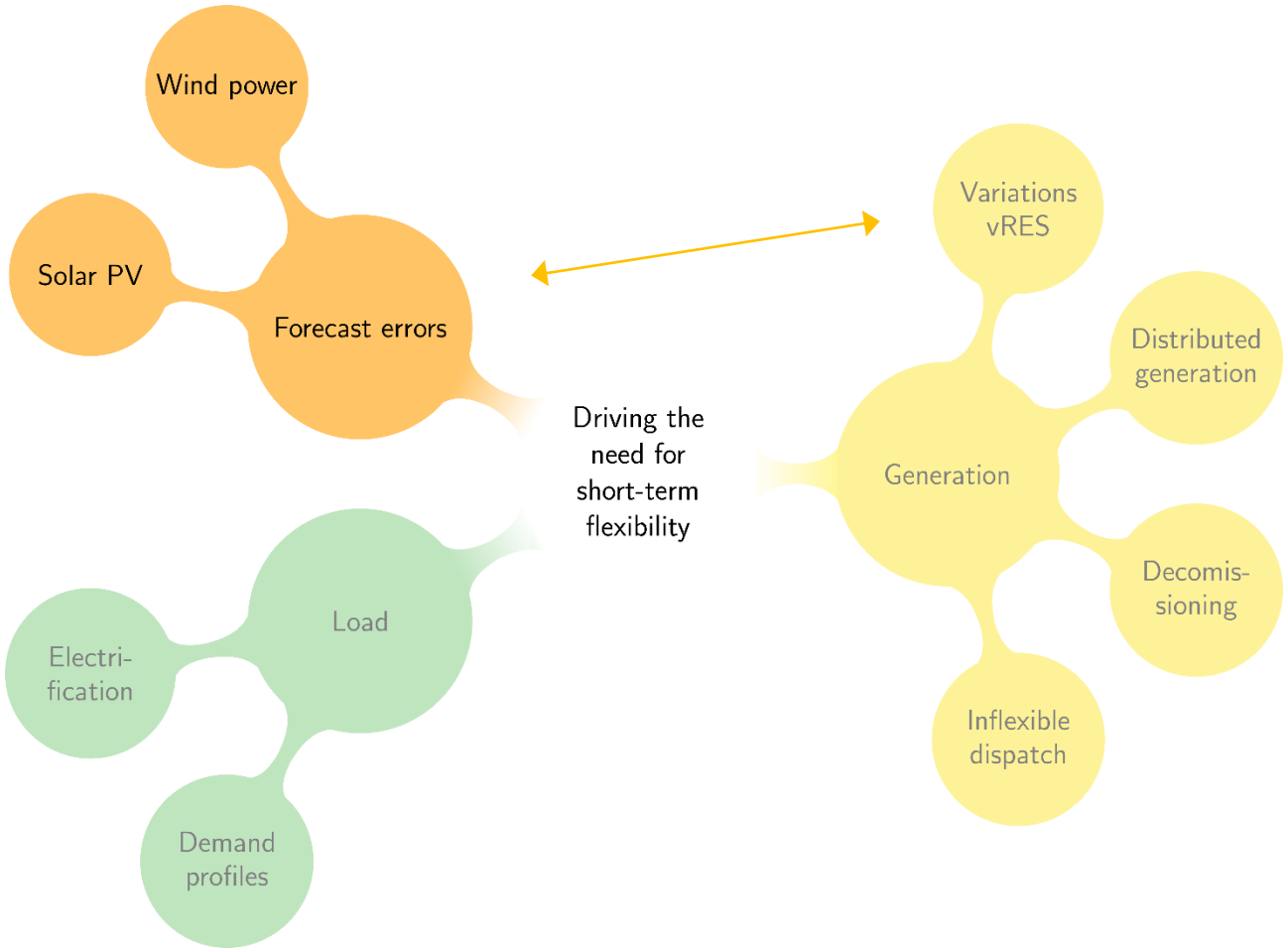

Driving the need for short-term flexibility

Forecasts: wind power, solar PV, load

Accuracy, confidence, robustness

Geographical smoothing

Lack of observability

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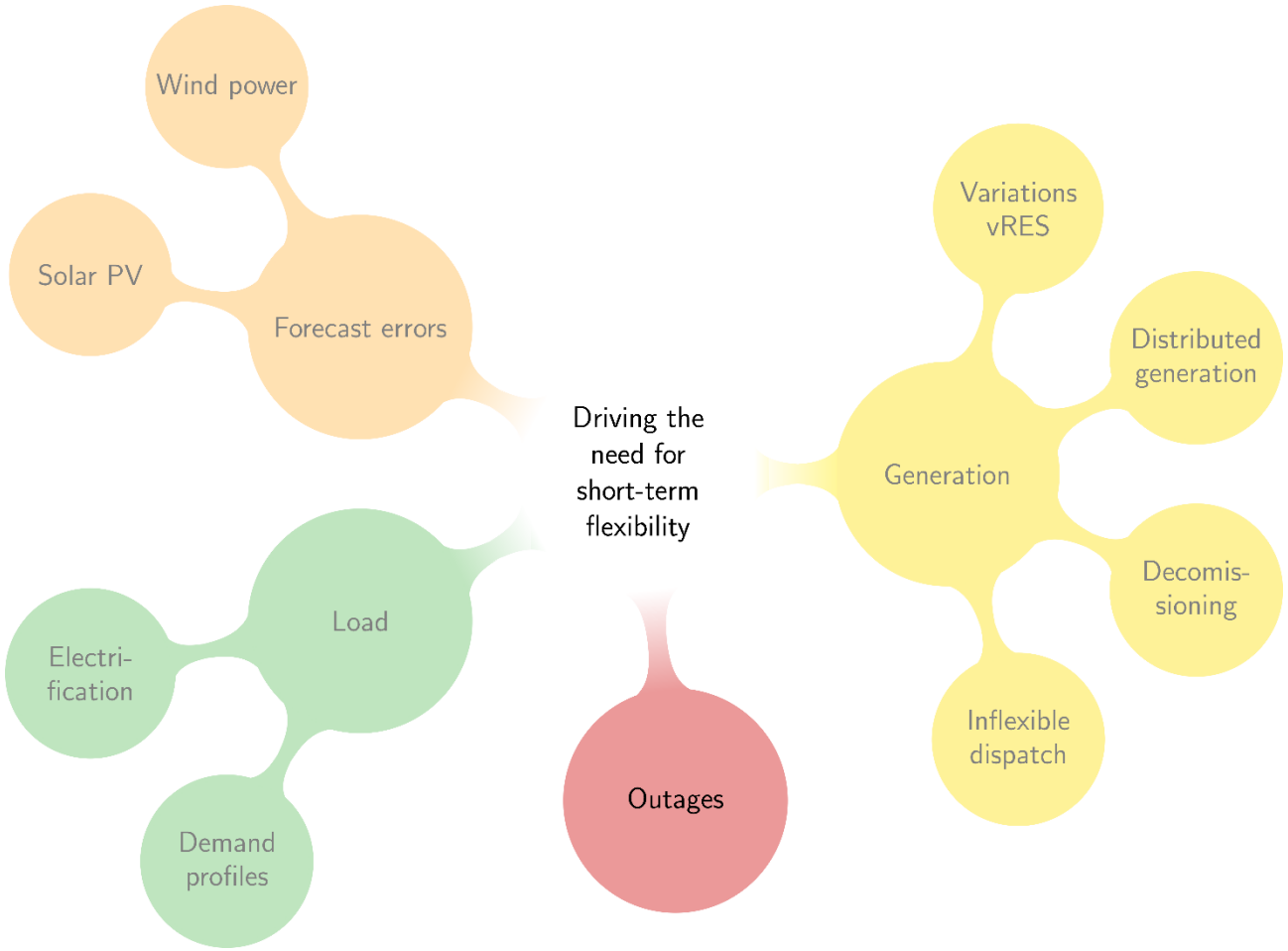

Driving the need for short-term flexibility

Outages (generation, load, transmission)

Contigencies (size, probability) → risk

Importance of system size

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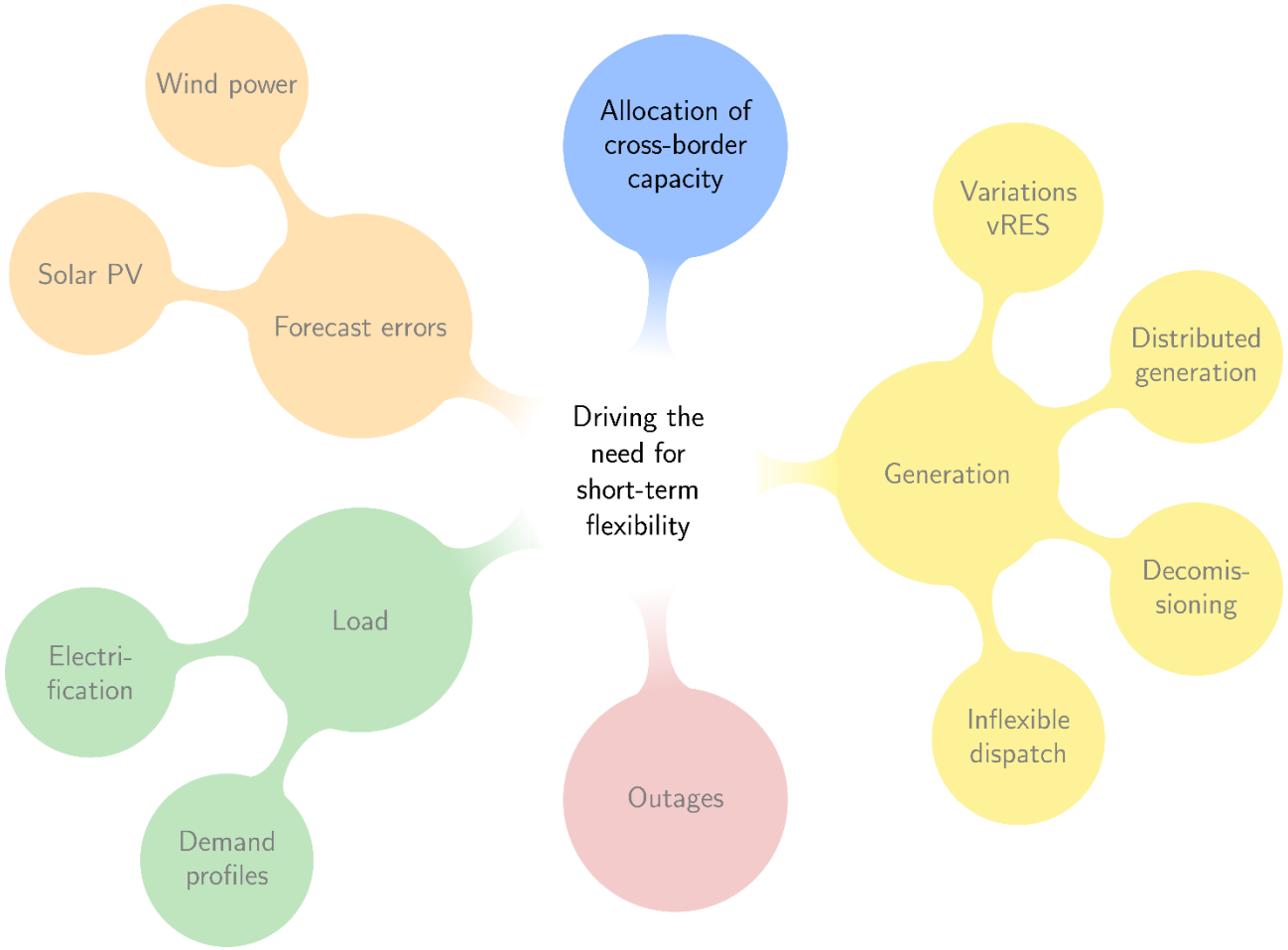

Driving the need for short-term flexibility

Allocation of transmission capacity

- Day-ahead
- Intraday
- Real time

Suggested research topic ☺

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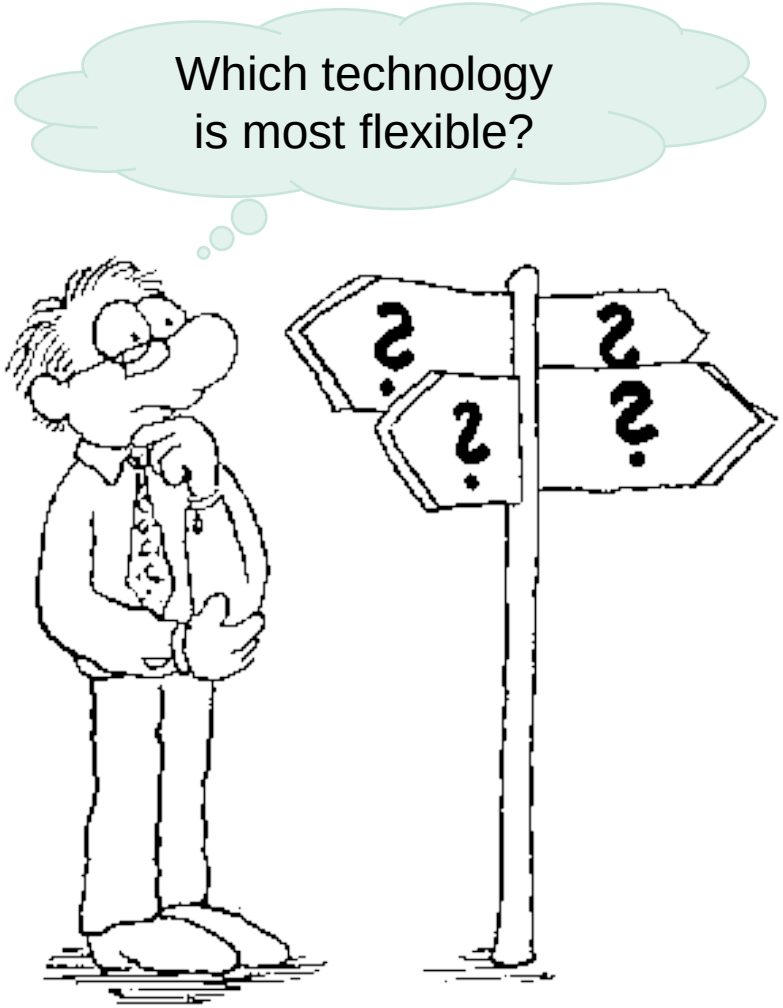
Is more flexibility needed, and **how will it be provided?**



Sources of flexibility (technical sources)

Generation

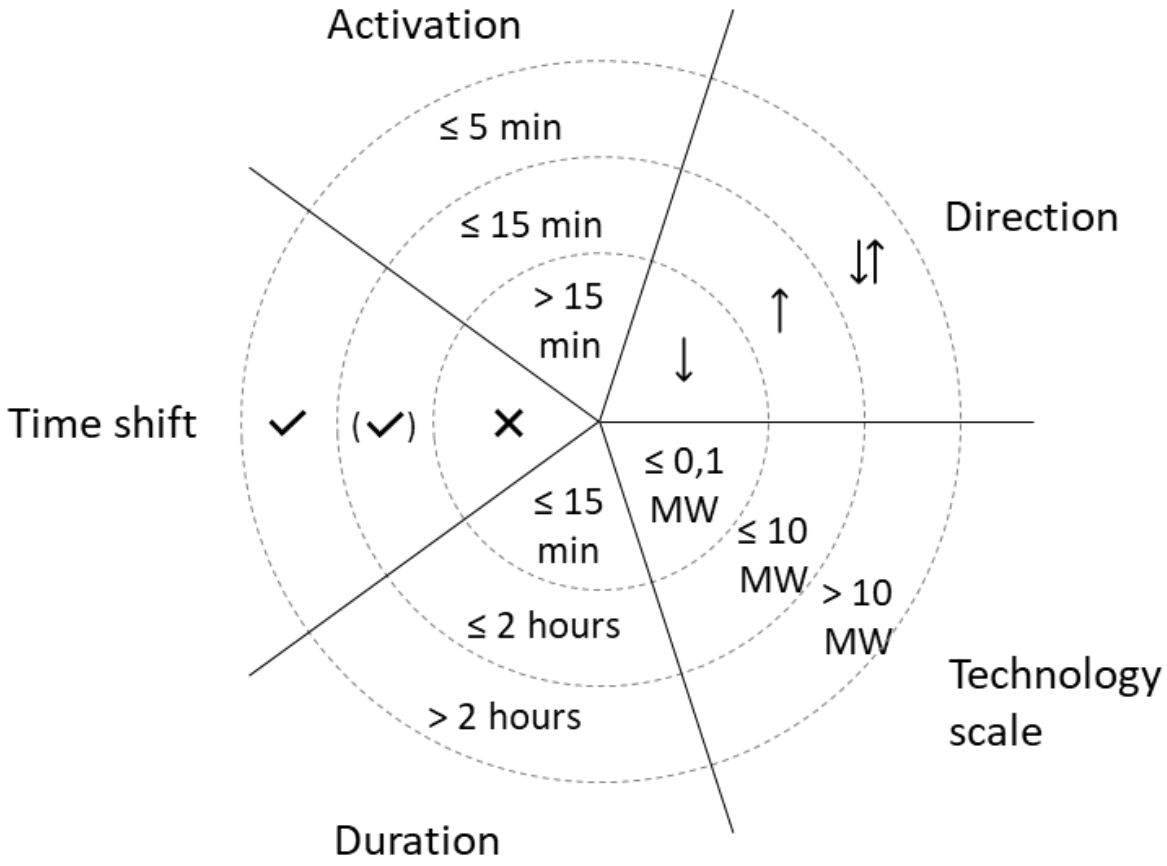
Storage

Demand response

Transmission

Aggregation

Picture: web.



Classification

Activation

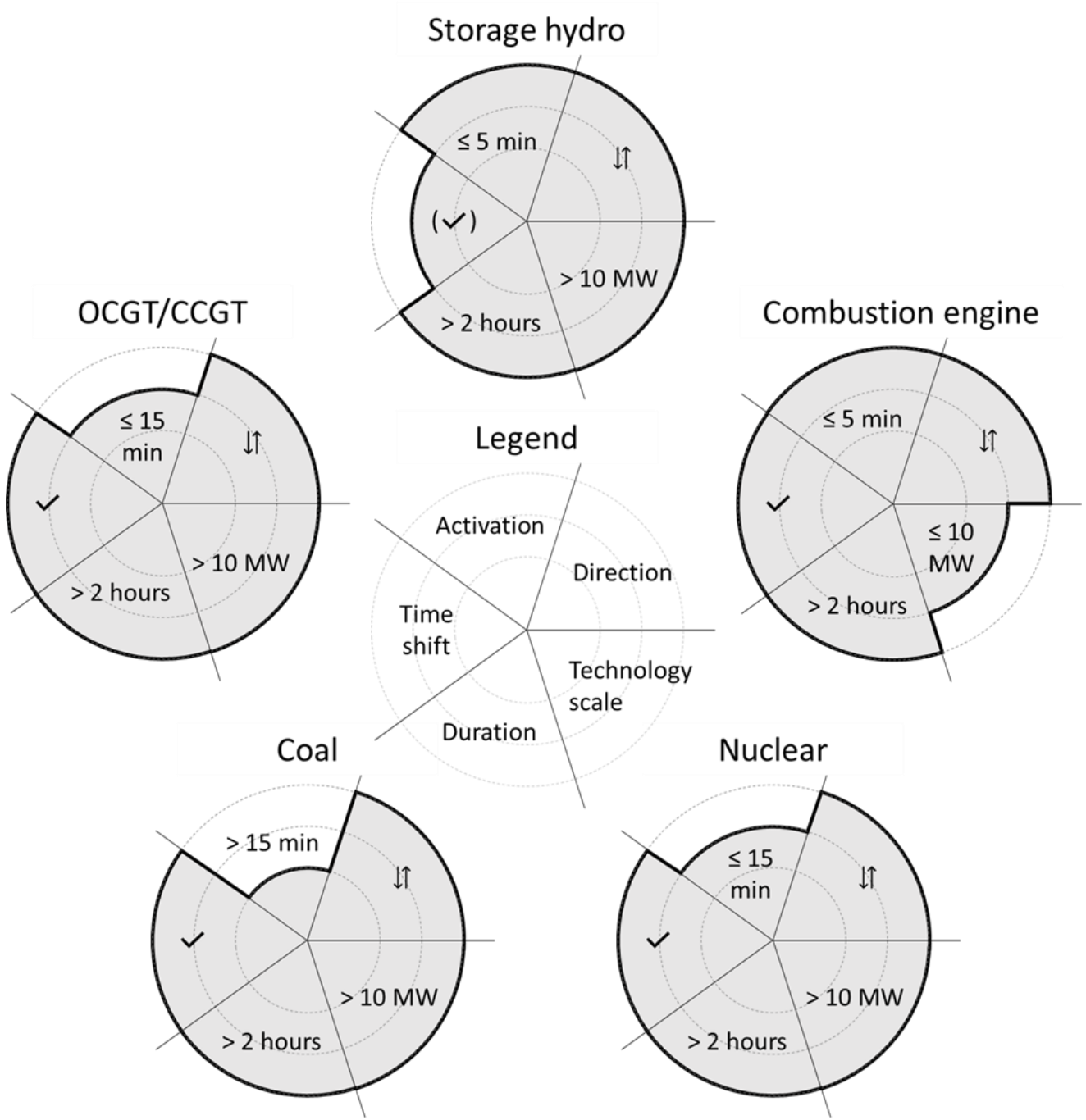
Direction

Technology scale

Duration

Time shift

→ ”The larger the circle, the more flexible.”



Sources of flexibility (technical sources)

Conventional generation

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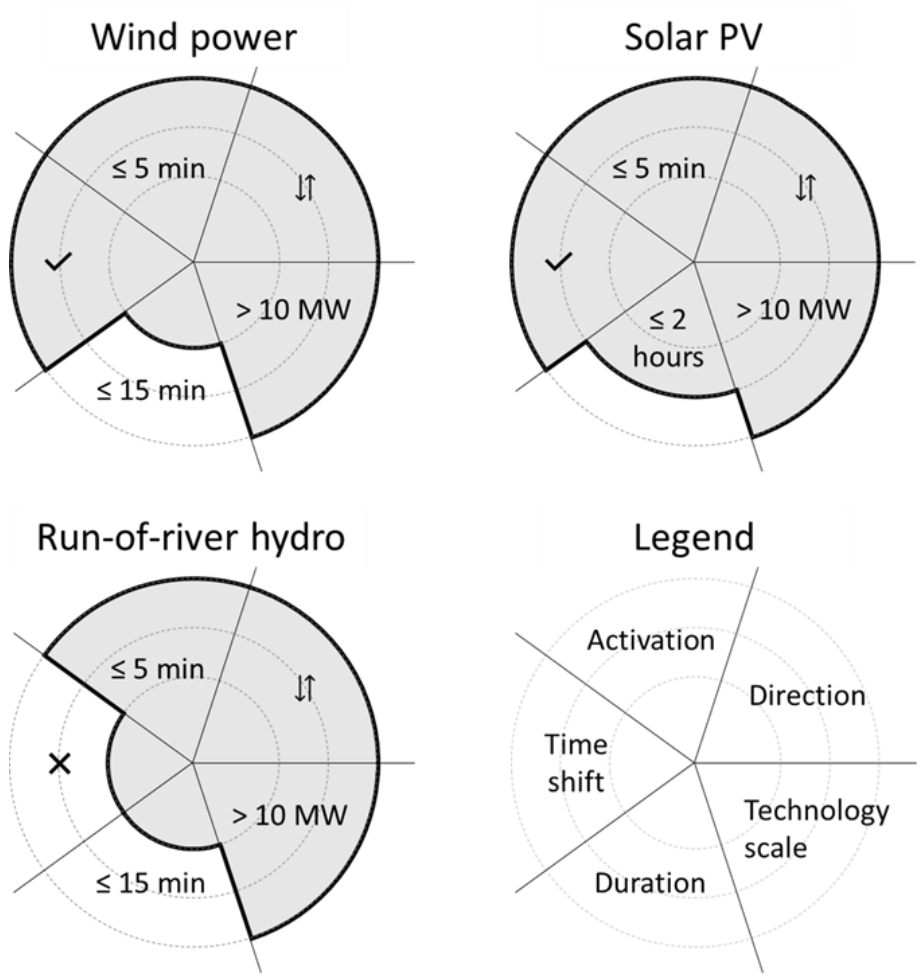

Sources of flexibility (technical sources)

Conventional generation

Variable renewable generation

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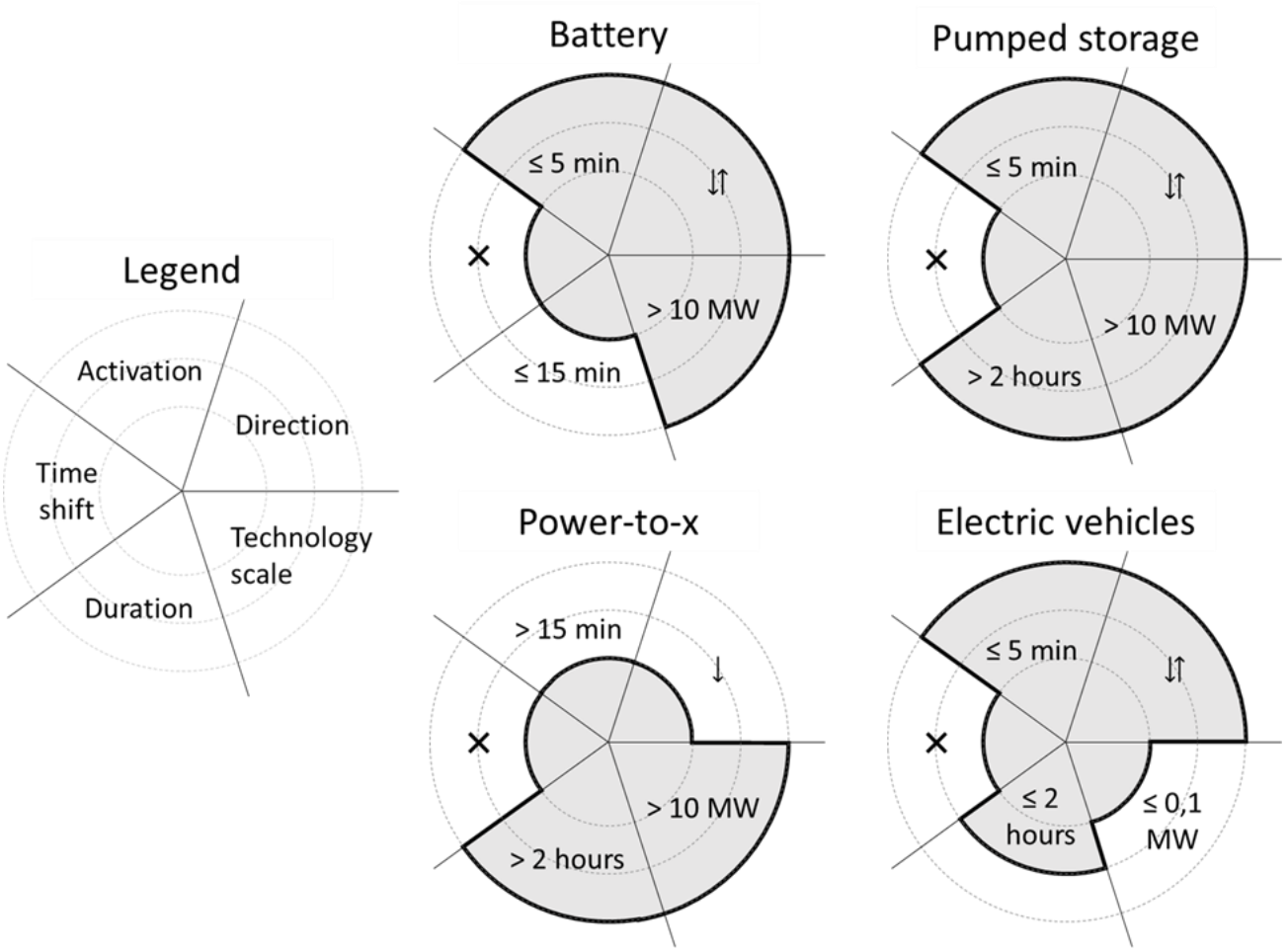

Sources of flexibility (technical sources)

Conventional generation

Variable renewable generation

Energy storage

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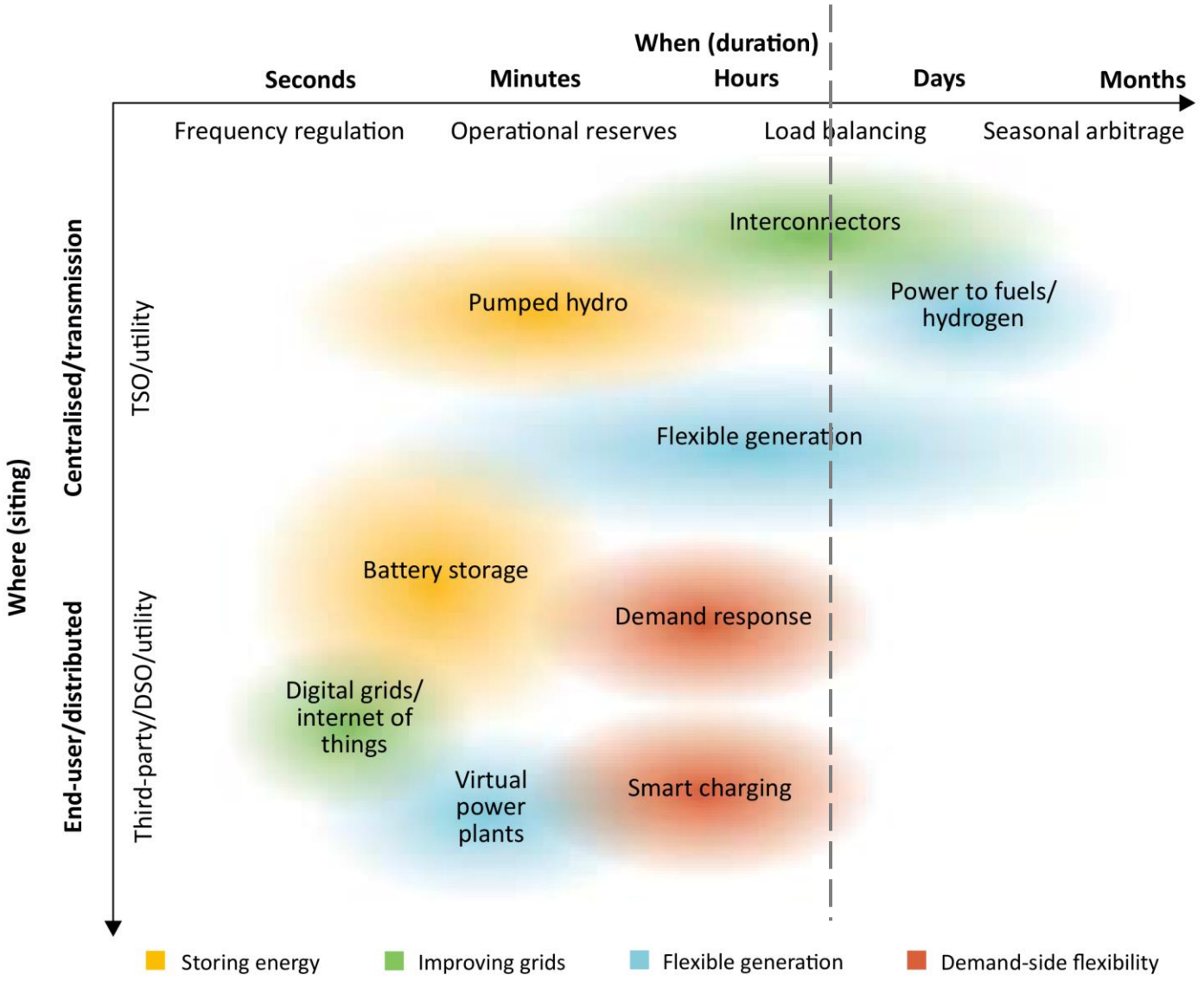
Real time ……..12 hours



Sources of flexibility (technical sources)

Conventional generation

Variable renewable generation

Energy storage

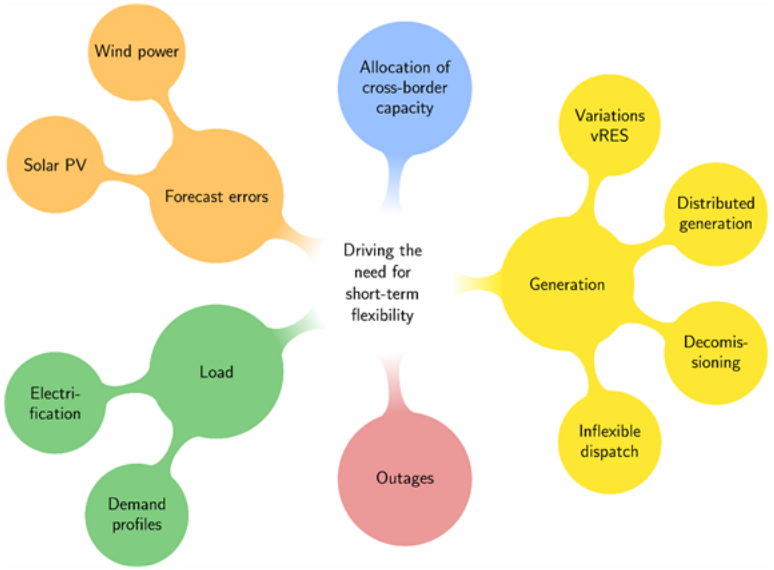
Demand response

Transmission

Aggregation

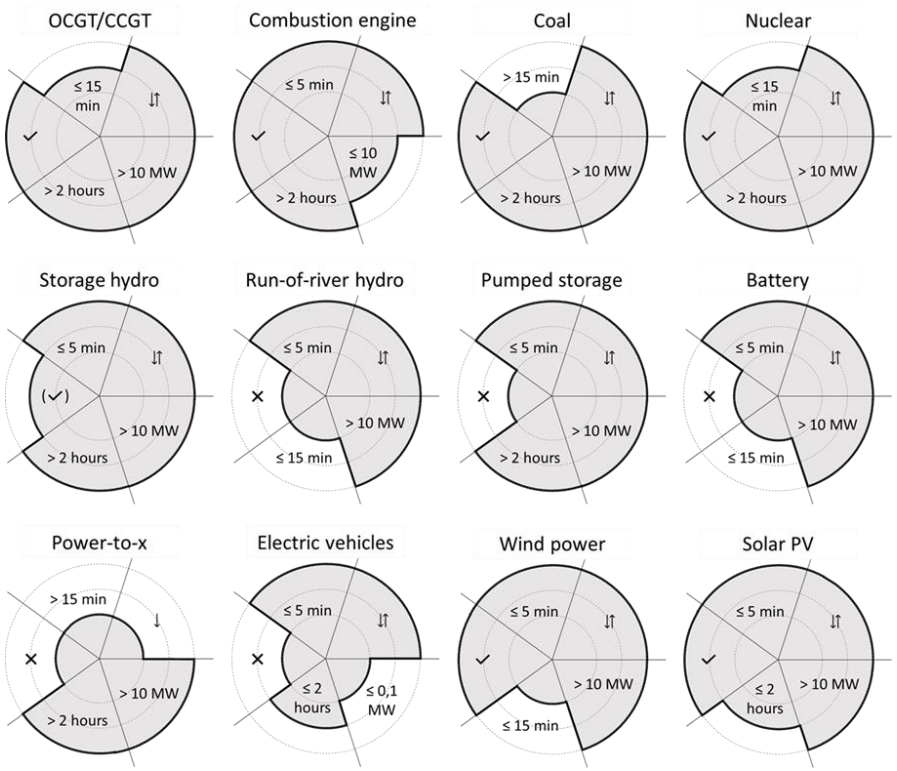
Picture: IEA World Energy Outlook 2018.

Summary: drivers & solutions as perceived by WG C5.27



- Variability…
- Forecast errors…
- Observability…

…of load, generation and transmission **requires broad range** of solutions.



- Flexibility exists, but comes at a cost
- Different characteristics & large potential
- Offered flexibility = f(value of flexibility, cost of providing flexibility,…)

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Survey results

Survey overview

- Background information
- Characteristics of power system and market

- Drivers that might change the need for flexibility
- Expected providers of future short term flexibility
- Arrangements to increase future short term flexibility

- Answers subdivided in 4 four time horizons
  - ✓ **Instantaneous, < 5 min, < 15 min, < 12 hours**
  - ✓ **Indicate if effect is low, medium, high**

➢Quite many answers → Challenging to present

➢20 of 22 respondents were TSOs

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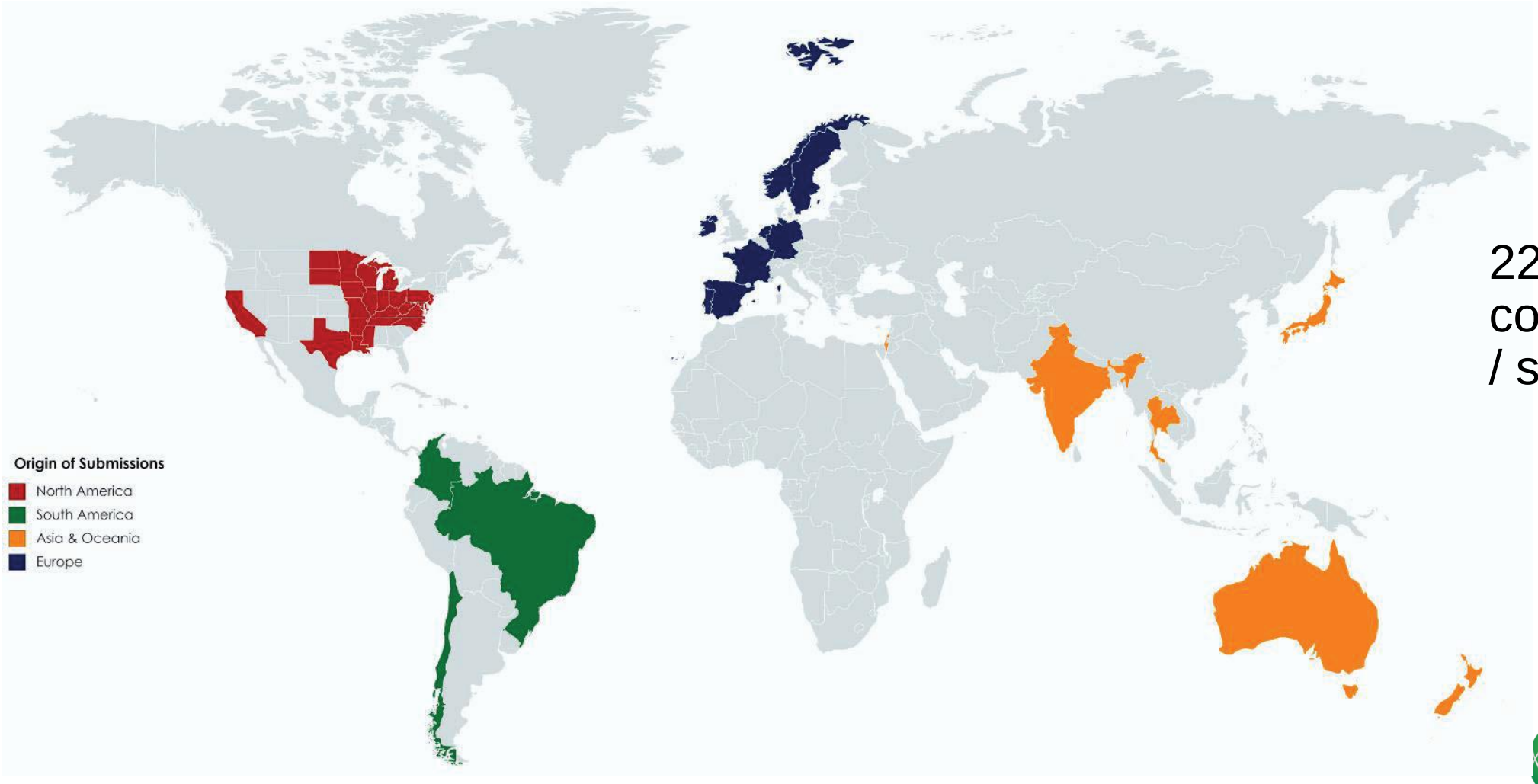
Responses



22 countries / states

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Presentation of survey results

Percentage that expects
L(ow) – M(edium) – H(igh) impact
(each line sums to 100%

Regions:
SA – South America, NA – North America,
A – Asia&Oceania, EU – Europe

Number of respondents on this question

Increase wind generation, TSO level	L %	M %	H %	all 21	SA 3	NA 4	A 6	EU 8
Real time (< 2s)	33	29	38	2.0	2.7	1.5	1.7	2.4
Almost real time (< 5 minutes)	36	27	36	2.0	2.7	1.5	1.8	2.1
Very short term (≥ 5 and < 15 minutes)	18	32	50	2.3	3	2.0	1.8	2.6
Short term (≥ 15 minutes and < 12 hours)	29	14	57	2.3	3	1.7	1.5	2.8

Colours indicate level of impact	
	Low impact
	Medium impact
	High impact

1: Low impact,
2: Medium impact,
3: High impact

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Survey results

Driving the need for flexibility – 1(2)

(disregarding timing dimension)

	L	M	H		all	SA	NA	A	EU
	%	%	%						
Increased wind generation, TSO level	29	25	45		2.2	2.8	1.7	1.7	2.5
Increased solar PV generation, TSO level	37	22	41		2.0	3.0	1.7	1.5	2.2
Increased wind generation, DSO level	33	30	37		2.0	2.7	1.5	1.6	2.3
Increased solar PV generation, DSO level	24	20	56		2.3	3.0	2.0	2.3	2.2
More volatile demand (due to electric vehicles, demand response etc).	45	29	25		1.8	1.7	1.4	1.7	2.1
More volatile exchange with other interconnected regions/countries	51	38	11		1.6	1.3	1.3	1.8	1.8
Reduced contribution from conventional plants	35	35	30		1.9	2.3	1.5	1.8	2.1
Inflexibility of conventional power plants	42	28	30		1.9	2.2	1.7	1.8	1.9
Changes in energy market design	51	21	27		1.8	2.2	1.4	1.5	2.0

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Survey results

Driving the need for flexibility – 1(2)

(disregarding timing dimension)

Average impact evaluation medium or larger

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More volatile exchange with other interconnected regions/countries	51	38	11		1.6	1.3	1.3	1.8	1.8
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Survey results

Driving the need for flexibility – 2(2)

(disregarding timing dimension)

	L	M	H		all	SA	NA	A	EU
	%	%	%						
Changes in system operational, scheduling and dispatch policies (e.g. externally imposed regulation)	48	24	28		1.8	2.2	1.3	1.7	2.0
Increased levels of behind the meter generation	40	31	29		1.9	2.3	1.8	2.0	1.7
Increased issues with transmission system congestion	43	30	26		1.8	1.8	1.9	1.3	2.1
System level forecasting errors and lack of observability	21	36	43		2.2	2.9	2.3	2.0	2.1
Transmission/interconnector outages	54	21	25		1.7	2.0	1.1	1.6	1.9
Generation outages	52	33	15		1.6	1.8	1.3	1.4	1.9
Changing weather patterns possibly caused by climate change	55	24	21		1.7	2.5	1.4	1.7	1.5

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Survey results

Driving the need for flexibility – 2(2)

(disregarding timing dimension)

Average impact evaluation medium or larger

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Survey results

Expected providers for short term flexibility

(disregarding timing dimension)

	L	M	H		all	SA	NA	A	EU
	%	%	%						
Existing conventional fossil generation	41	18	41		2.0	2.3	2.3	2.4	1.6
New conventional fossil generation	45	20	35		1.9	1.6	2.3	2.2	1.6
Existing hydro, including pumped storage	23	12	64		2.4	2.9	2.4	2.6	2.1
New hydro, including pumped storage	37	10	54		2.2	2.9	2.8	2.2	1.8
Biomass generation	78	15	7		1.3	1.1	1.3	1.1	1.4
Wind generation	33	40	26		1.9	1.8	2.1	1.4	2.3
PV generation	55	24	21		1.7	1.7	1.8	1.3	1.8
Demand response, industrial level	32	27	41		2.1	2.6	1.3	1.8	2.5
Demand response, small consumers	47	29	24		1.8	1.3	1.3	1.7	2.2
Batteries	19	26	55		2.4	2.6	2.1	2.4	2.3
Other forms of storage (flywheels,…)	71	8	21		1.5	1.0	1.7	1.5	1.6
Power to gas	77	17	6		1.3	1.2	1.4	1.0	1.3
Hybrid flexible heating systems with electricity and other energy sources	67	27	6		1.4	1.3	1.1	1.0	1.6
Heat (cold) storage	85	9	6		1.2	1.0	1.1	1.0	1.4
Increased capacity of and/or new AC interconnectors	44	22	33		1.9	2.0	1.4	2.4	1.9
Increased capacity of and/or new DC interconnectors	36	26	38		2.0	1.7	1.6	1.6	2.5

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Survey results

Expected providers for short term flexibility

(disregarding timing dimension)

Average impact evaluation medium or larger

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Survey results

New arrangements – 1(2)

(disregarding timing dimension)

Note: these questions were answered by fewer respondents than the other groups, typicaly 50-60 % against 90-100 %. Sometimes very few for a whole region.

	L %	M %	H %		all	SA	NA	A	EU	
Increased volume of droop control (in Europe: FCR)[1]	61	20	20		1.6	1.7	1.0	1.8	1.7	
New providers of droop control[1]	24	33	42		2.2	1.0	2.3	2.6	2.5	
Increased volume of secondary (synchronized, spinning) reserves (in Europe: aFRR)[2]	40	30	30		1.9	2.0	1.3	2.1	1.9	
New providers of secondary (synchronized, spinning) reserves[2]	30	46	24		1.9	1.0	2.0	2.4	2.1	
Increased volume of tertiary (non-synchronized, non-spinning) reserves (in Europe: mFRR)[3]	42	35	23		1.8	2.2	1.7	2.5	1.6	
New providers of tertiary (non-synchronized, non-spinning) reserves[3]	38	41	22		1.8	1.3	1.9	1.8	2.1	
Establish intraday markets (if not already present)[4]	64	23	14		2.0	1.7	1.0	2.7	2.0	very few respondents!
Improve functioning of existing intraday markets[4]	43	22	35		2.5	1.0	3.0	2.0	2.8	few respondents!

[1]: averages over real time and almost real time (0 to 5 minutes)
[2]: averages over almost real time and very short term (2 seconds to 15 minutes)
[3]: averages over very short term and short term (5 minutes to 12 hours)
[4]: averages over short term (15 minutes to 12 hours)

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Survey results

New arrangements – 1(2)

(disregarding timing dimension)

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Survey results

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New arrangements – 2(2)

(disregarding timing dimension)

	L %	M %	H %		all	SA	NA	A	EU
Lower barriers for participation in balancing markets	27	7	66		2.4	1.8	2.3	2.8	2.4
• Lower minimum bid size	42	16	42		2.0	1.3	2.0	1.7	2.2
• Allow more aggregation, e.g. from unit to larger area	23	26	51		2.3	1.3	2.7	2.0	2.4
• Reduce gate closure times	46	35	19		1.7	1.3	1.5	1.6	1.9
• Decrease commitment period (e.g. 4 hours instead of full day)	49	23	28		1.8	1.1	1.3	2.0	2.0
Establish/enhance cooperation between DSOs and TSOs in order to utilize mutual resources	19	23	57		2.4	1.9	2.7	2.2	2.5
Increased integration of balancing/flexibility arrangements with other regions/markets	37	12	50		2.1	1.3	2.0	2.2	2.4
Changing real-time/balancing market arrangements to better reflect the value of flexibility	25	38	37		2.1	2.0	2.3	2.2	2.0
Changing capacity mechanism arrangements to better reflect the value of flexibility	51	28	21		1.7	1.5	2.5	1.5	1.6
Shorter trading and imbalance settlement periods	55	16	29		1.7	1.5	1.2	1.8	1.9
Stronger emphasis on "scarcity pricing", e.g. increased price caps/floors	51	18	31		1.8	1.5	2.3	1.7	1.7
Establish other new markets and/or products	29	25	46		2.2		2.0	2.4	2.1

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Survey results

New arrangements – 2(2)

(disregarding timing dimension)

Average impact evaluation medium or larger

	L %	M %	H %		all	SA	NA	A	EU
Lower barriers for participation in balancing markets	27	7	66		2.4	1.8	2.3	2.8	2.4
• **Lower minimum bid size**	42	16	42		2.0	1.3	2.0	1.7	2.2
• **Allow more aggregation, e.g. from unit to larger area**	23	26	51		2.3	1.3	2.7	2.0	2.4
• Reduce gate closure times	46	35	19		1.7	1.3	1.5	1.6	1.9
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Establish other new markets and/or products	29	25	46		2.2		2.0	2.4	2.1

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Conclusions – 1

- Do we need more flexibility in the future, major drivers:
  - ✓ **Increased wind power production at the TSO level**
  - ✓ **Increased solar PV production at the DSO level**
  - ✓ **System level forecasting errors and lack of observability**
- Major future providers of flexibility
  - ✓ **Existing and new hydro power**
  - ✓ **Batteries**
  - ✓ **Industrial demand response**
- Major arrangements to improve provision of flexibility
  - ✓ **Lower barriers for participating in balancing markets**
  - ✓ **Establishing and enhancing cooperation between TSOs and DSOs**
  - ✓ **Allowing more aggregation, e.g. from unit to areas**

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Conclusions – 2

- Final remarks
  - ✓ **Significant regional variation**
  - ✓ **Also much variation between countries in same region**
  - ✓ **Some results depend on time horizon: real time → 12 hours**
  - ✓ **Renewables and especially wind can also provide flexibility (high score in Europe)**

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