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ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

Smart4RES - Data science for renewable energy prediction

Georges Kariniotakis, MINES ParisTech, ARMINES
Pierre Pinson, Technical University of Denmark (DTU)

05 June 2020

ISGAN Academy webinar #22
Recorded webinars available at: https://www.iea-isgan.org/our-work/annex-8/

iea Energy Technology Network

CLEAN ENERGY MINISTERIAL

ISGAN in a Nutshell

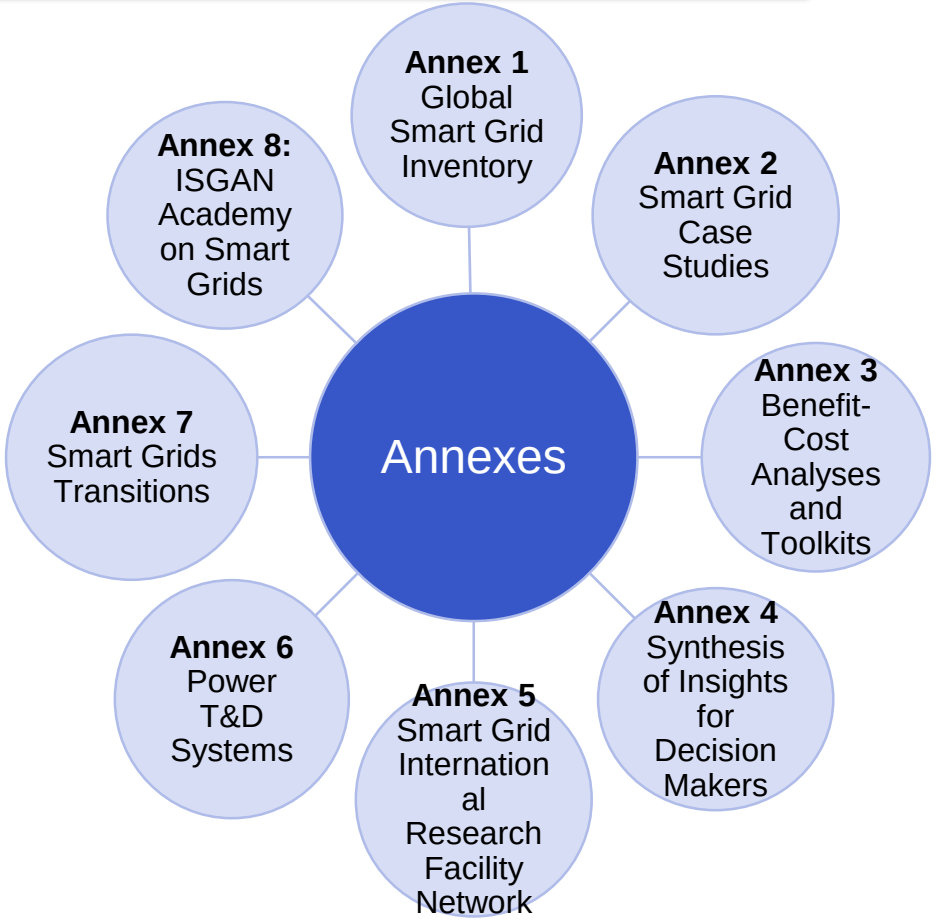
Created under the auspices of:

the Implementing Agreement for a Co-operative Programme on Smart Grids

an initiative of the Clean Energy Ministerial (CEM)

Strategic platform to support high-level government knowledge transfer and action for the accelerated development and deployment of smarter, cleaner electricity grids around the world

International Smart Grid Action Network is the only global government-to-government forum on smart grids.



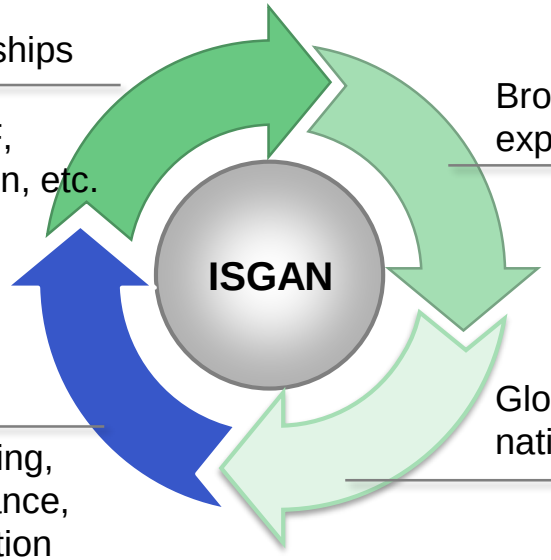
ISGAN's worldwide presence

Value proposition

Strategic partnerships

IEA, CEM, GSGF, Mission Innovation, etc.

Knowledge sharing, technical assistance, project coordination



Broad international expert network

Global, regional & national policy support

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Agenda

1. Introduction to the Smart4RES project	Georges Kariniotakis (MINES ParisTech, ARMINES)
2. Challenges addressed	Georges Kariniotakis (MINES ParisTech, ARMINES)
3. Research for innovative weather and RES production forecasting products	Pierre Pinson (Technical University of Denmark, DTU)

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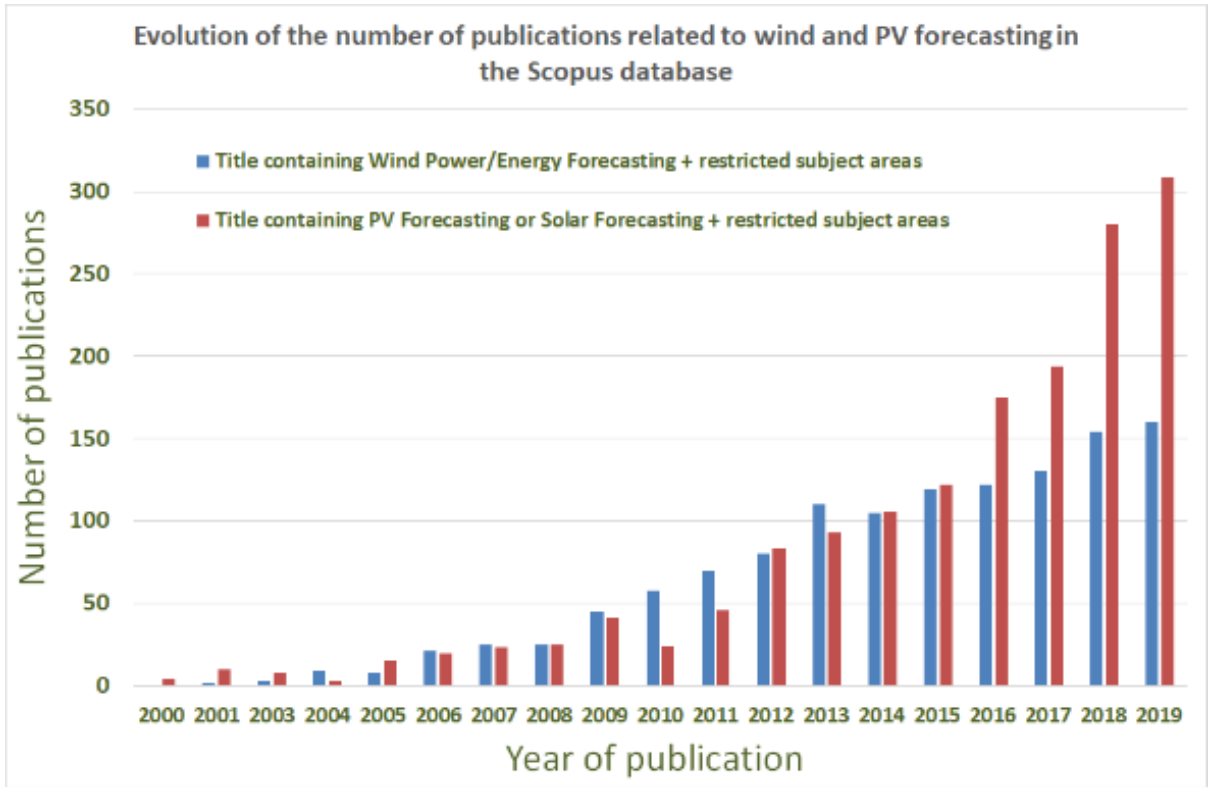
Introduction

- Renewable Energy Sources (RES) forecasting is a “mature” technology with operational tools and services used by different actors
- However, there are several gaps and bottlenecks in the **model & value chain** stimulating significant research worldwide
- **Our objective today:**

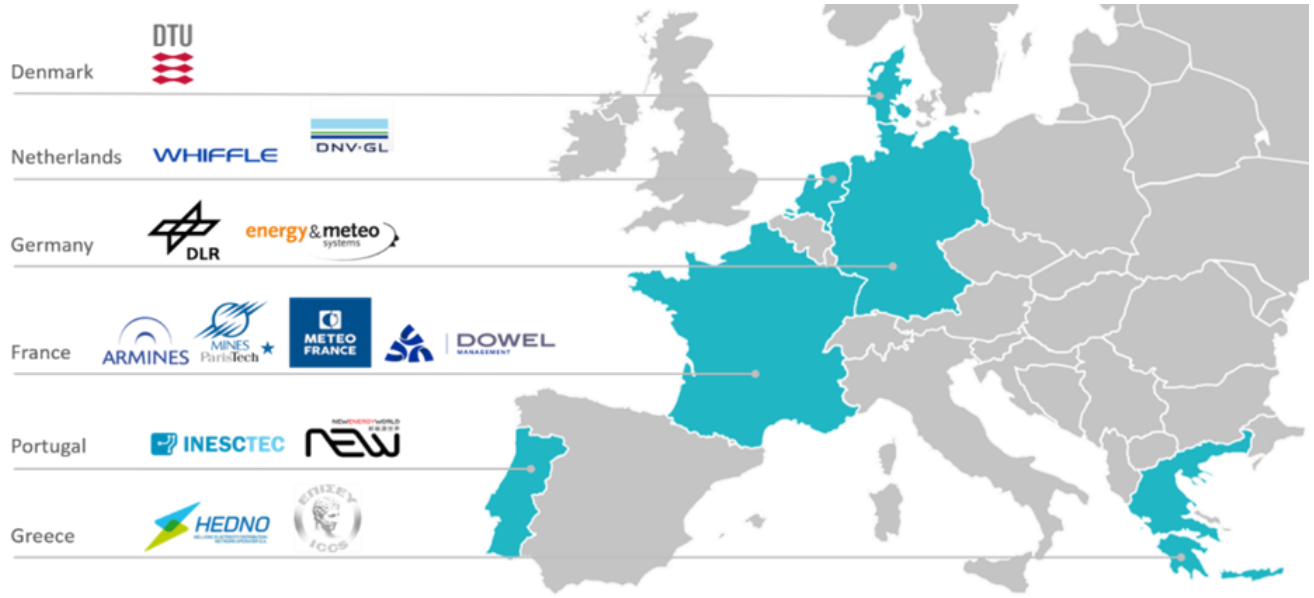
Present the challenges and innovative research towards the next generation tools for RES forecasting and related decision making



What is Smart4RES?

A new collaborative research project aiming to give a new boost to the RES forecasting technology through some disruptive ideas.

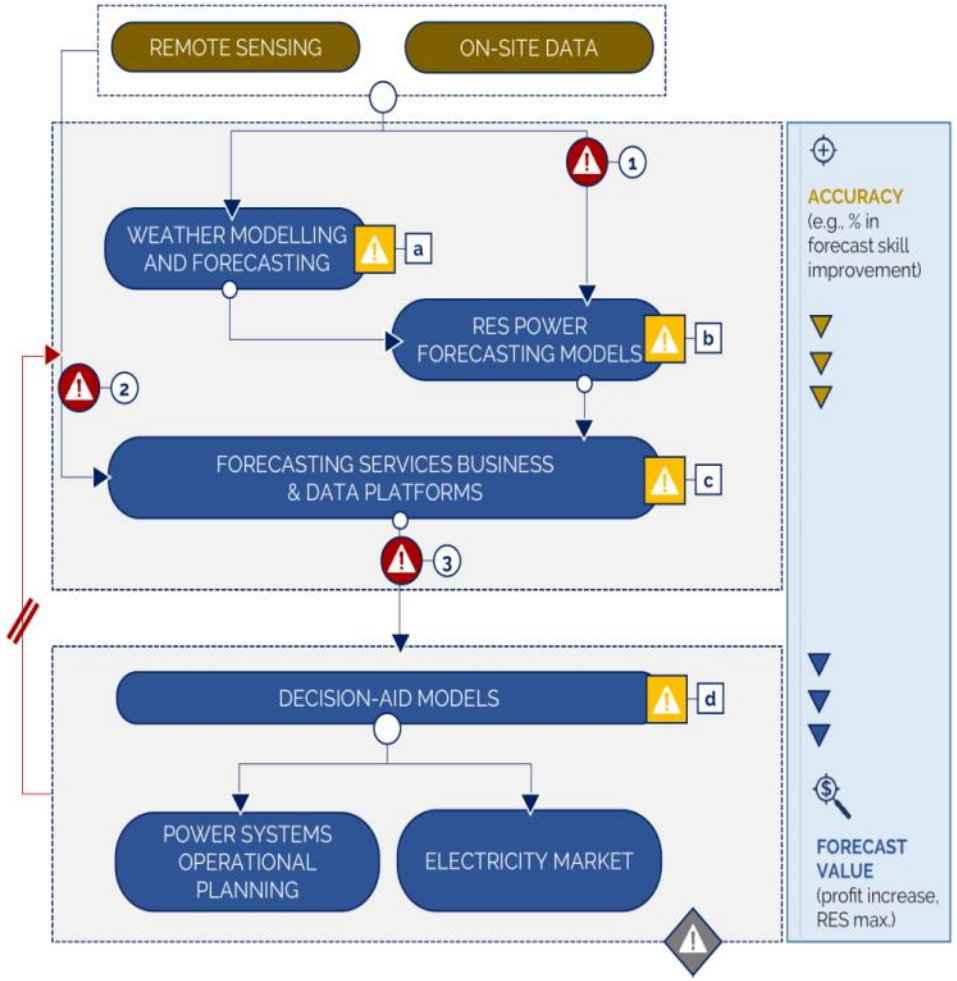
- 6 countries, 12 partners
- Budget: 4 M€
- Duration: 11/2019 - 04/2023
- End-users / Industry / Research / Universities / Meteorologists
- TRLs: 1-5



HORIZON 2020

Smart4RES

The RES forecasting model & value chain

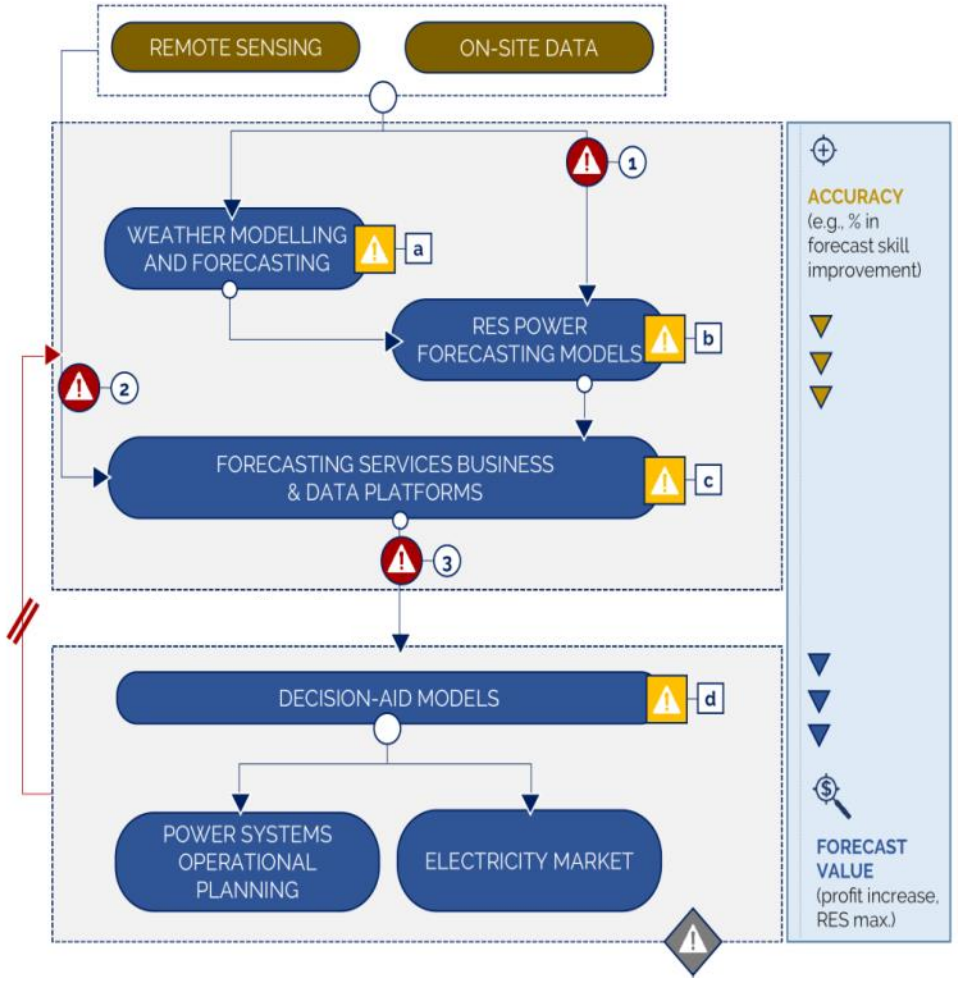


Power, weather variables measurements, satellite images, sky cameras, radars, lidars….

Forecasts of RES production for the next minutes up to the next days

storage management
reserve allocation
predictive maintenance
trading
economic dispatch
scheduling
congestion management

The RES forecasting model & value chain

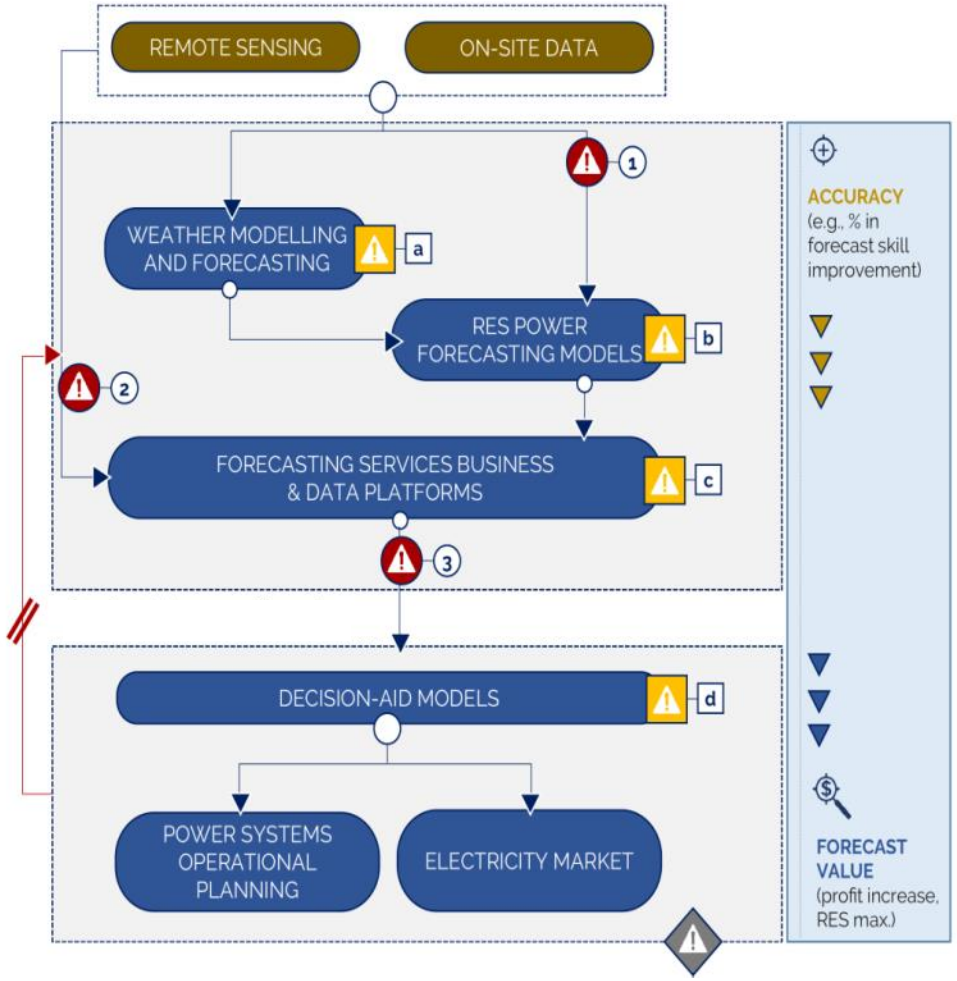


….."mature technology", but forecasting accuracy remains low

Impacts

- Financial losses in electricity markets
- Increased need for costly remedies (reserves, storage, demand response…)
- Limited capacity of RES plants to deliver reliable ancillary services (AS)
- Lower RES acceptability by operators
- RES curtailment
- Higher maintenance costs for RES plants
- …

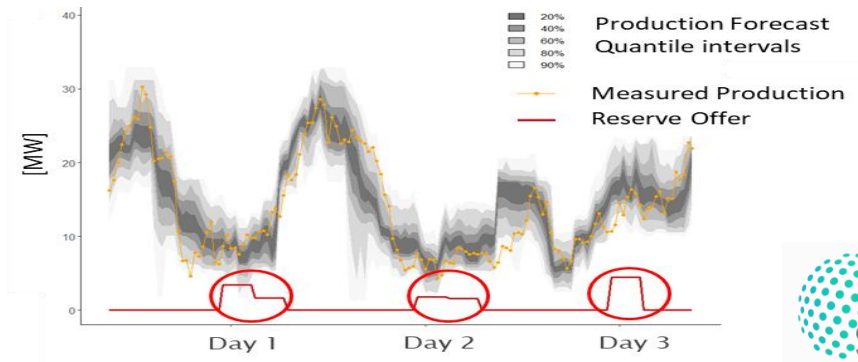
The RES forecasting model & value chain



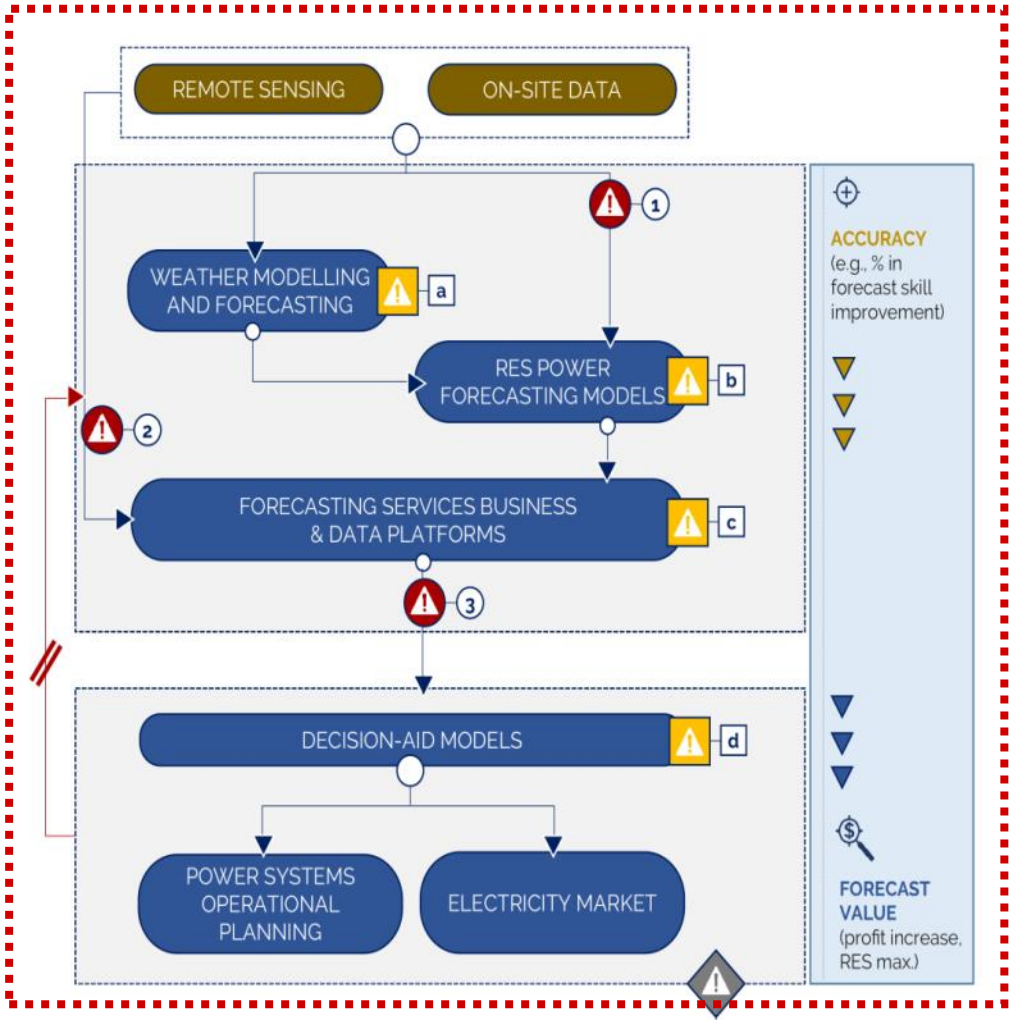
….."mature technology", but forecasting accuracy remains low and new needs are emerging

new needs

- Forecasts for aggregated RES plants
- Forecasts for net load at different points of the grid
- Dedicated forecasts for ancillary service provision
- …

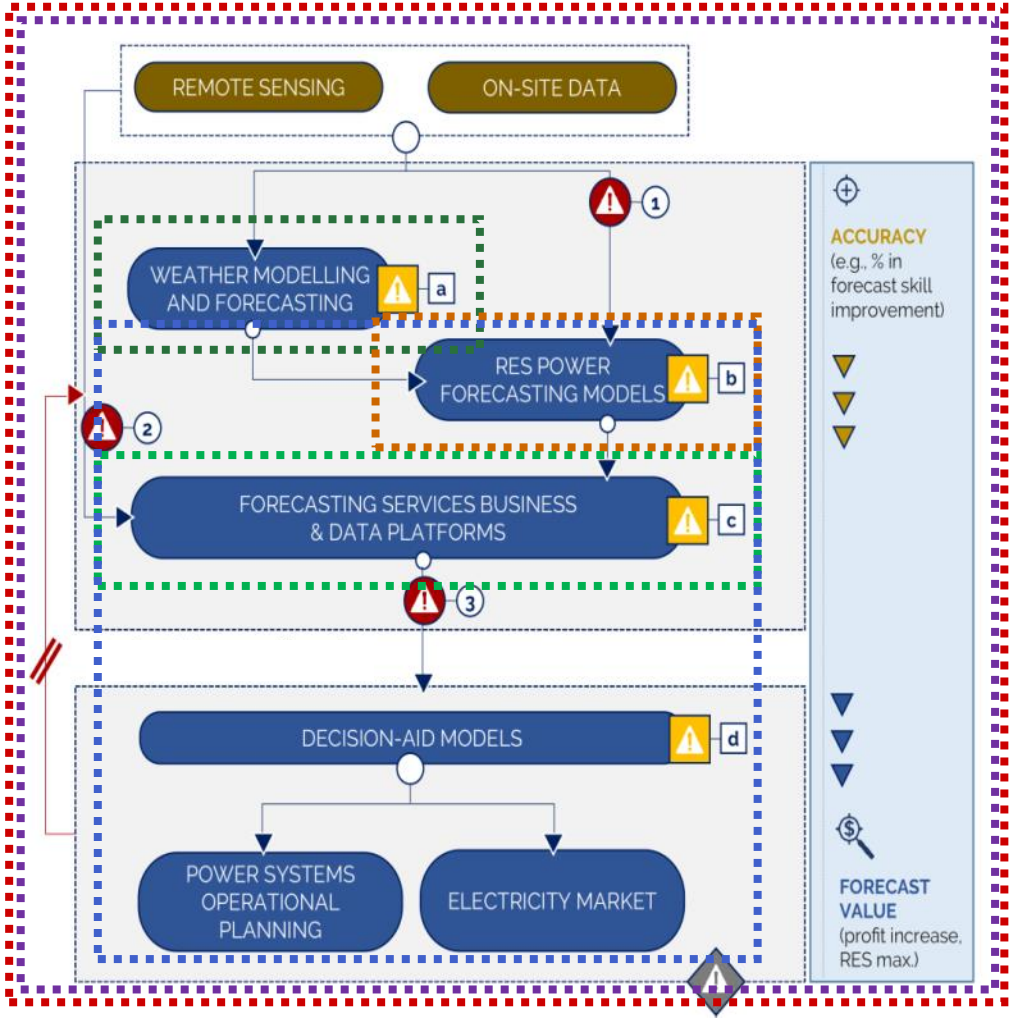


The Smart4RES vision



Achieve outstanding improvement in RES predictability through a holistic approach, that covers the whole model and value chain related to RES forecasting

The Smart4RES objectives



1. Requirements for forecasting solutions to enable 100% RES penetration
2. RES-dedicated weather forecasting with 10-15% improvement using various sources of data and very high resolution approaches.
3. New generation of RES production forecasting tools enabling 15% improvement in performance.
4. Streamline the process of getting optimal value through new forecasting products, data market places, and novel business models
5. New data-driven optimisation and decision aid tools for power system management and market participation
6. Validation of new models in living labs and assessment of forecasting value vs remedies.

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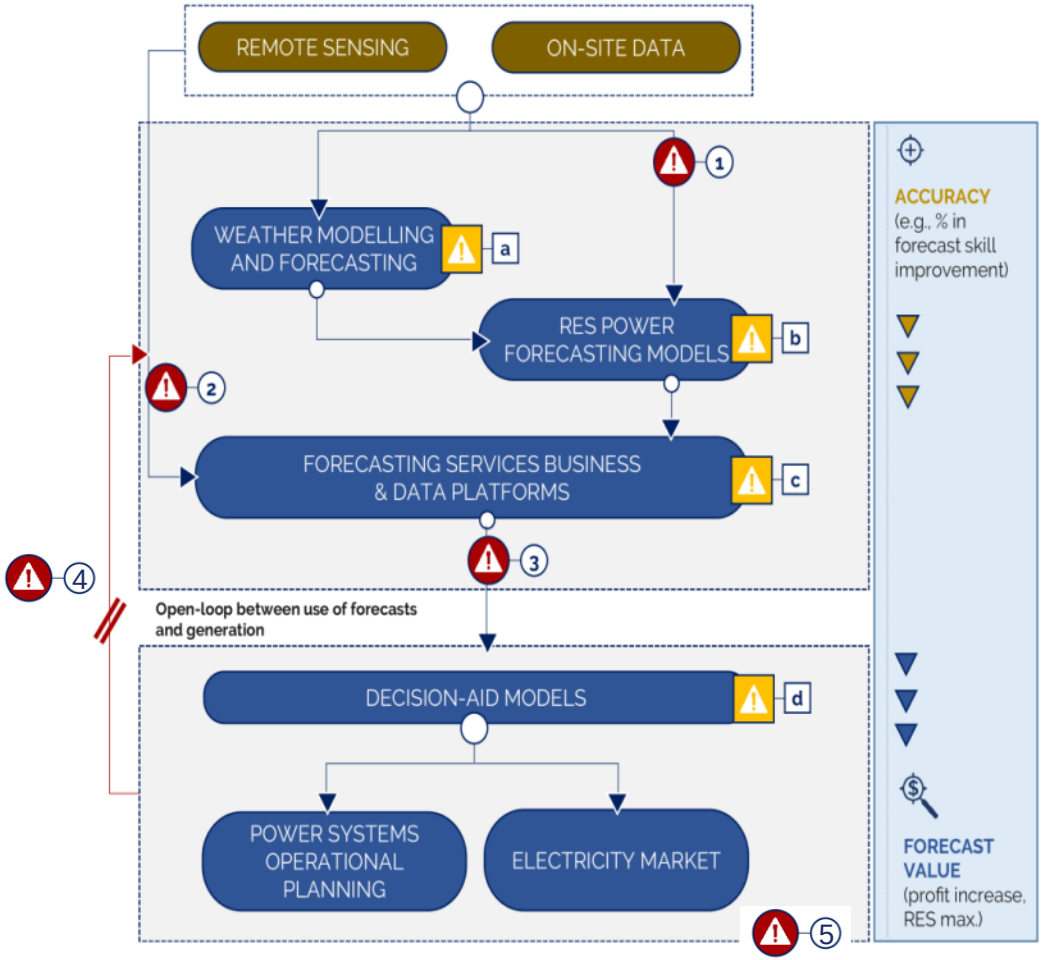
Gaps and bottlenecks



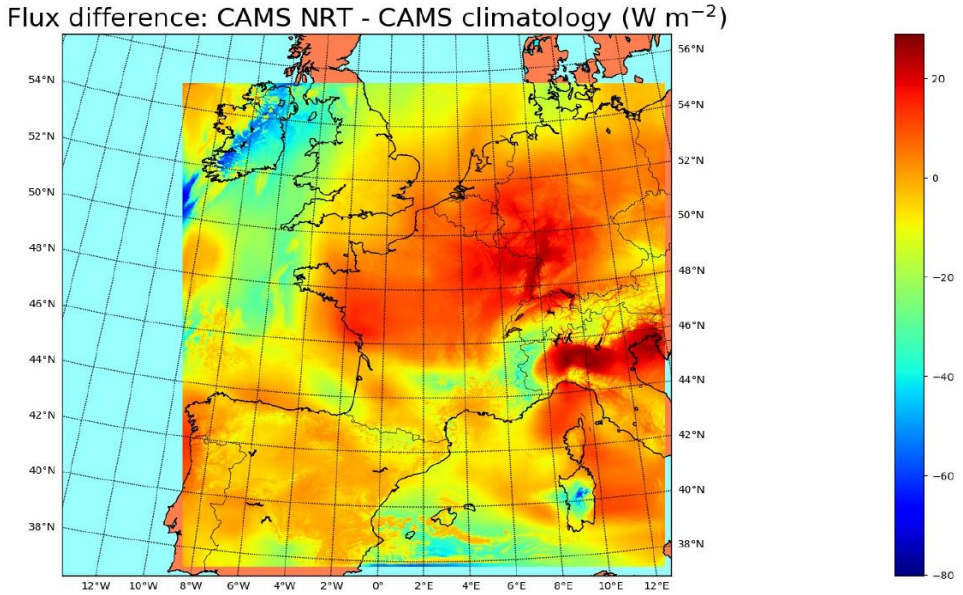
Challenges in the models and the connections:

a

Need for Numerical Weather Prediction (NWP) products adapted to RES use-cases.

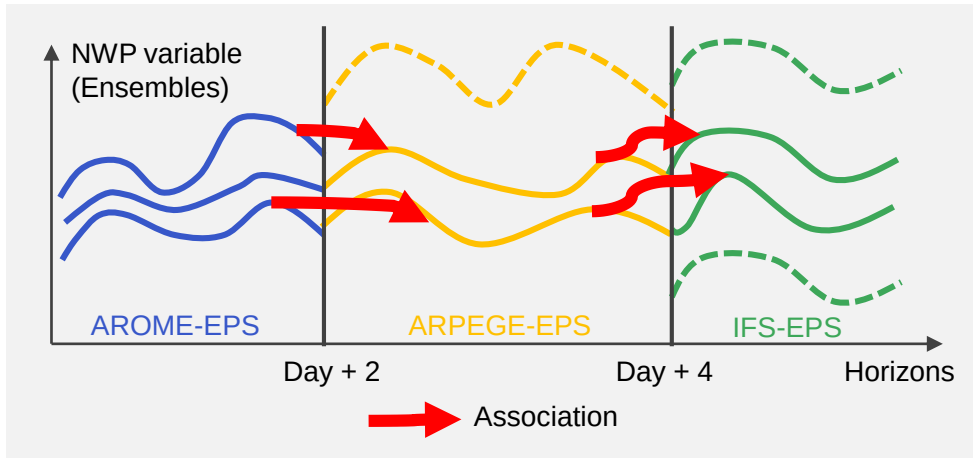
Gaps and bottlenecks (NWPs)

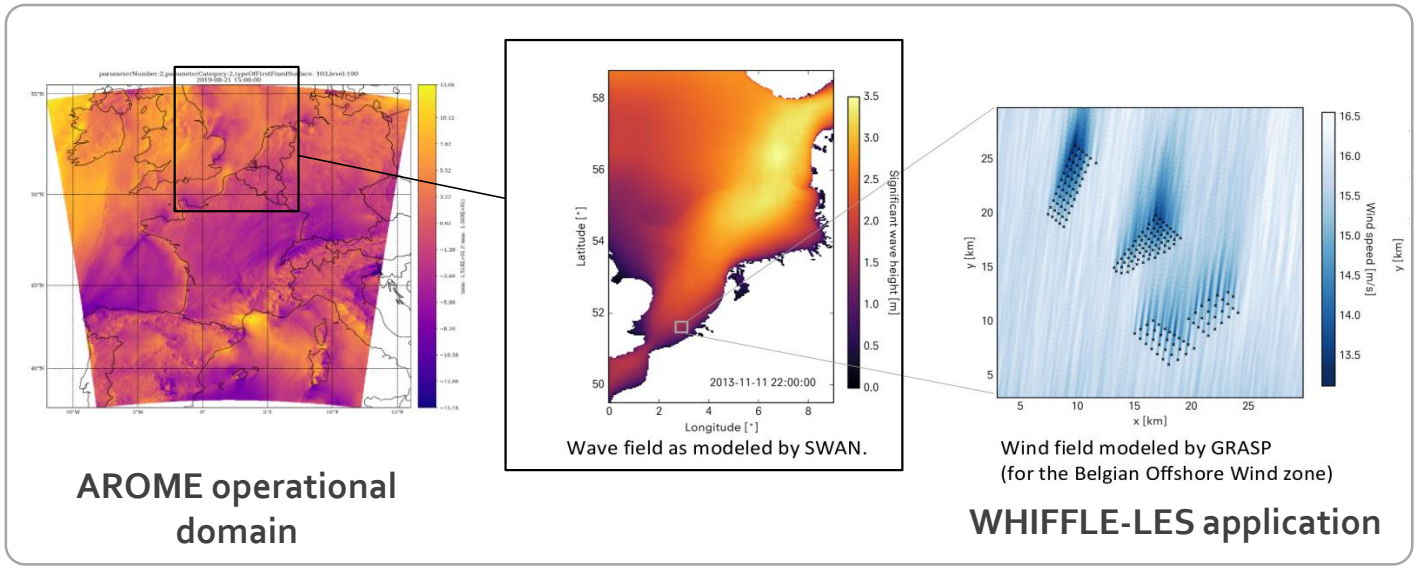
- Improved RES-oriented modelling of NWP variables. I.e.:
  - Refined cloud radiative impact for solar irradiance forecast. Dynamic consideration of aerosols.



Gaps and bottlenecks (NWPs)

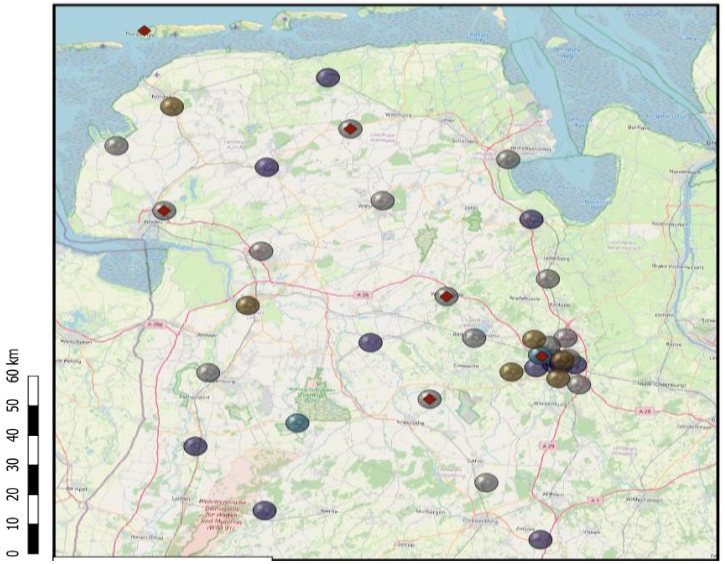
- Improved RES-oriented modelling of NWP variables. I.e.:
  - Refined cloud radiative impact for solar irradiance forecast. Dynamic consideration of aerosols.
- Need for seamless NWPs in applications
- Need for higher spatial/temporal resolution & updates frequency





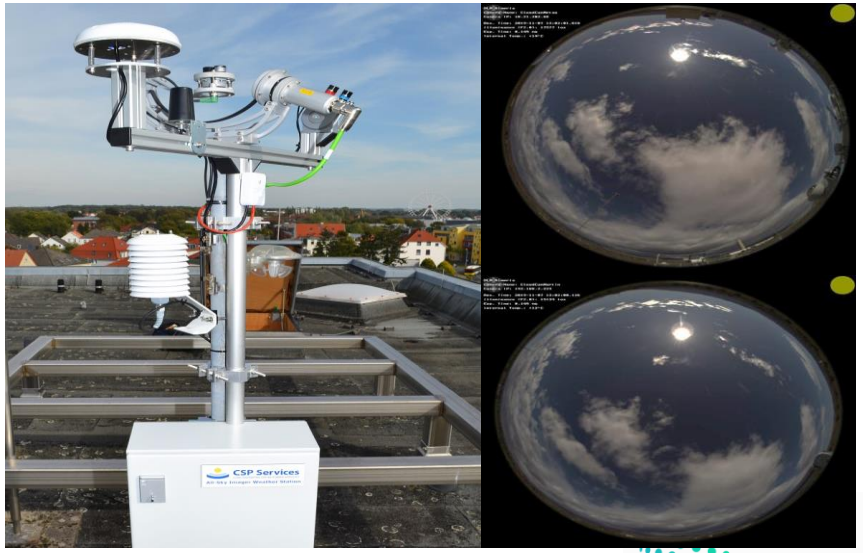
Gaps and bottlenecks (NWPs)

- Improved RES-oriented modelling of NWP variables. I.e.:
  - Refined cloud radiative impact for solar irradiance forecast. Dynamic consideration of aerosols.
- Need for seamless NWPs in applications.
- Need for higher spatial/temporal resolution & updates frequency
- Better modelling of weather conditions through remote sensing (sky imaging)

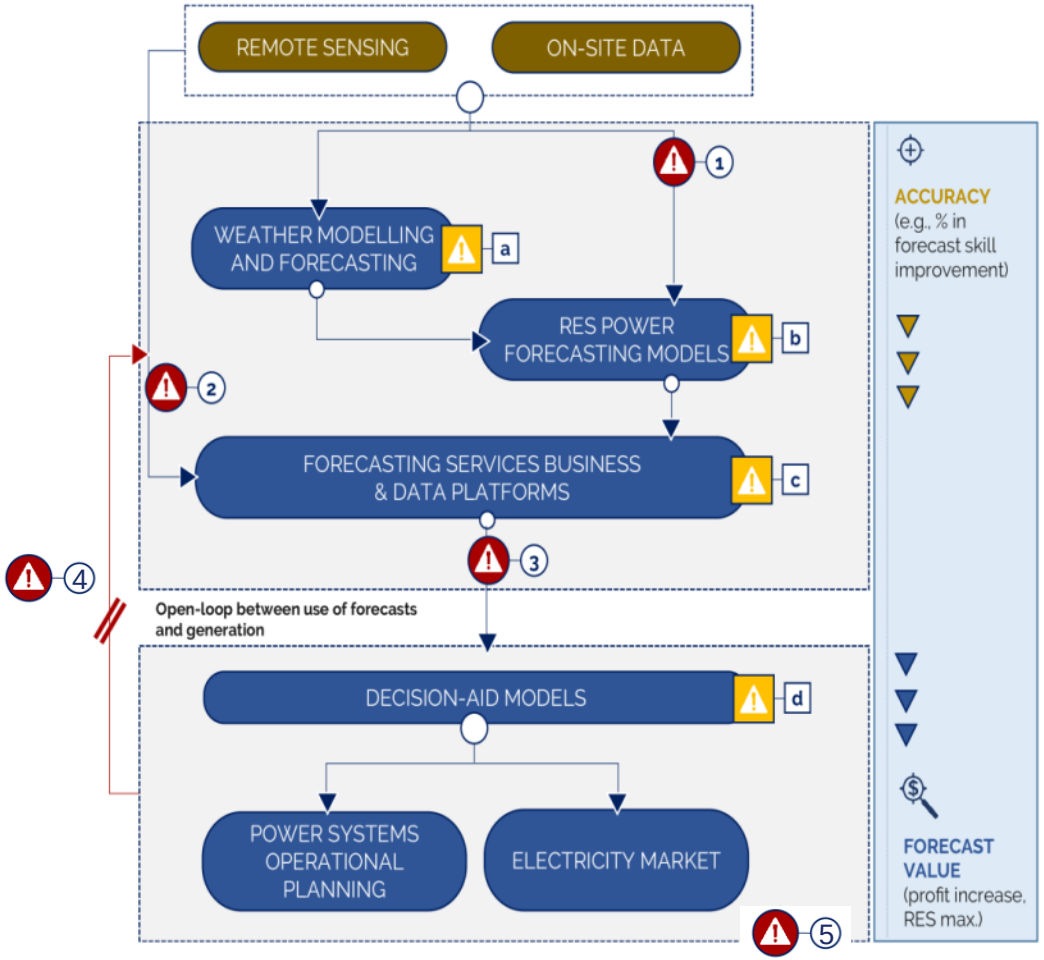


- Camera only x 13 (5 planned)
- Camera + meteo (RSI) x 7 (5 planned)
- Camera + ref. meteo x 2
- Camera in PV plant x 1 (Solarpark Ammerland)
- Ceilometer x 6

Stations
Camera
Meteo
Reference
Planned
Ceilometer
Trafo District



Gaps and bottlenecks



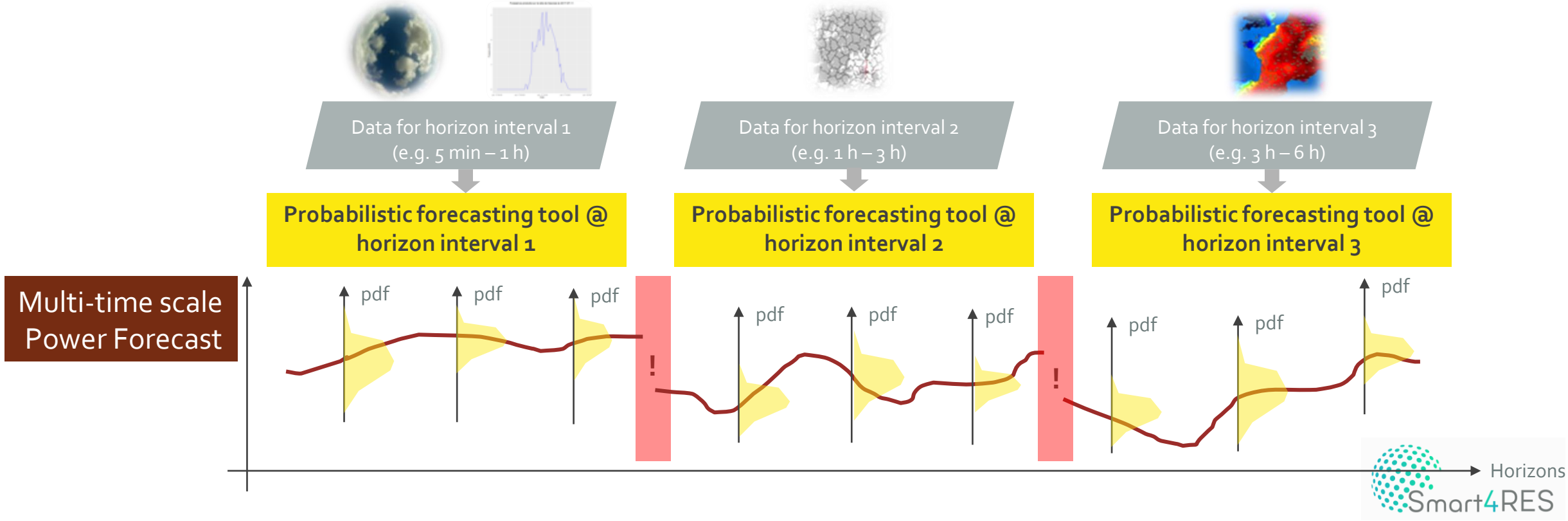
Challenges in the models and the connections:

a — Need for NWP products adapted to RES use-cases.

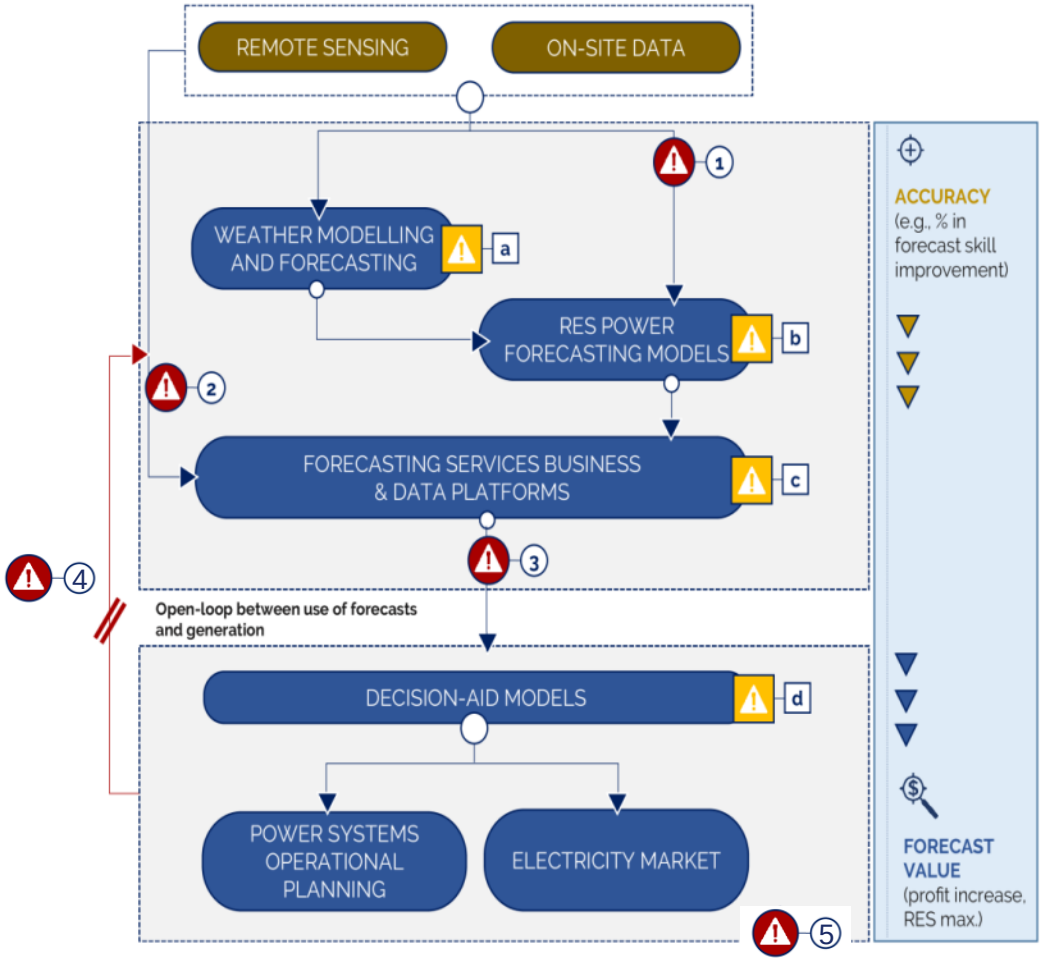
b — Limitations of RES prediction models to exploit large amounts of heterogenous data

Gaps and bottlenecks (RES models)

- State of the art consists in separate models for different time frames (e.g. 5 min to 1 h, 1h to 6h, 6h to 48h ahead…), each exploiting different data sources as input.
- Need for **seamless** and **generic** forecasting approaches, able to consider simultaneously **heterogenous data**. => Possible a convergence of forecasting solutions?



Gaps and bottlenecks



Challenges in the models and the connections:

a — Need for NWP products adapted to RES use-cases.

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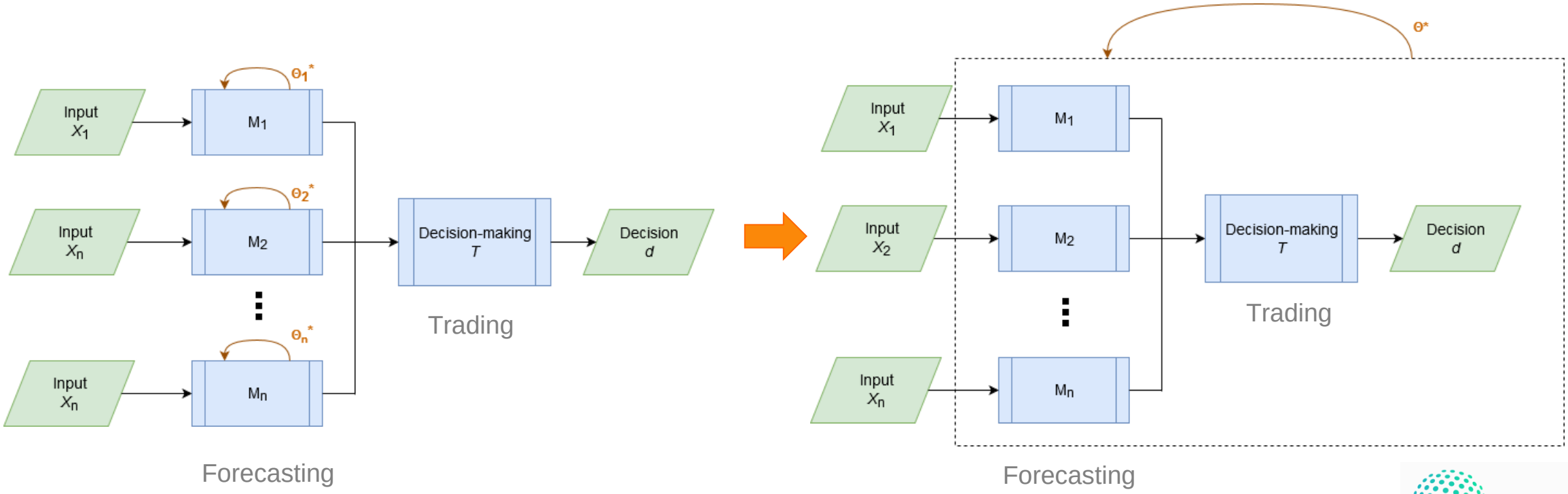
4 — Open loop between forecasts generation and their use in apps

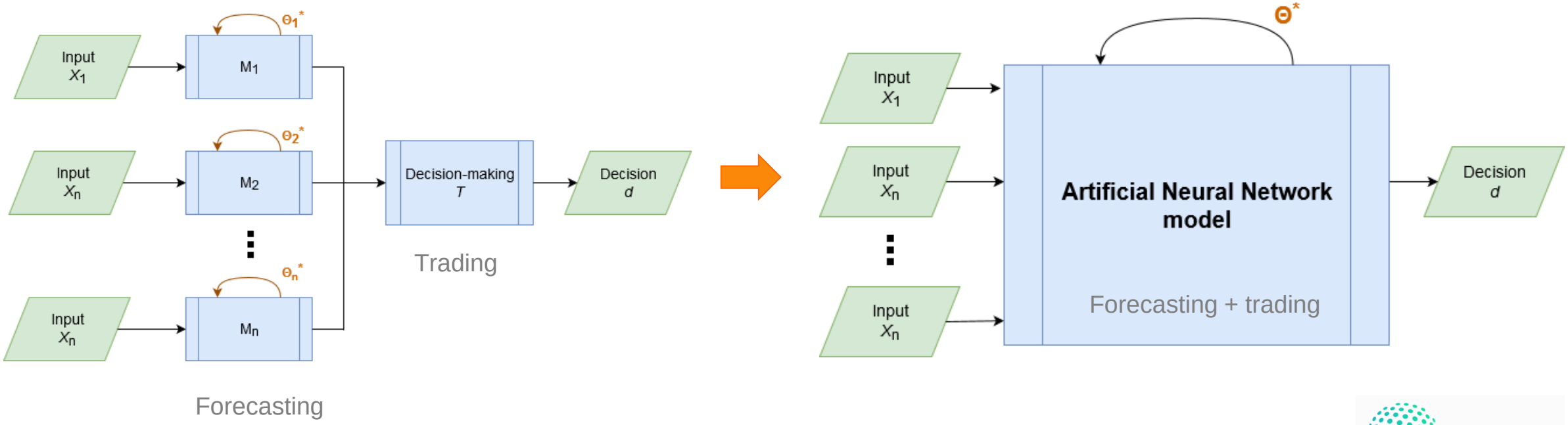
Gaps and bottlenecks (“open loop ”)

- RES forecasting models today are centered on **accuracy**.
- An alternative could be to “tune” them considering, not only accuracy, but also the “**value**” they bring when used in a specific application (i.e. €s in trading).

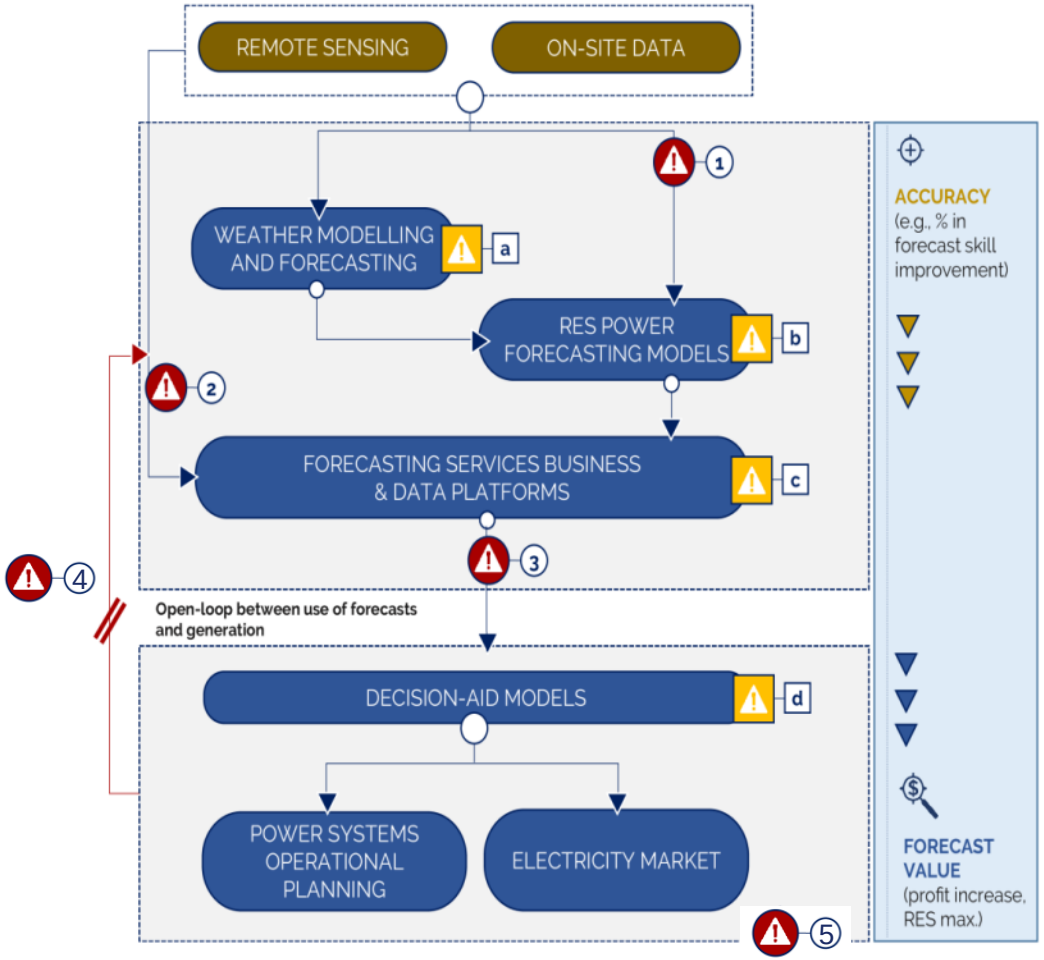


Gaps and bottlenecks (“open loop ”)

- RES forecasting models are tuned today upon their accuracy.
- An alternative could be to tune them considering, not only accuracy, but also the “value” the bring when used in a specific application (i.e. revenue € in trading).
- But why not **use AI to simplify** the whole model chain?



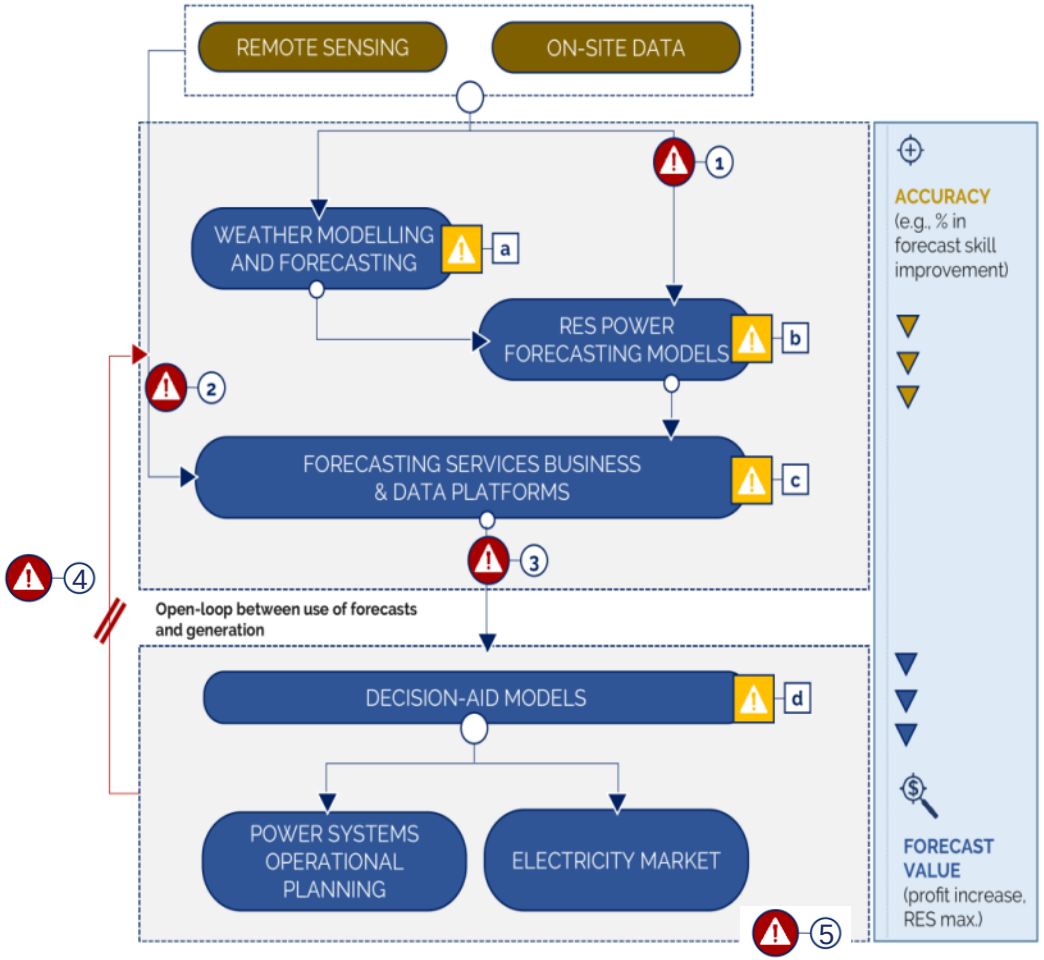
Gaps and bottlenecks



Challenges in the models and the connections:

- a — Need for NWP products adapted to RES use-cases.
- b — Limitations of RES prediction models to exploit large amounts of heterogenous data
- 4 — Open loop between forecasts generation and their use in apps.
- c — Decaying commercial value of forecast products.

Gaps and bottlenecks



Challenges in the models and the connections:

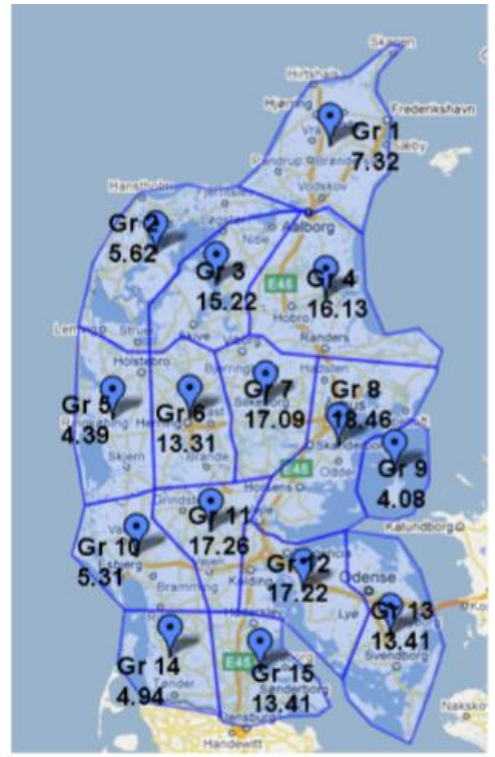
1 Lack of meaningful open data (privacy issues)

2 Lack of price incentives to share data

Gaps and bottlenecks (value from data)

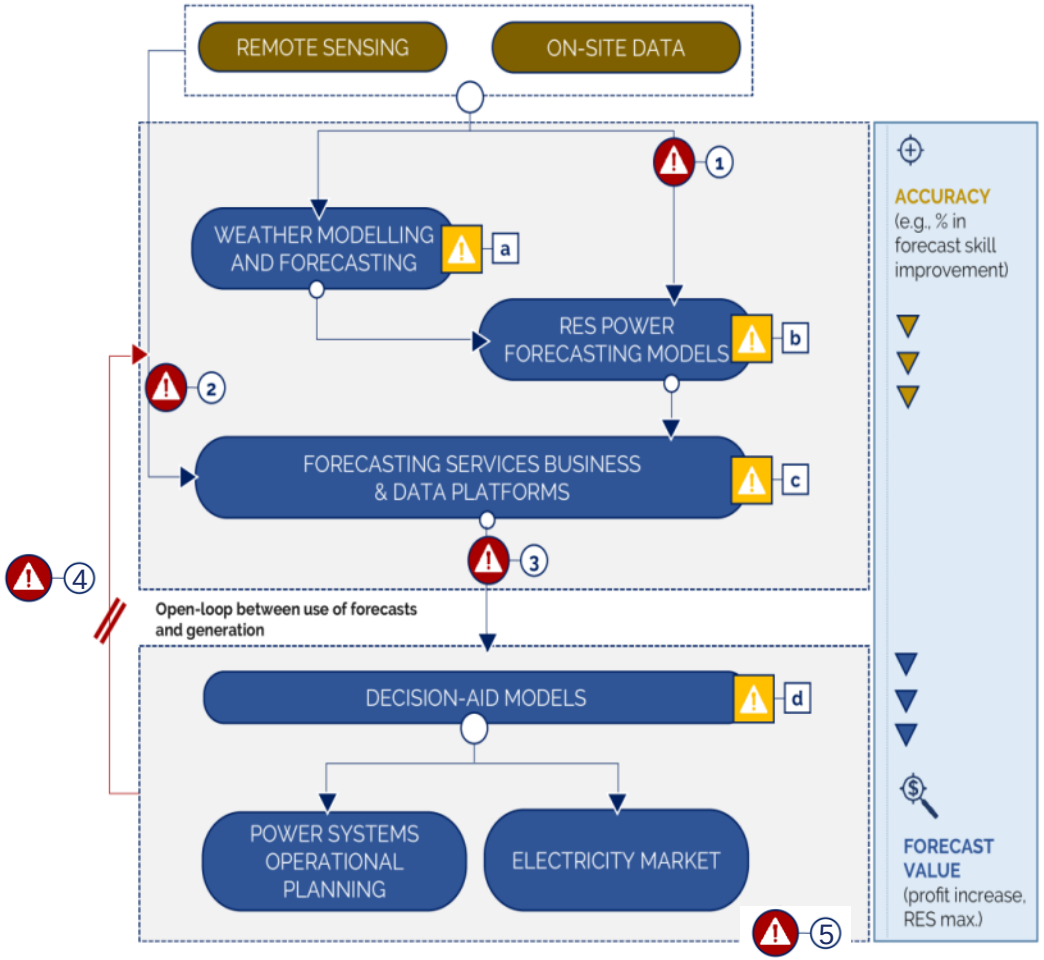
- In an era of energy digitalization, the focus is on more data. But what real value can be extracted from data?

- Many works have shown the benefits of integrating spatially distributed information (neighbor PV/wind farms as sensors).
- With Smart4RES we will exploit data science techniques, like federated learning, to develop a framework for **collaborative forecasting** through **data sharing** that respects **privacy and confidentiality constraints**
- And a **data market concept** to foster data sharing



improvement of 1-hour ahead forecast RMSE

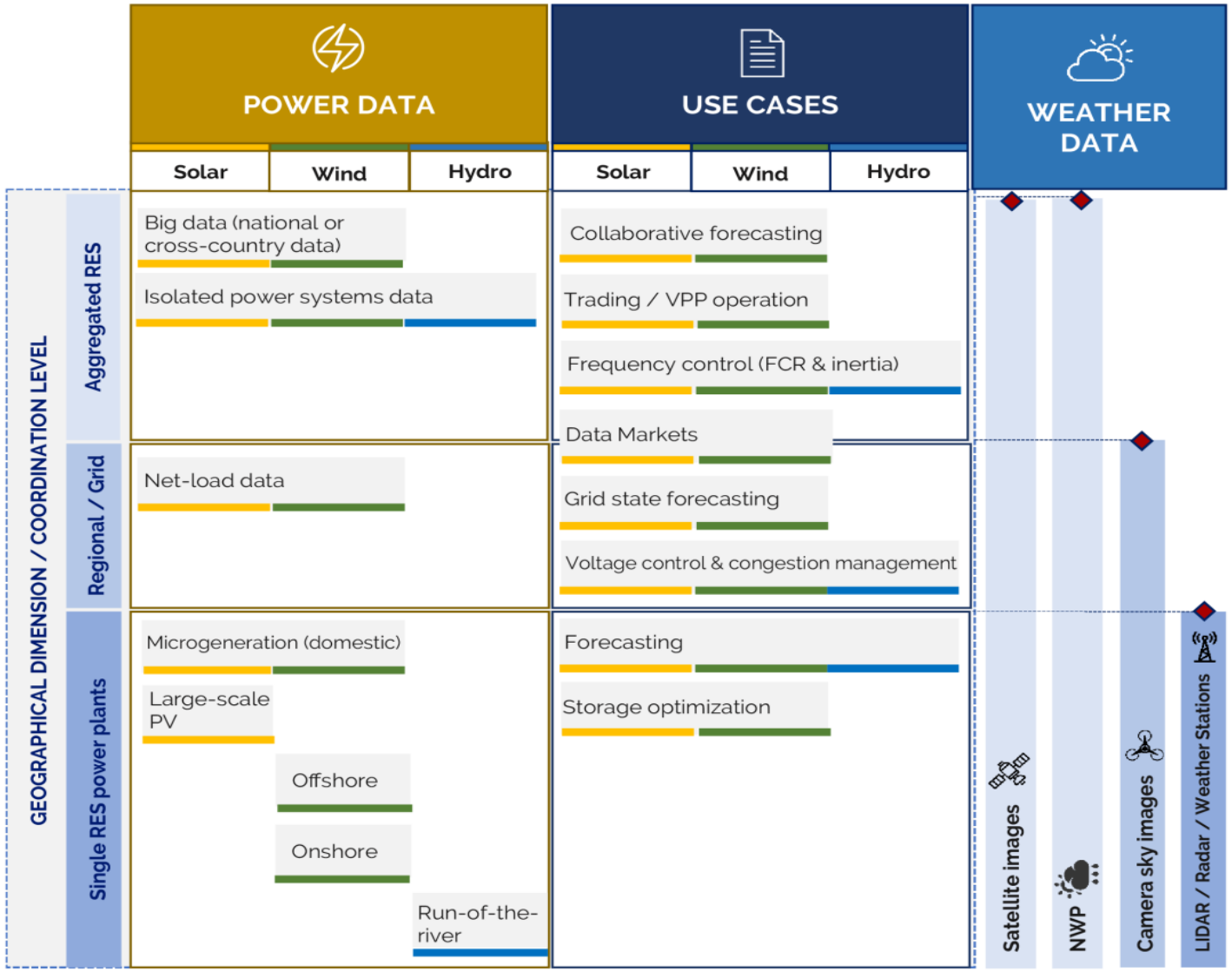
Gaps and bottlenecks



Challenges in the models and the connections:

1. Lack of meaningful open data (privacy issues)
2. Lack of price incentives to share data
3. Lack of standardisation
- d Need for decision aid models adequate for high RES integration scenarios
5. Need for business cases that demonstrate the value of integrating uncertainty forecasts to industry

Gaps and bottlenecks (the apps…)



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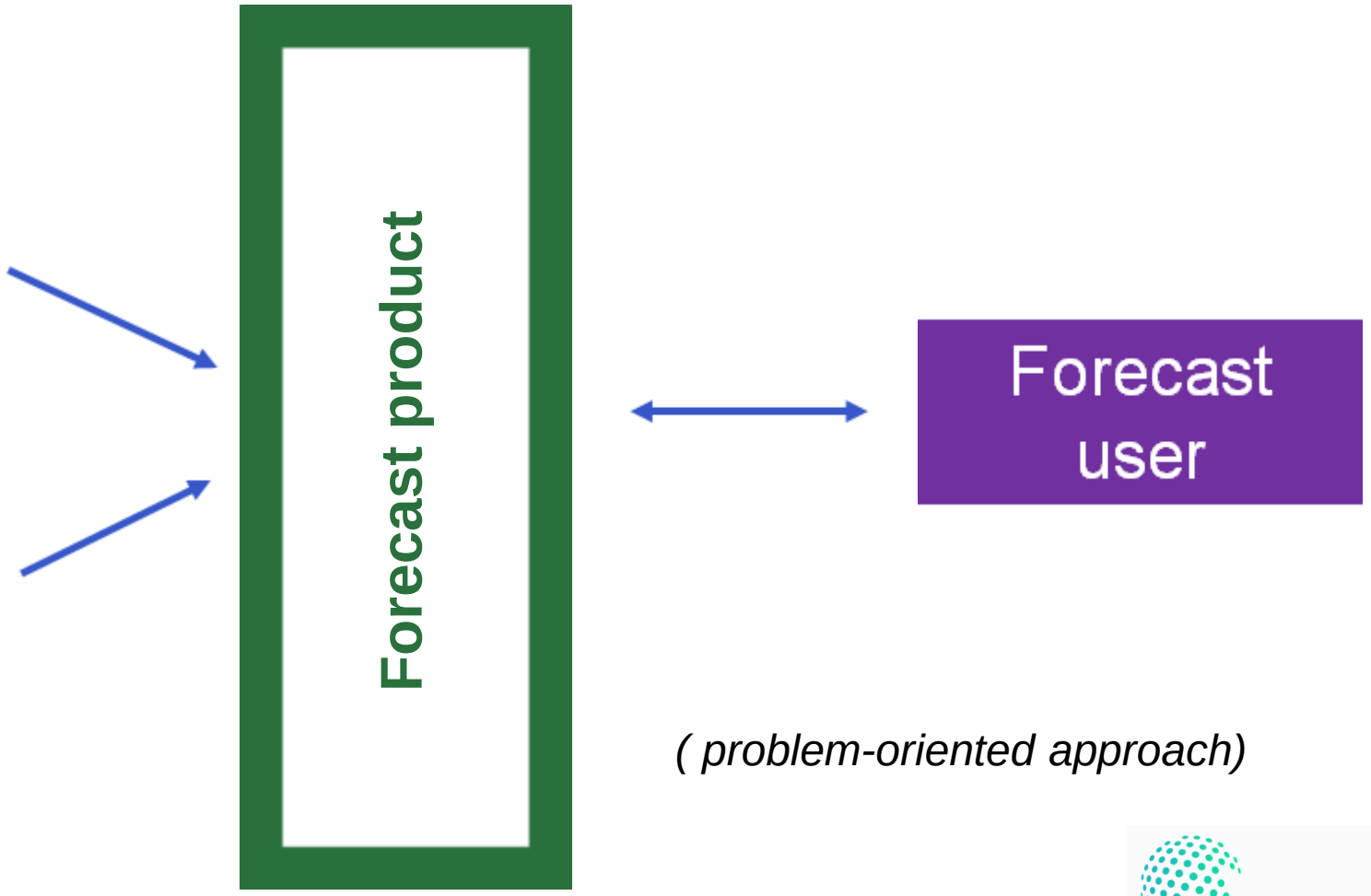
3. Research for innovative weather and RES production forecasting products	**Pierre Pinson (DTU)**

What is a forecast product?

- Data streams
- Models
- Forecasting approaches
- Forecasting expertise
- Analytics and visualization



(problem-oriented approach)

Motivations for new forecast products

Regulatory and market framework

- New **markets** e.g. p2p or flexibility markets
- New market **products** e.g. resolution, ancillary services
- Requirements from the **regulatory** side

Technology and its development

- Larger wind turbines
- Hybrid power plants
- Prosumer setups
- Storage
- New paradigms in power system operation

End-users expressed needs

”Please tell us!”

A push from the R&D side

- Forecasting R&D is very active
- New concepts have continuously emerged
- Profit of latest advances in analytics and decision-support

Motivations for new forecast products

- Exemple of high-resolution case

Regulatory and market framework

- New **markets** e.g. p2p or flexibility markets
- New market **products** e.g. resolution, ...

- Temporal resolution ancillary services
- Prosumer markets e.g. p2p
- Etc.

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Technology and its development

- Larger wind turbines
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- New paradigms in

- Offshore wind farm control
- Storage operation
- Etc.

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Regulatory and market framework	Technology and its development	End-users expressed needs	A push from the R&D side
• New **markets** e.g. p2p or flexibility markets • New market **products** e.g. resolution,	• Larger wind turbines • Hybrid power plants • Prosumer setups • Storage • New paradigms in	”Please tell us!”	• Forecasting R&D is very active • New concepts have continuously emerged • Profit of latest advances in analytics and decision-support
• Temporal resolution ancillary services • Prosumer markets e.g. p2p • Etc.	• Offshore wind farm control • Storage operation • Etc.	• Many examples e.g. Copenhagen airport	

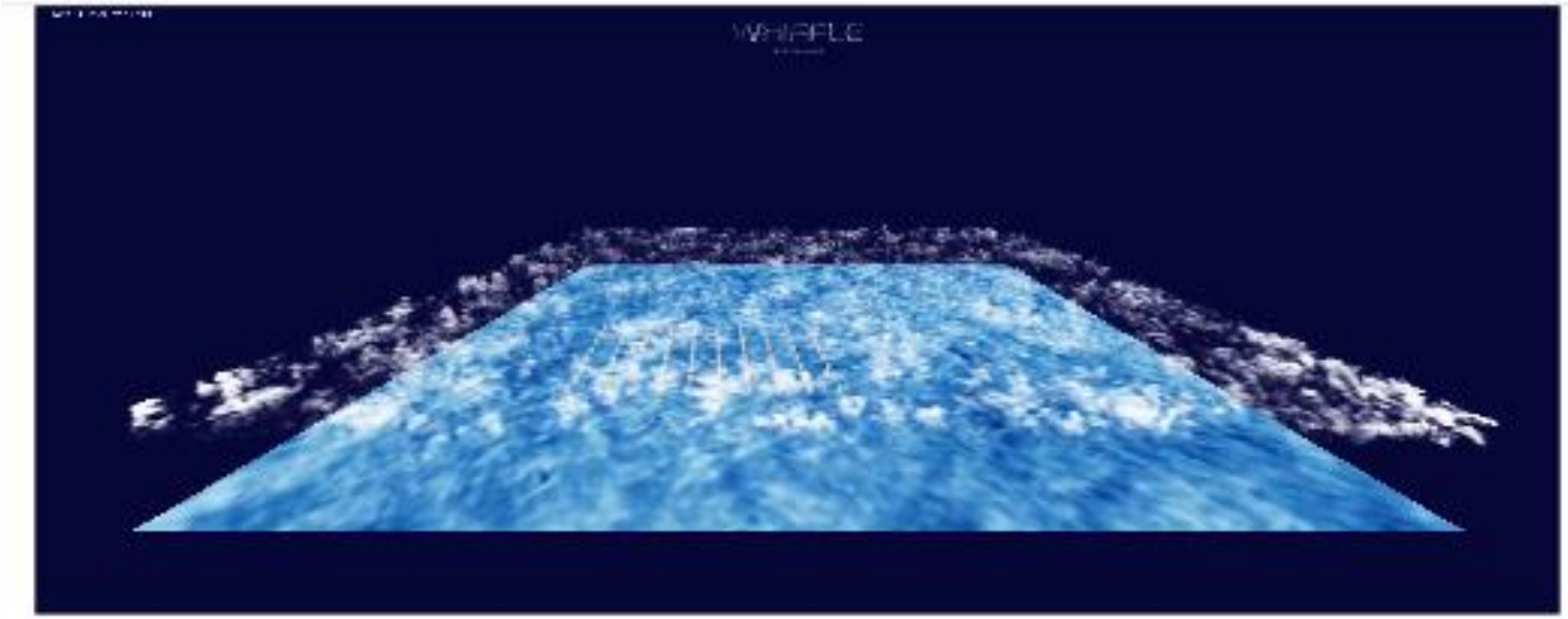
Motivations for new forecast products

- Exemple of high-resolution case

Regulatory and market framework	Technology and its development	End-users expressed needs	A push from the R&D side
• New **markets** e.g. p2p or flexibility markets • New market **products** e.g. resolution,	• Larger wind turbines • Hybrid power plants • Prosumer setups • Storage • New paradigms in	”Please tell us!”	• Forecasting R&D is very active • New concepts have continuously
• Temporal resolution ancillary services • Prosumer markets e.g. p2p • Etc.	• Offshore wind farm control • Storage operation • Etc.	• Many examples e.g. Copenhagen airport	• Early push towards high resolution in the late 90s • Today different (very) high resolution approaches • Especially relevant for offshore wind

From high-resolution information and data…

- A company like Whiffle (among others) can provide very-high resolution weather forecasts e.g. here for Horns Rev (spatial: 50-100m – temporal: app. 30s)

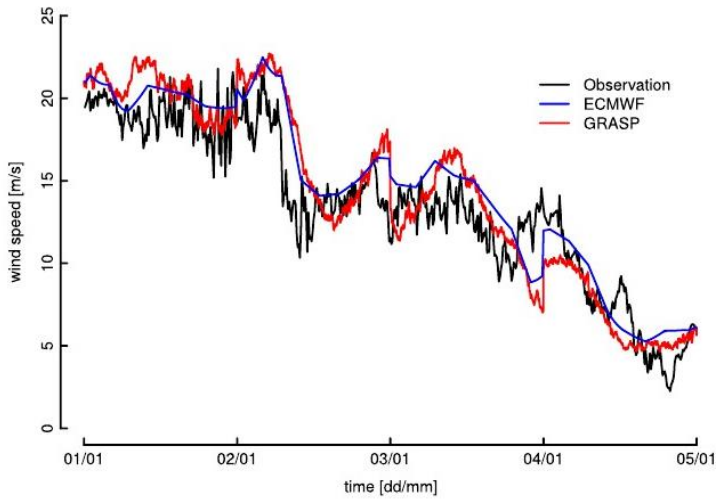


- How to use the produced information optimally?

C. Gilbert et al. (2020) Statistical post-processing of turbulence-resolving weather forecasts for offshore wind power forecasting. *Wind Energy* **23**(4), pp. 884-897

… to meaningful forecast products through post-processing

- Post-processing is usually considered for **improving forecast quality** (e.g. model output statistics, machine learning. etc.)
- However, it can also be used to go from ”raw forecast data” to a ***tailored forecast product***



Classical hourly **single-valued** forecasts (or 5-15 mns)

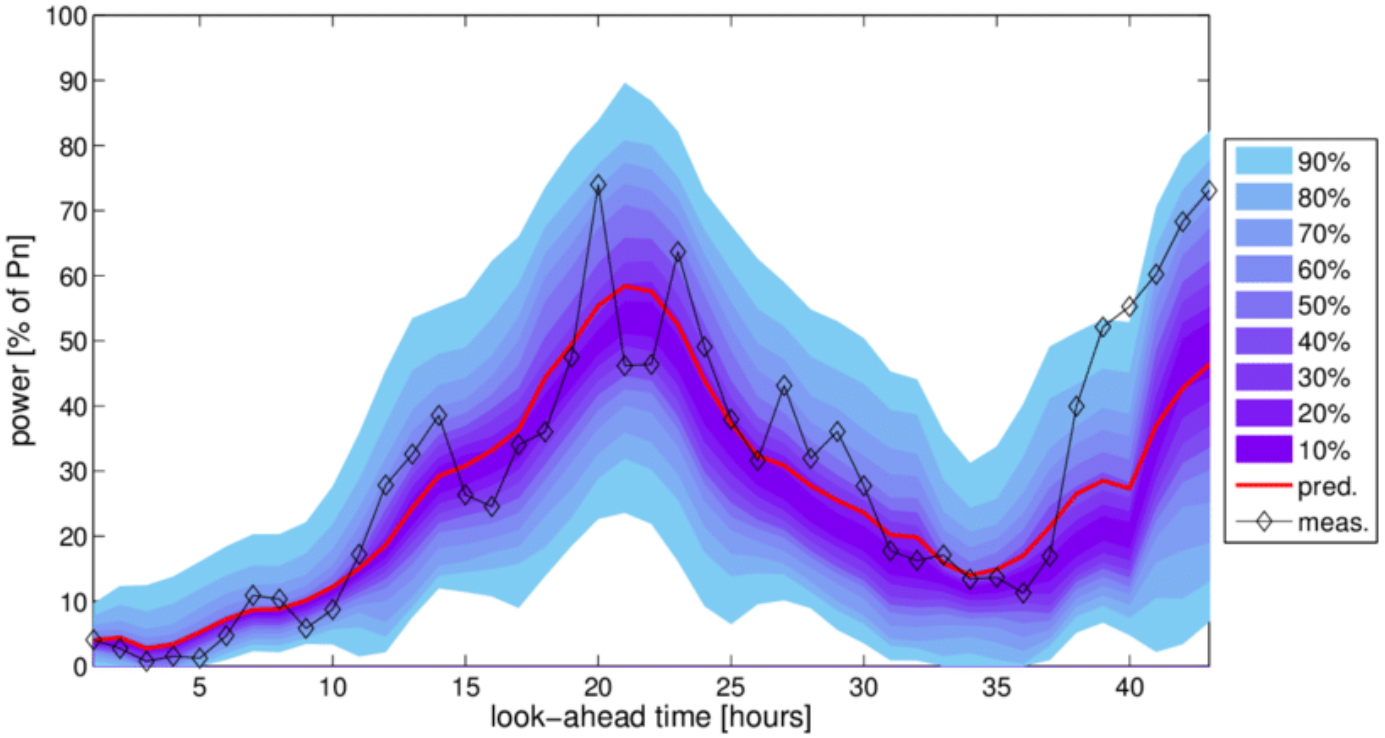
Variability forecasts

Forecasts of **potential minimum and maximum** production values within periods

The probabilistic side

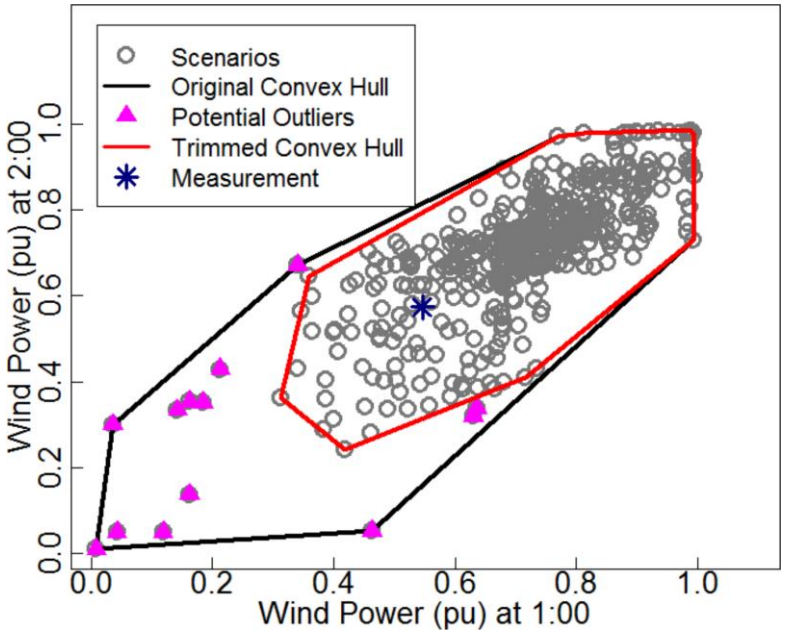
- Probabilistic forecasts are increasingly used in operations and electricity markets

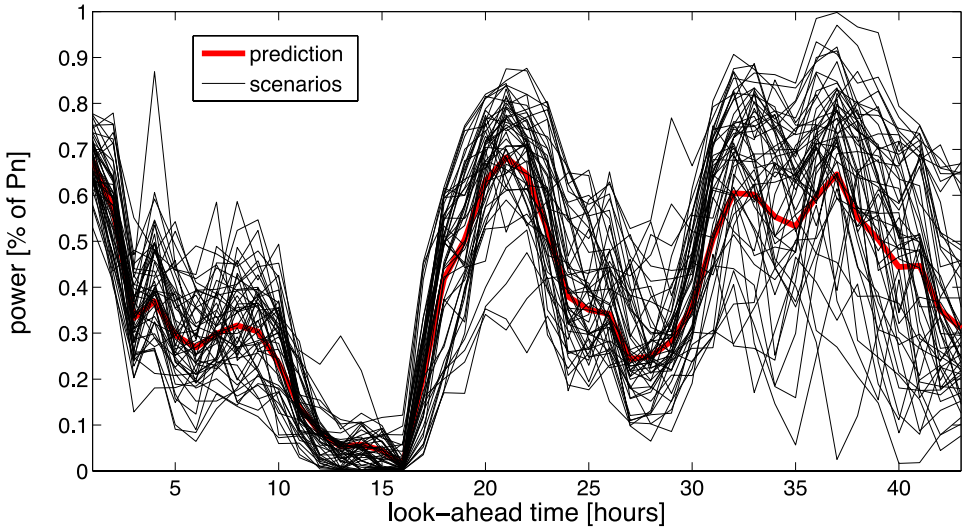
- Such concepts and visualizations were pushed forward in the early 2000's… now getting quite common



New probabilistic forecasting products

- For many novel approaches to d**ecision-making under uncertainty**, those probabilistic forecasts are not sufficient…



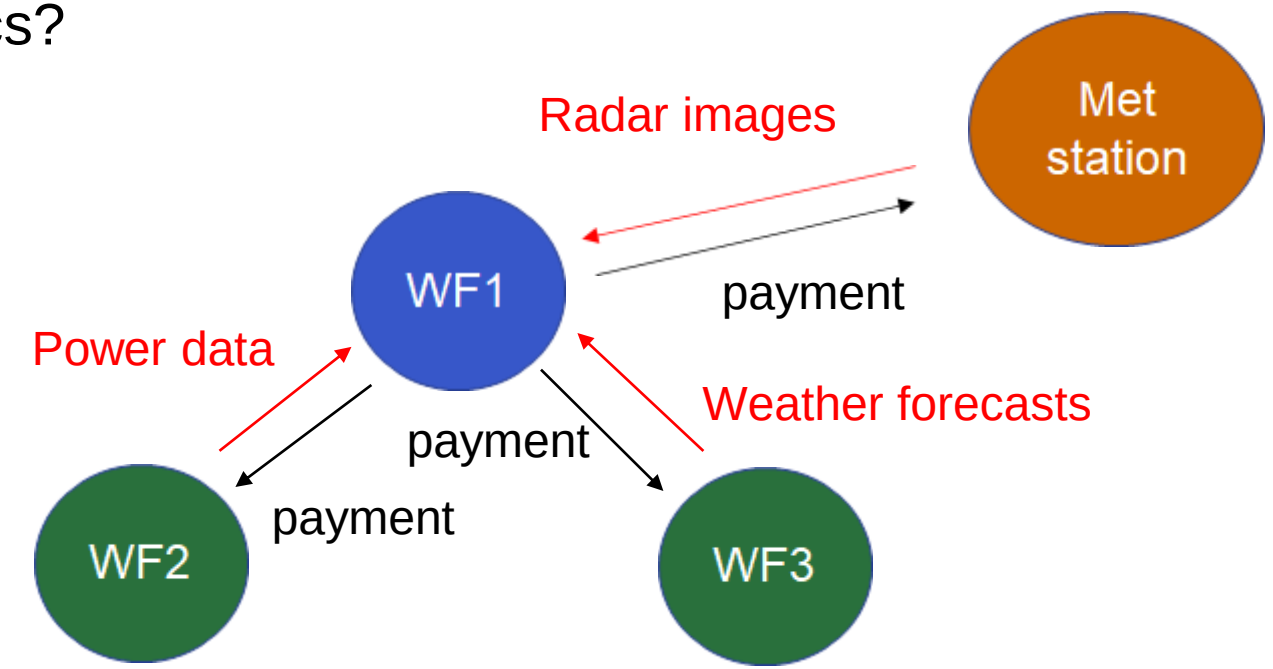


- This is why scenarios and now polyhedra and ellipsoids (uncertainty regions) were proposed

Data and forecasts are products themselves!

- What if various agents and operators sell each other forecasts, data or contribution to collaborative analytics?

- Assume for instance a central agent (a wind farm) that wants to improve its forecasts and contract neighboring ones to help…

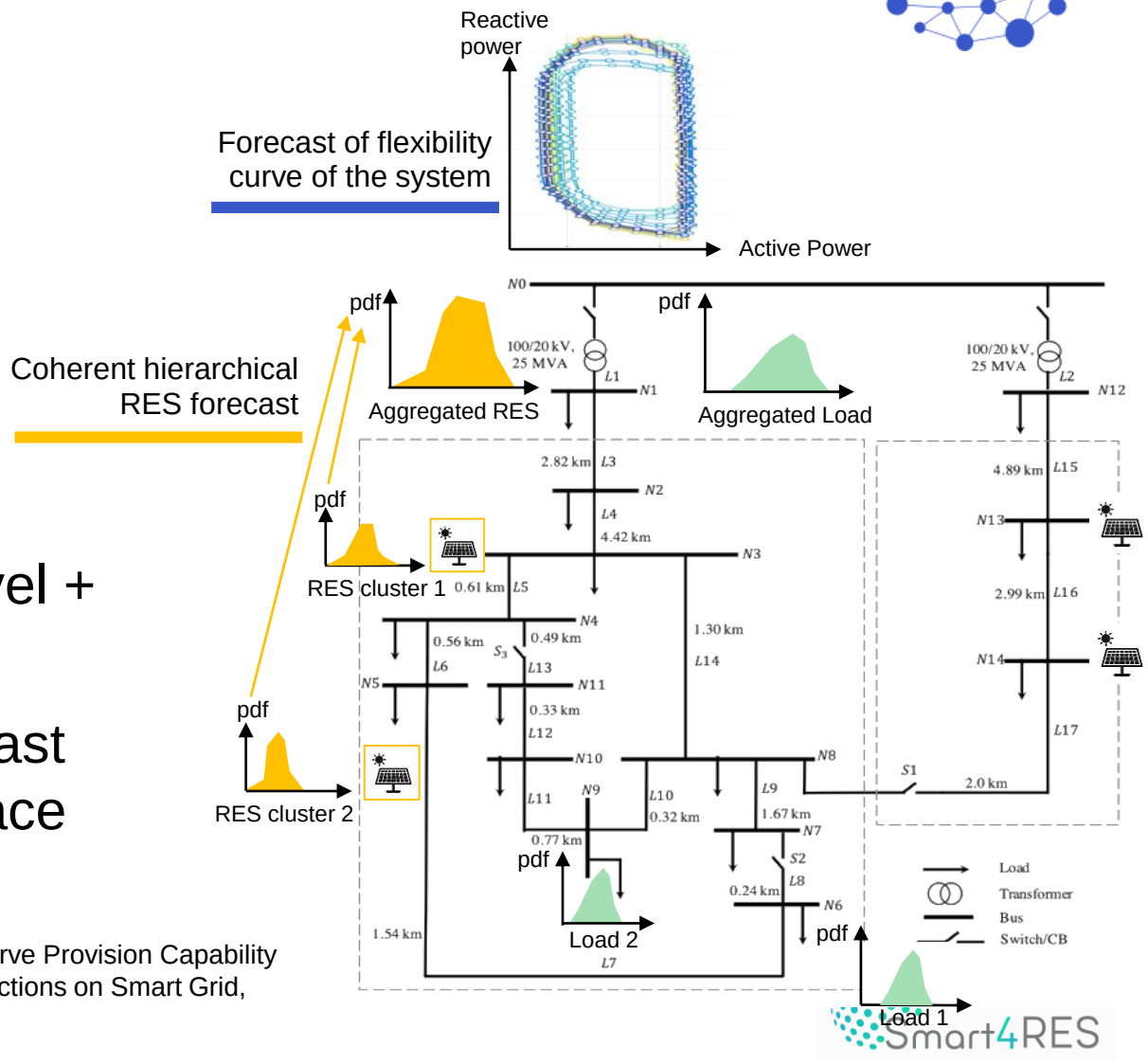


- How to design mechanisms for that purpose, while also respecting potential privacy and business competition concerns?

New forecast products for grid management

- How can data from distributed RES help power system operators?

- RES forecasts at plant and aggregated level + Grid topology
- = New product: Grid-aware flexibility forecast of distributed resources at a HV/MV interface



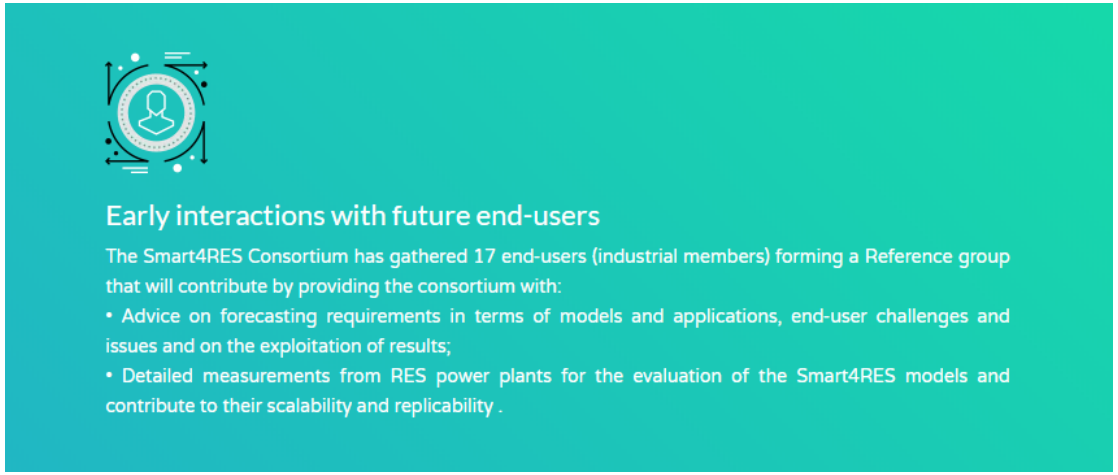
M. Kalantar-Neyestanaki, F. Sossan, M. Bozorg and R. Cherkaoui, "Characterizing the Reserve Provision Capability Area of Active Distribution Networks: A Linear Robust Optimization Method," in IEEE Transactions on Smart Grid, vol. 11, no. 3, pp. 2464-2475, May 2020

Take away messages

- RES-oriented research for **improving weather forecasting**
- Seamless approaches to permit **convergence of the technology**
- Data science approaches for **alternative forecasting and decision-making paradigms.**
- Data sharing and data markets to extract the **value out of data**!

Be involved

- Want to take part of the Smart4RES project?
  - ⇨ Complete our questionnaire on your use of forecasts and forecast-based decision-aid tools
  - ⇨ Be involved in our **Reference Group**



Stay tuned

Smart4RES Webinar Series (under preparation):

Episode #2 - October 2020 RES forecasting and data marketplace: a collaborative framework
Episode #3 - December 2020 Optimising participation of RES generation in electricity markets: new opportunities and the role of forecasting

⇨ Newsletter: subscribe at www.smart4res.eu

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APPENDIX

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