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Towards the next generation forecasting tools of renewable energy production

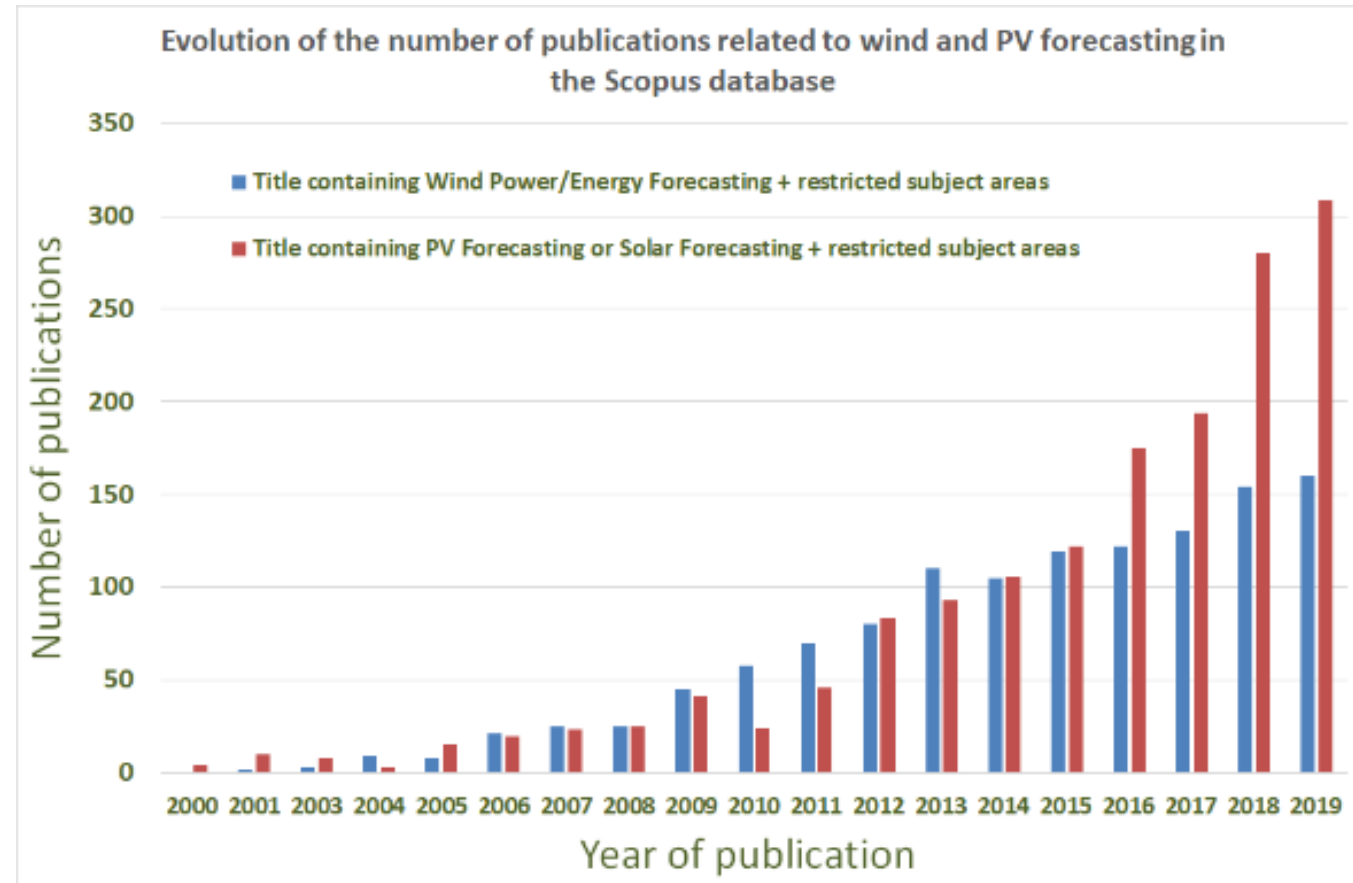
George Kariniotakis | ARMINES, MINES ParisTech, Center PERSEE



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Context

- 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



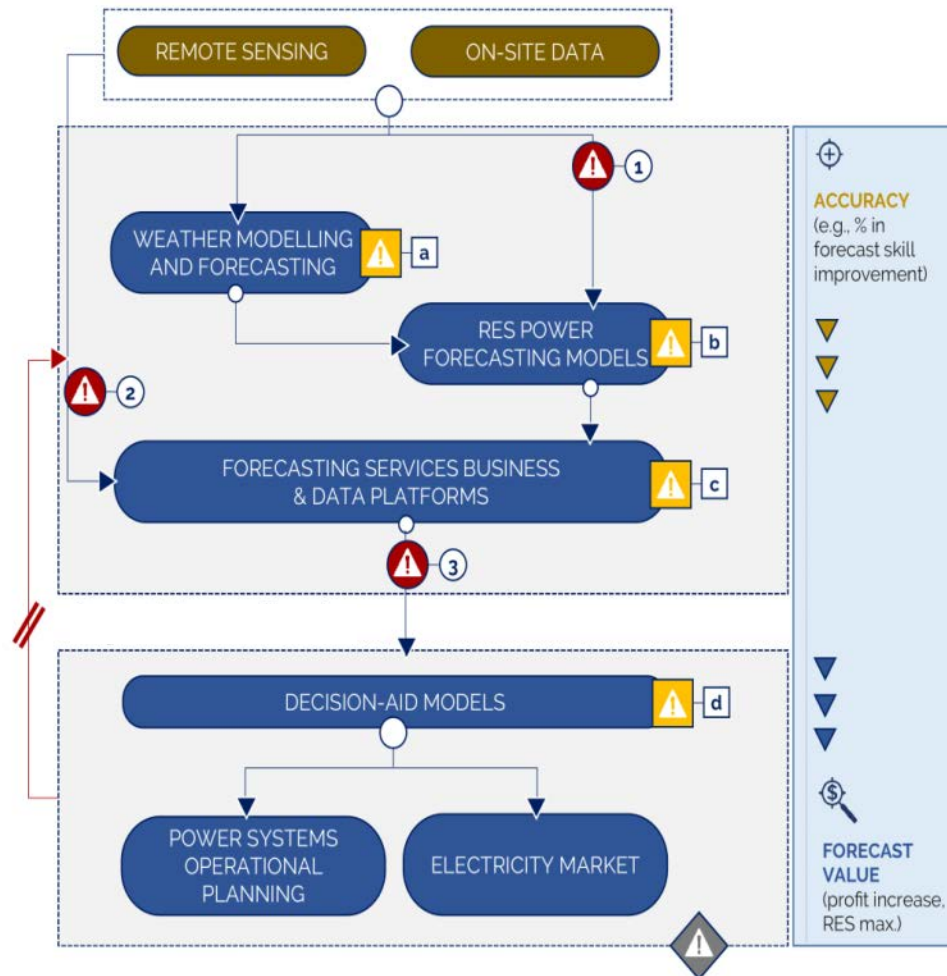
What is Smart4RES?

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



The RES forecasting model & value chain



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

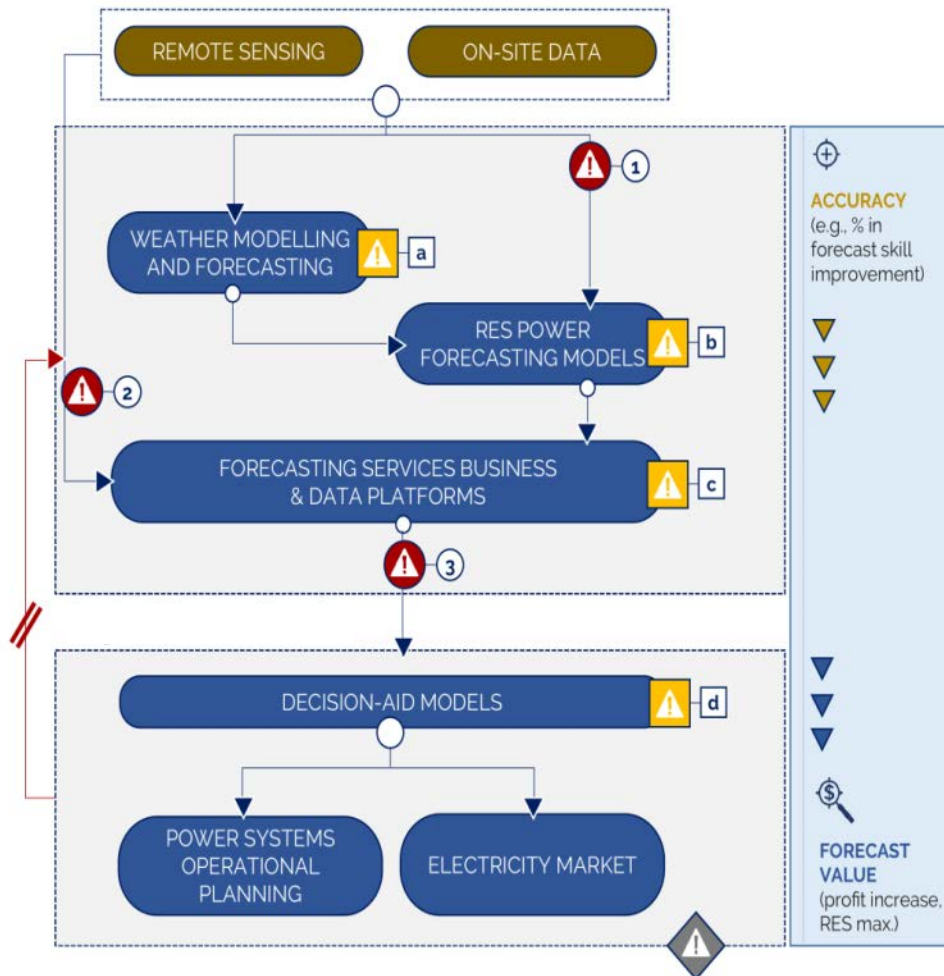
Forecasts of RES production for the next minutes up to the next days

storage management

reserve allocation
predictive maintenance

trading
economic dispatch
scheduling
congestion management

The RES forecasting model & value chain

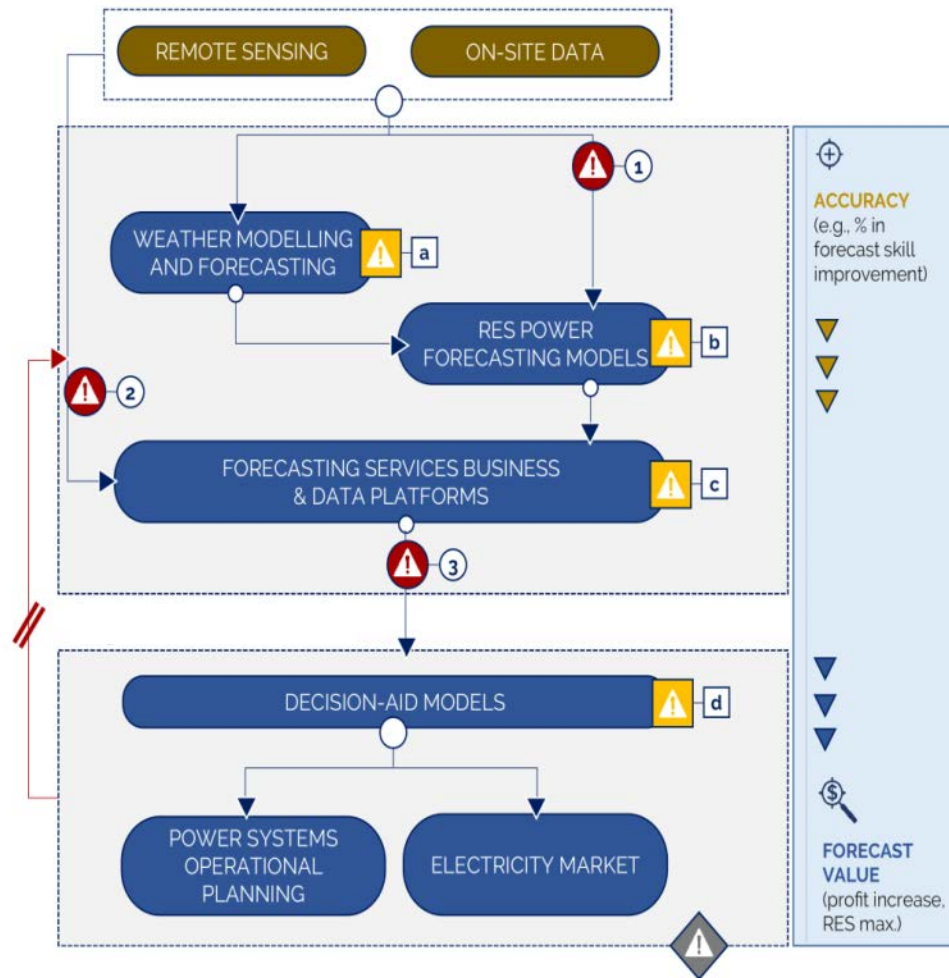


...."mature technology", but forecasting accuracy remains low

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
- ...

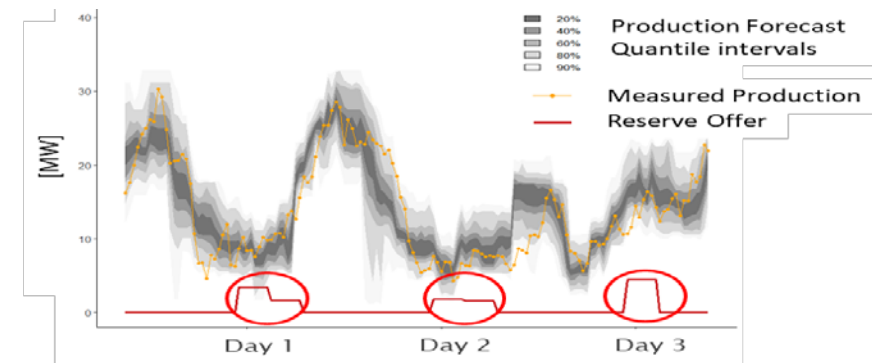
The RES forecasting model & value chain



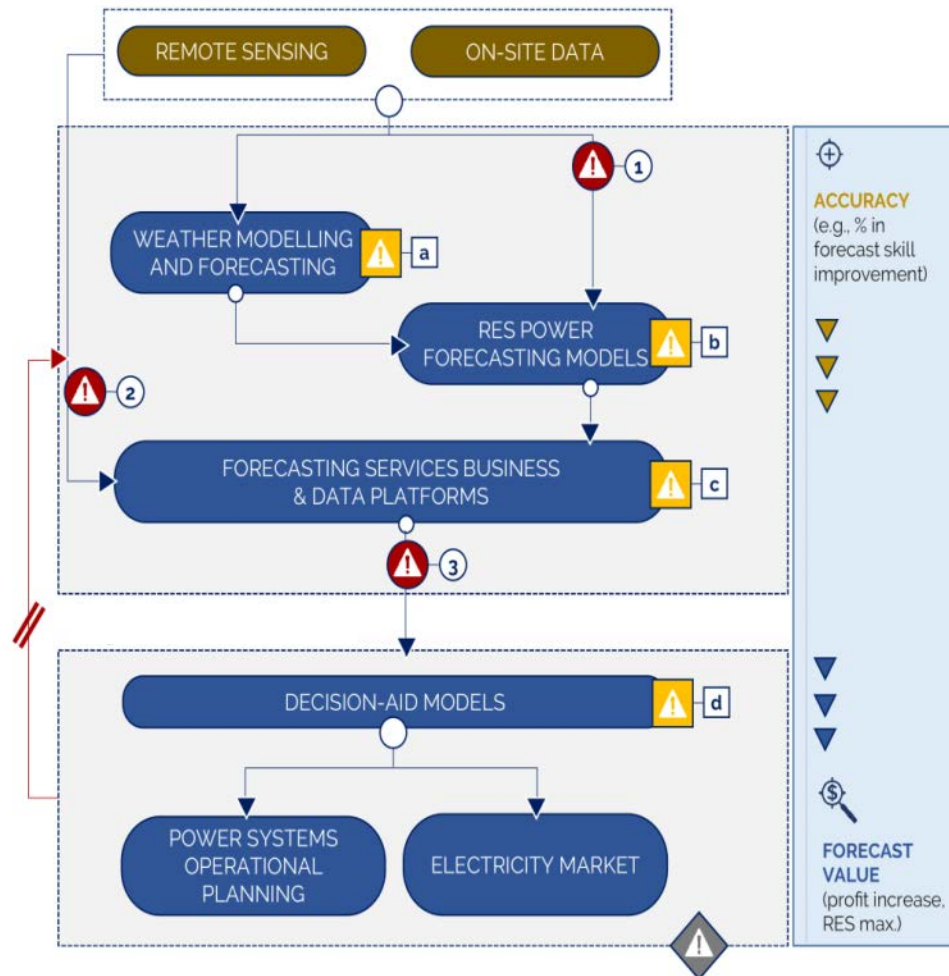
...."mature technology", but forecasting accuracy remains low and new needs are emerging

new
needs

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



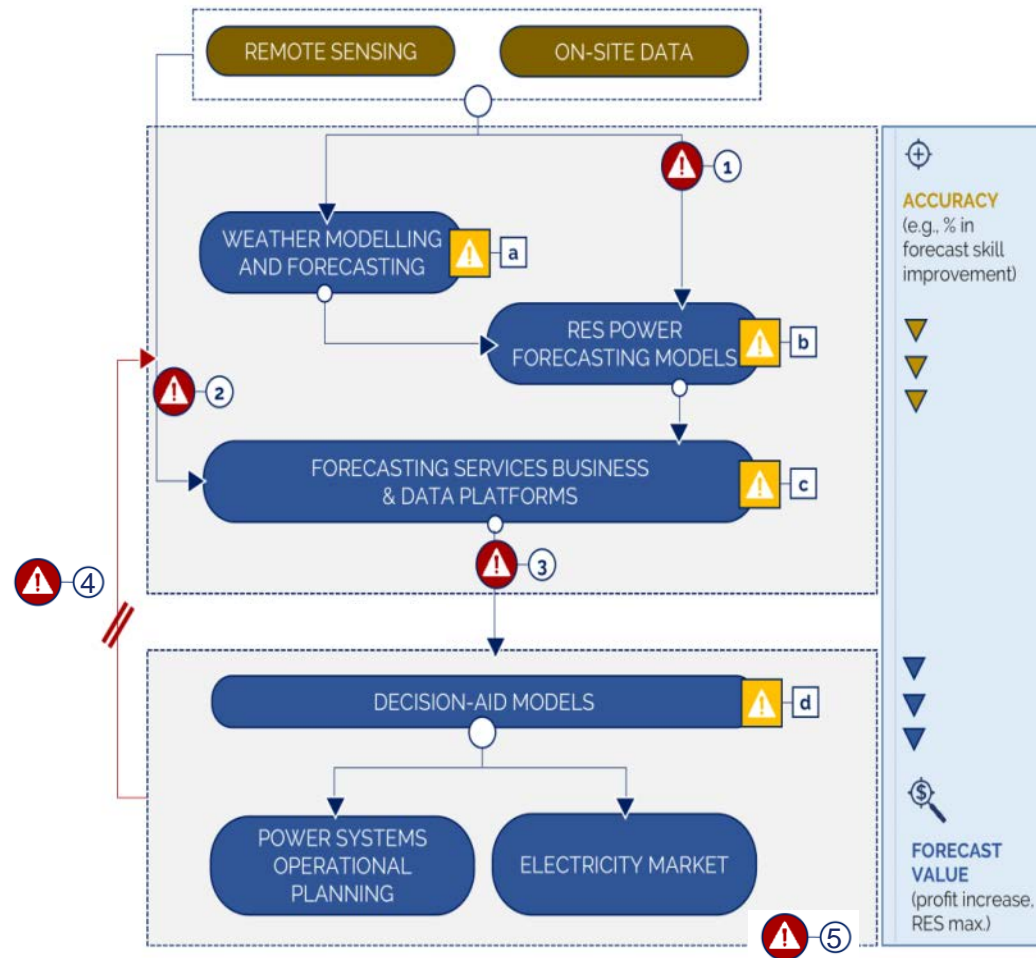
The Smart4RES vision & objectives



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

- 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.

Gaps & bottlenecks



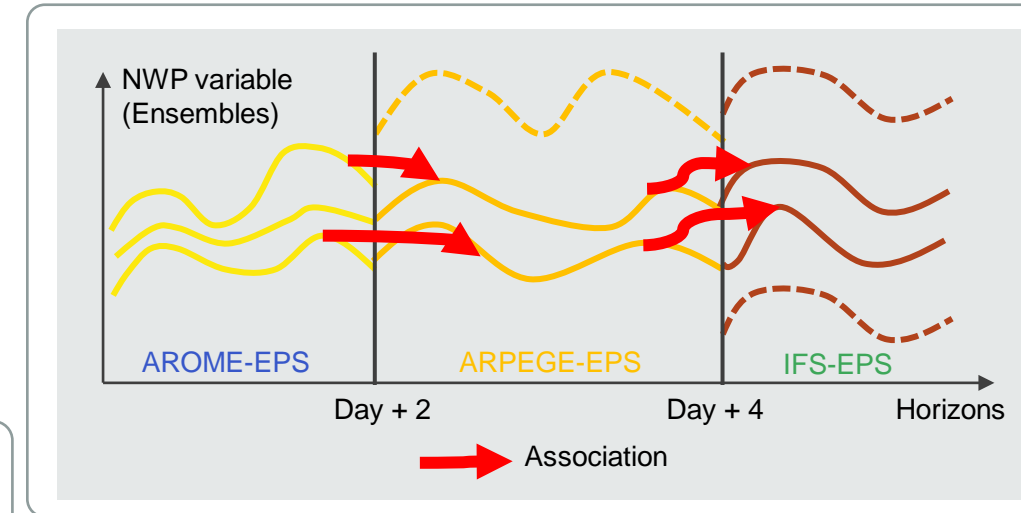
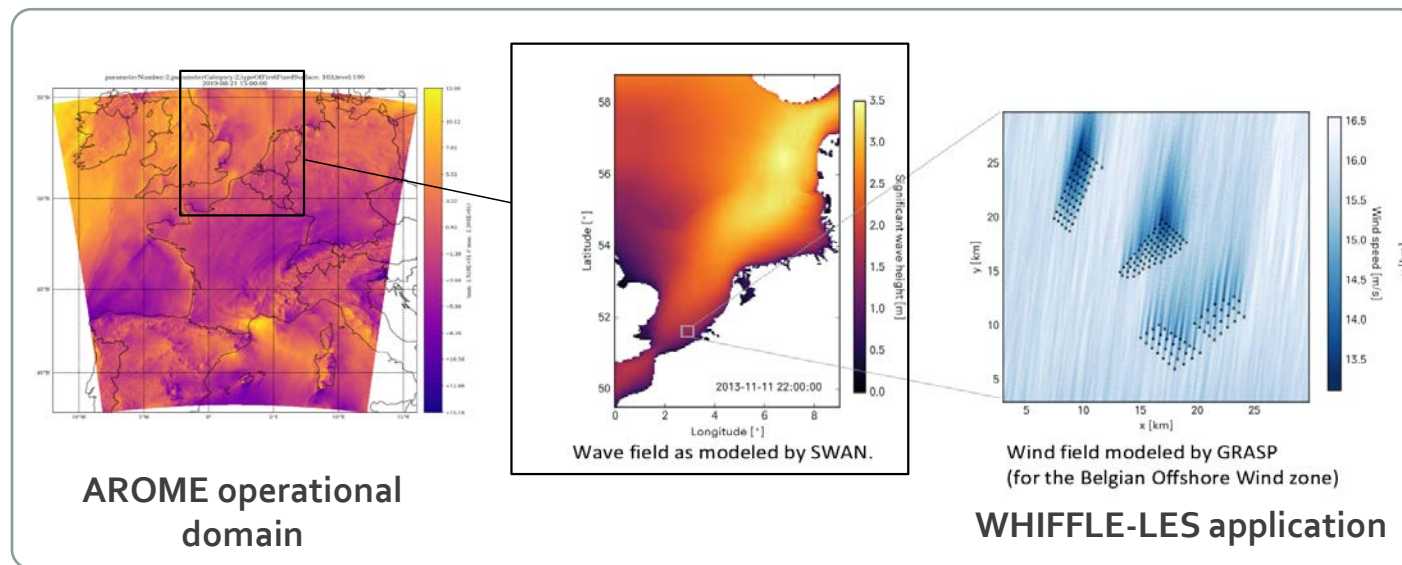
Challenges in the models and the connections:



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

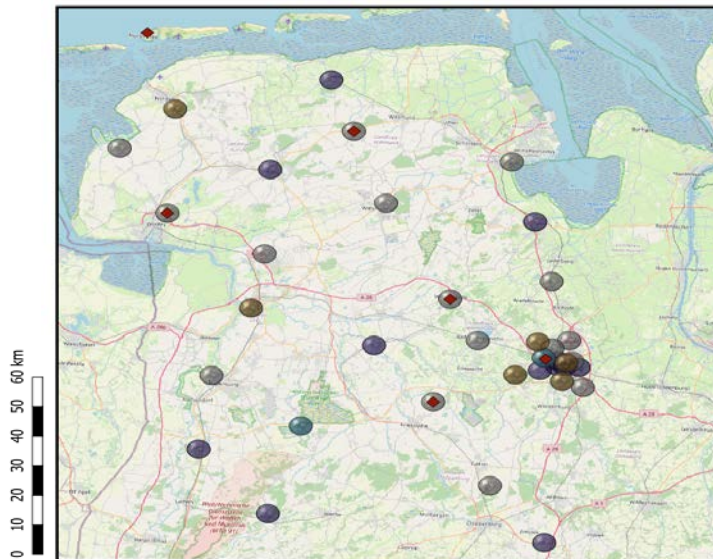
Gaps & bottlenecks (NWP)

- Improved RES-oriented modelling of NWP variables.
- Need for seamless NWP in applications
- Need for higher spatial/temporal resolution & updates frequency



Gaps & bottlenecks (NWP)

- Improved RES-oriented modelling of NWP variables.
- Need for seamless NWP in applications
- Need for higher spatial/temporal resolution & updates frequency
- Better modelling of weather conditions through remote sensing (sky imaging)



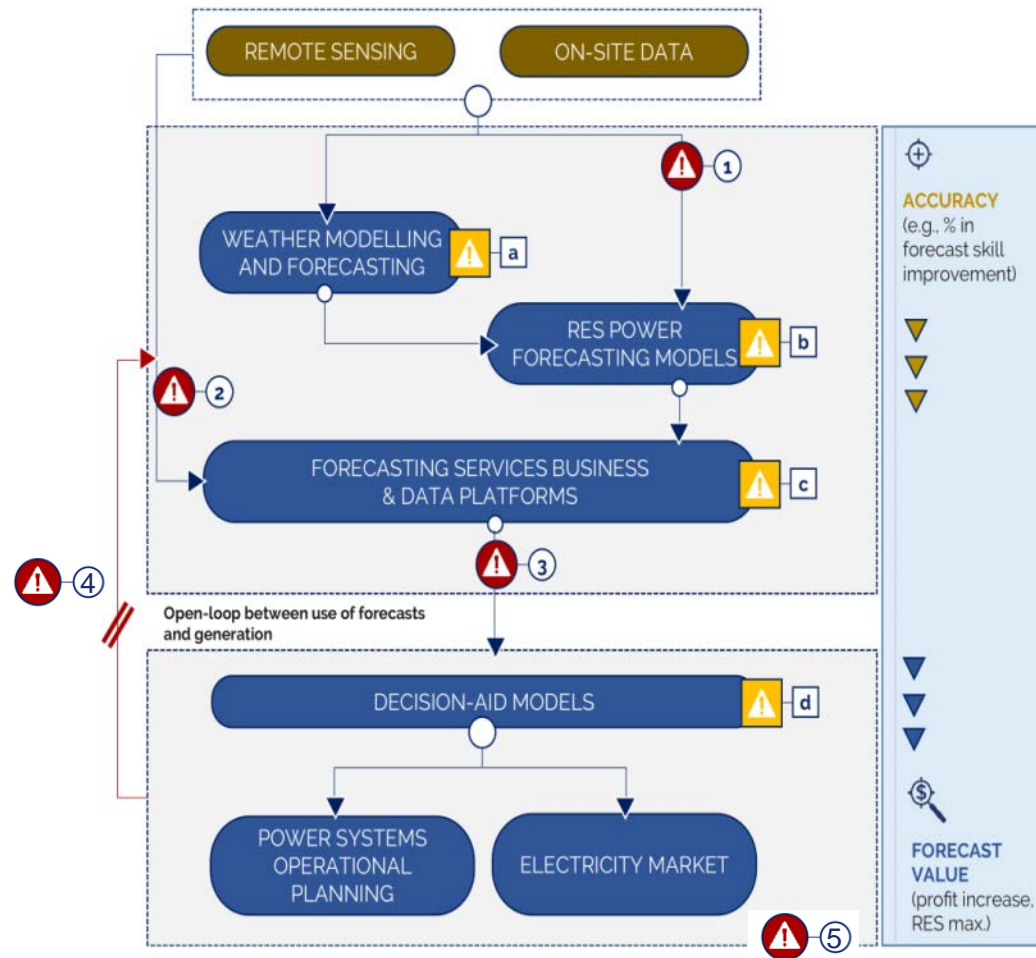
- Camera only x 13 (5 planned)
- Camera + meteo (RSI) x 7 (5 planned)
- Camera + ref. meteo x 2
- Camera in PV plant x 1 (Solarpark Ammerland)
- Ceilometer x 6

Stations

- Camera
- Meteo
- Reference
- Planned
- ◆ Ceilometer
- Trafo District



Gaps & bottlenecks



Challenges in the models and the connections:



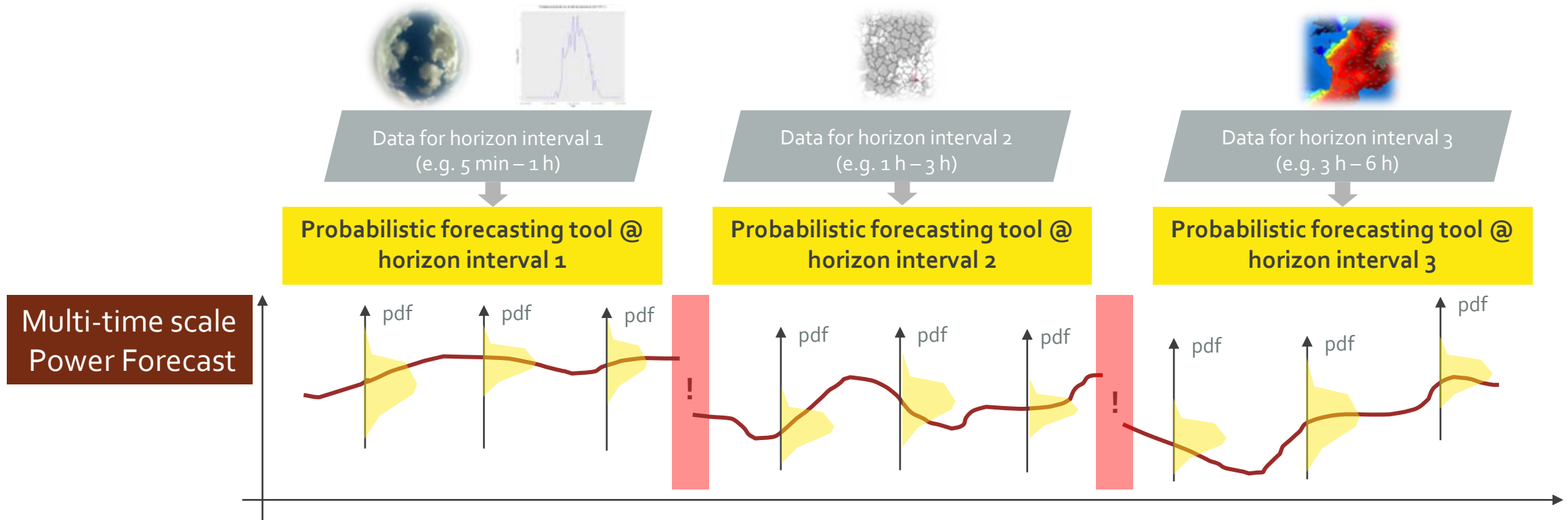
Need for NWP products adapted to RES use-cases.



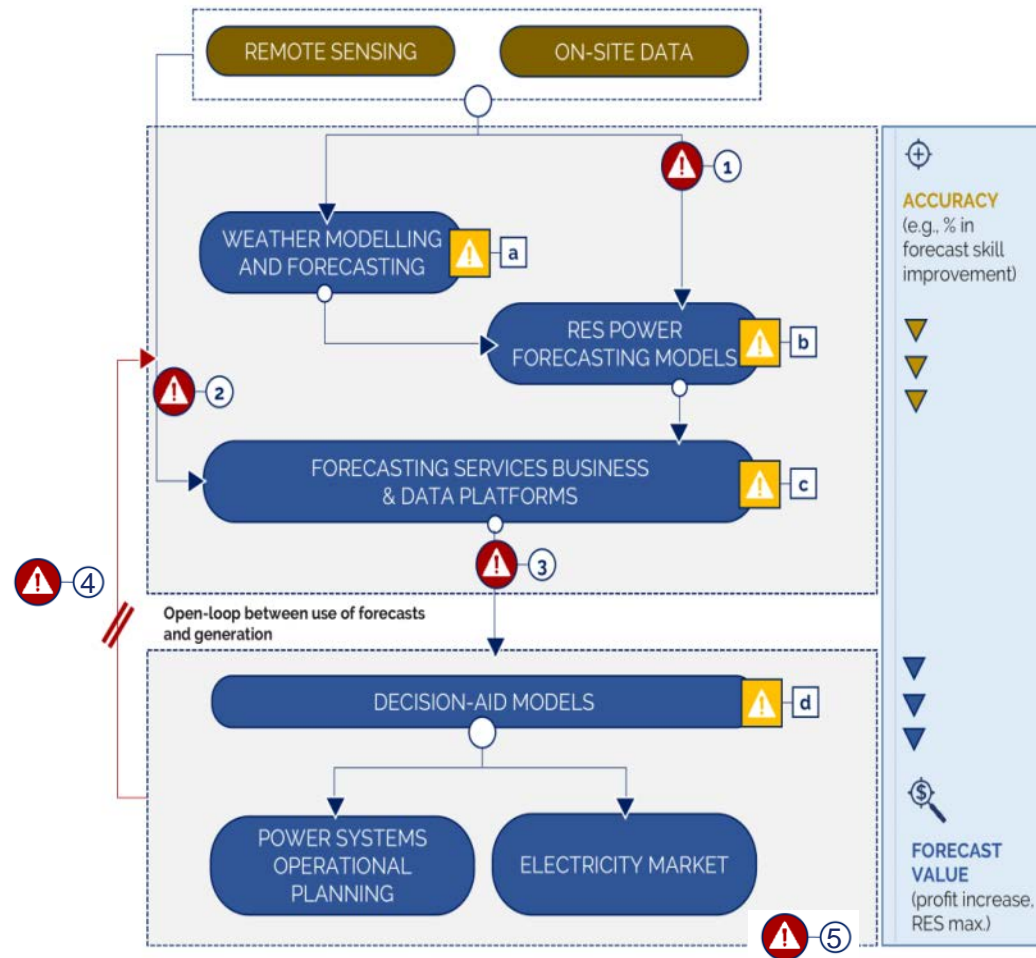
Limitations of RES prediction models to exploit large amounts of heterogenous data

Gaps & 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 & bottlenecks



Challenges in the models and the connections:



Need for NWP products adapted to RES use-cases.



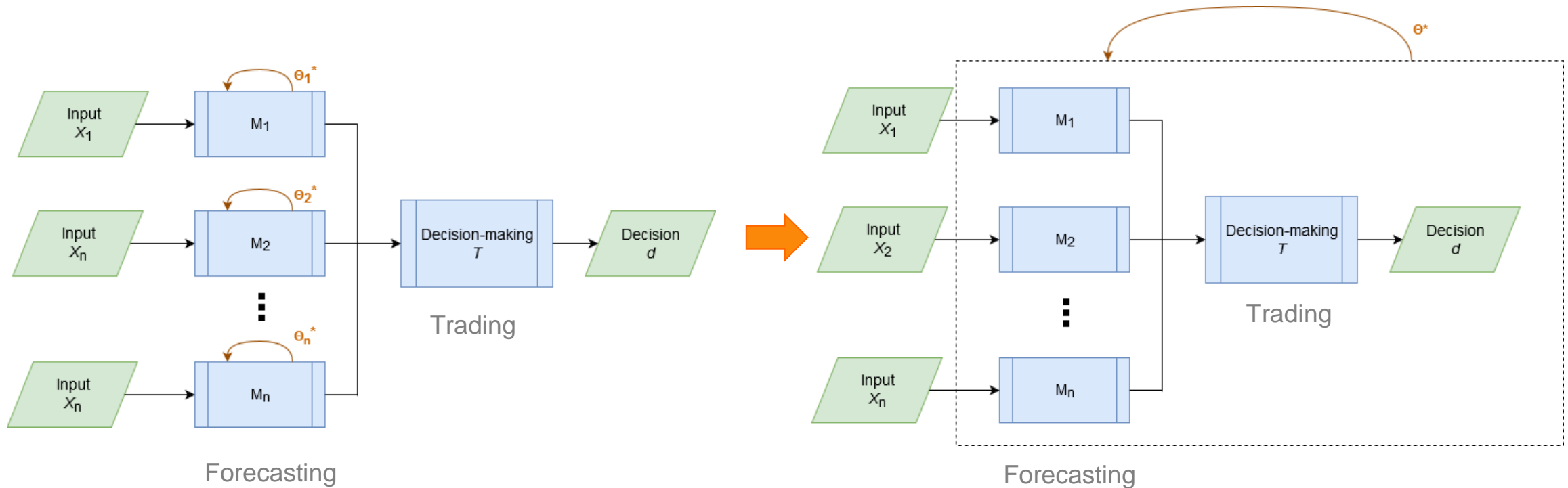
Limitations of RES prediction models to exploit large amounts of heterogenous data



Open loop between forecasts generation and their use in apps

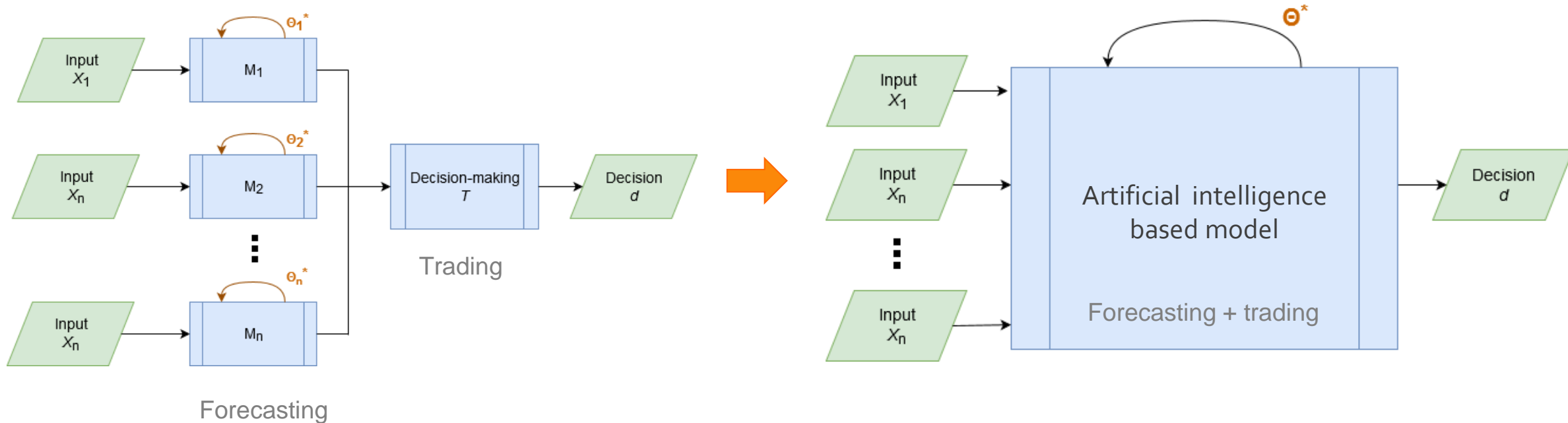
Gaps & bottlenecks (“open loop”)

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

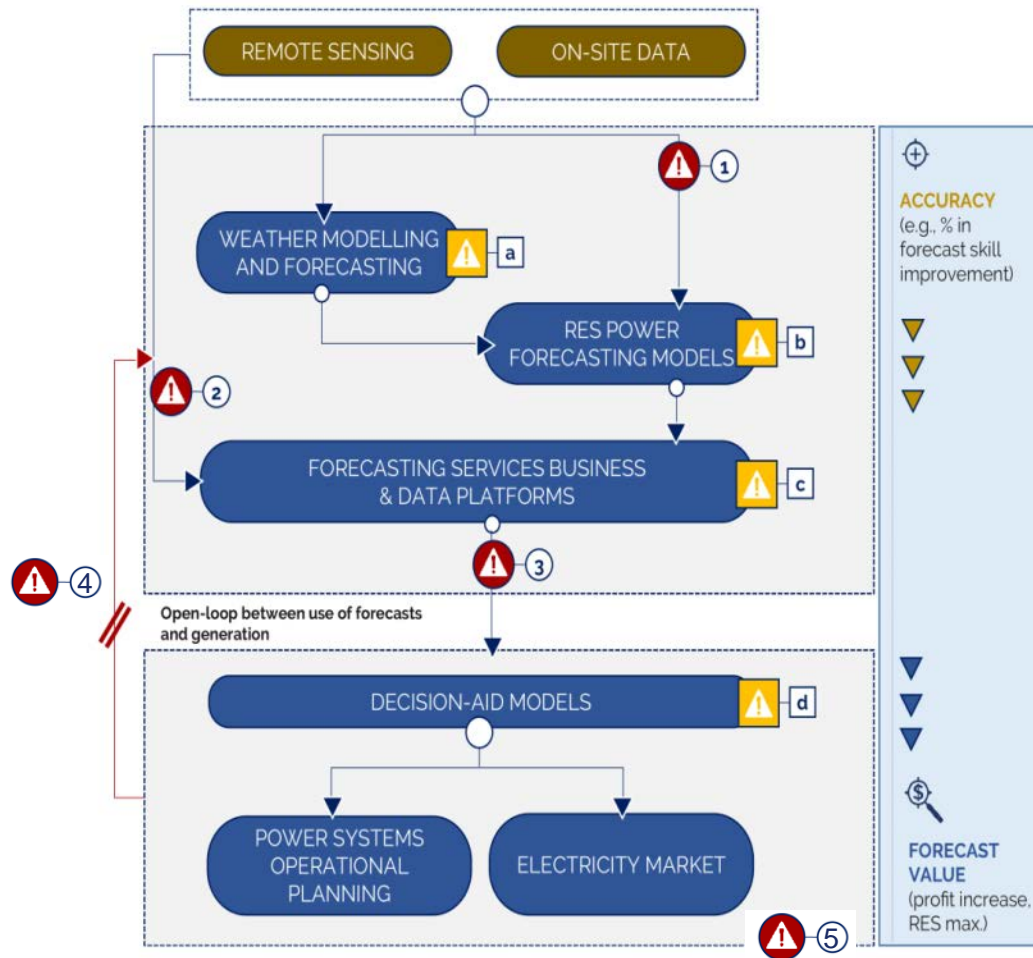


Gaps & bottlenecks (“open loop”)

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



Gaps & bottlenecks



Challenges in the models and the connections:



Need for NWP products adapted to RES use-cases.



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



Open loop between forecasts generation and their use in apps.



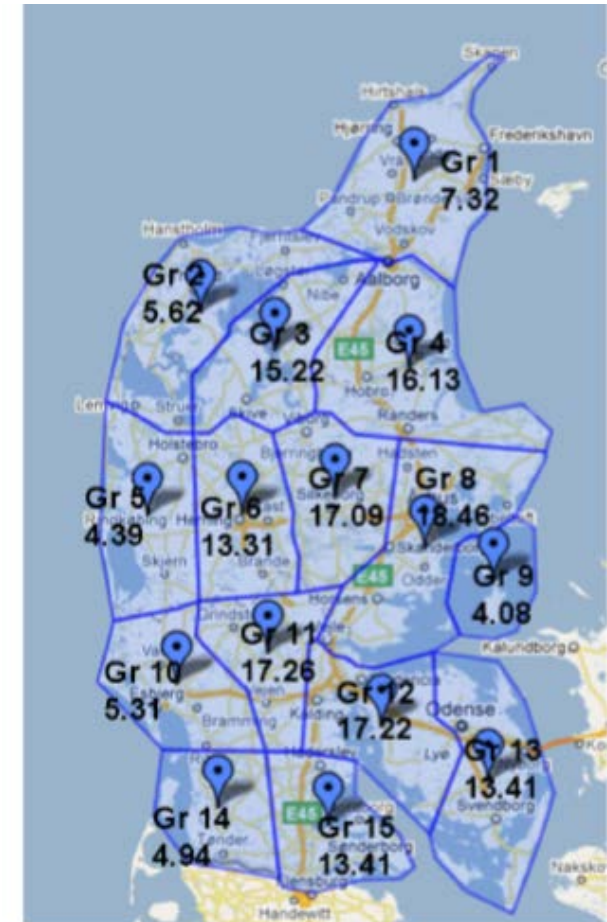
Lack of meaningful open data (privacy issues)



Lack of price incentives to share data

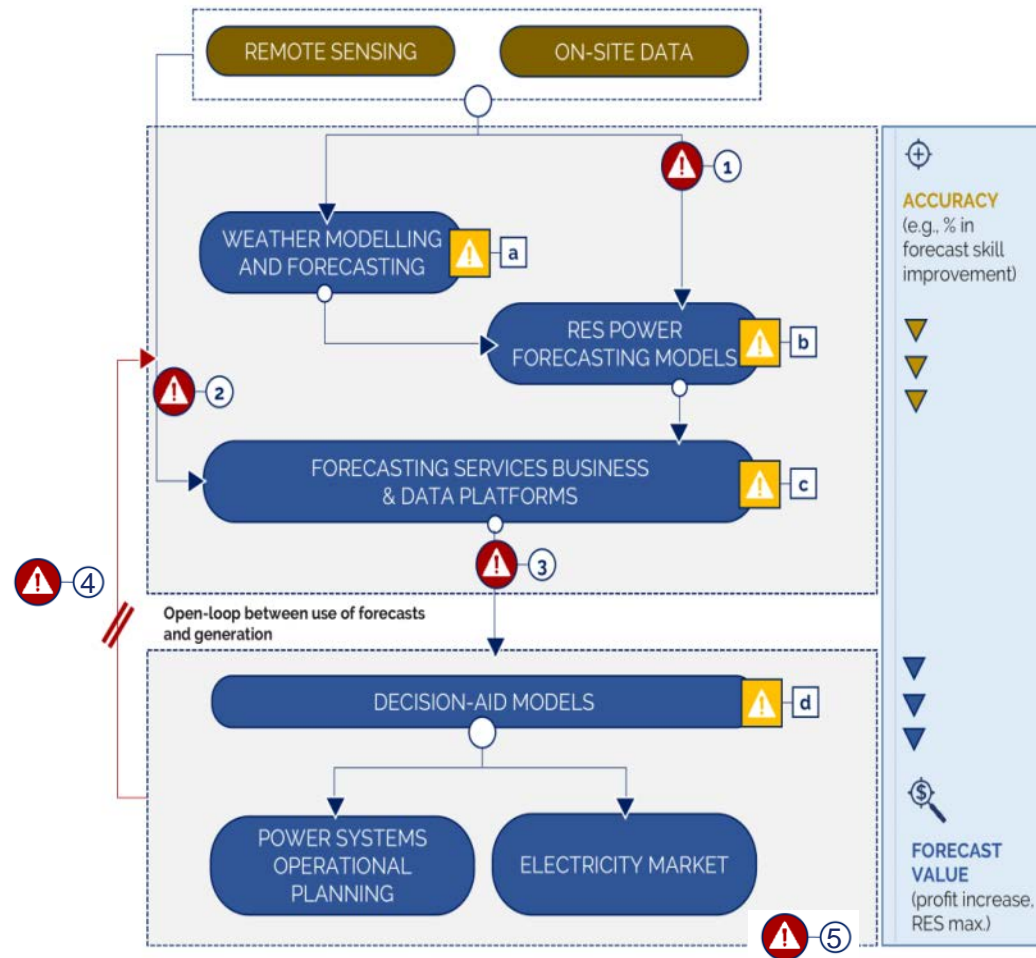
Gaps & bottlenecks (value from data)

- 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 & bottlenecks



Challenges in the models and the connections:



Lack of standardisation

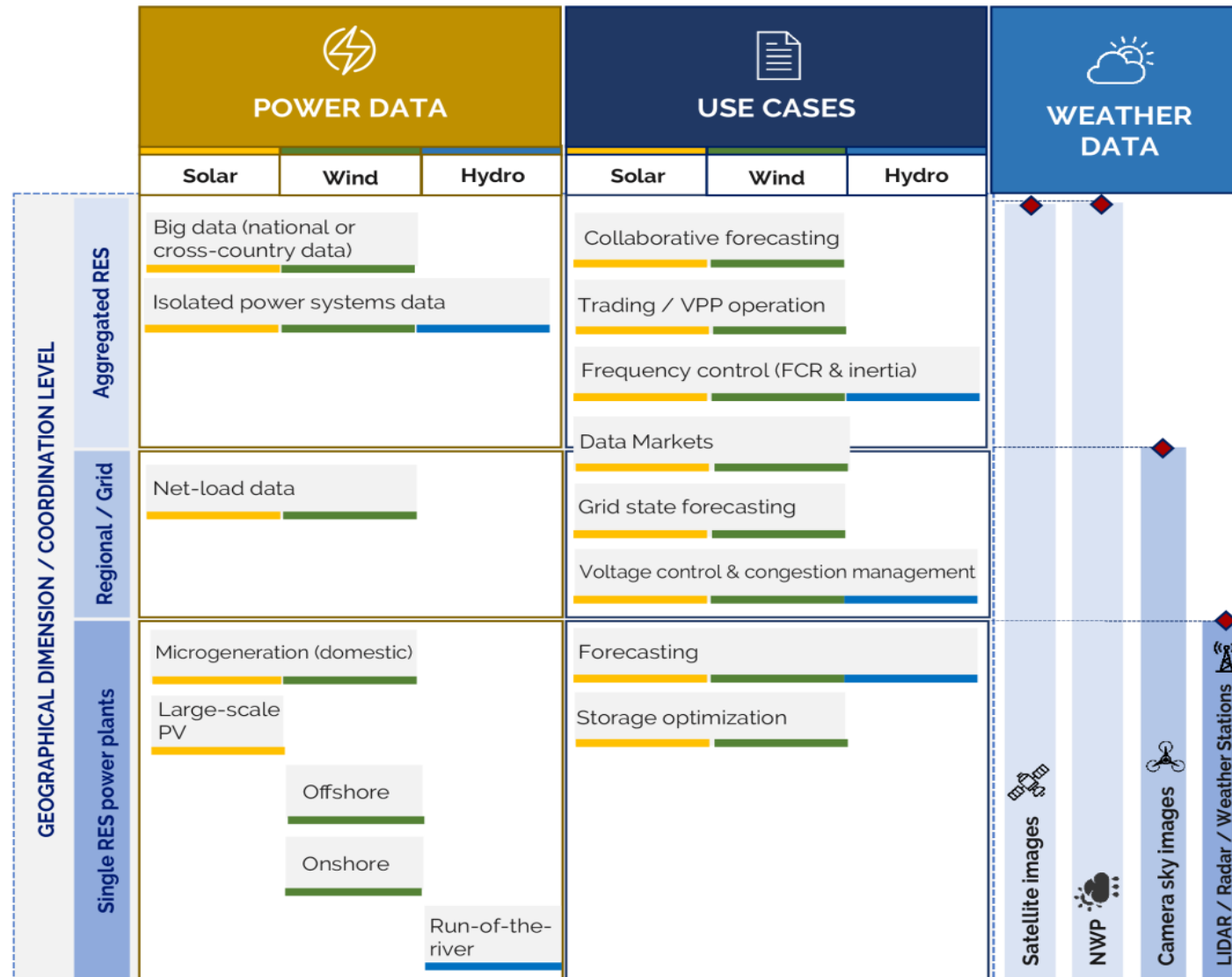


Need for decision aid models adequate for high RES integration scenarios



Need for business cases that demonstrate the value of integrating uncertainty forecasts to industry

Gaps & bottlenecks (the apps...)

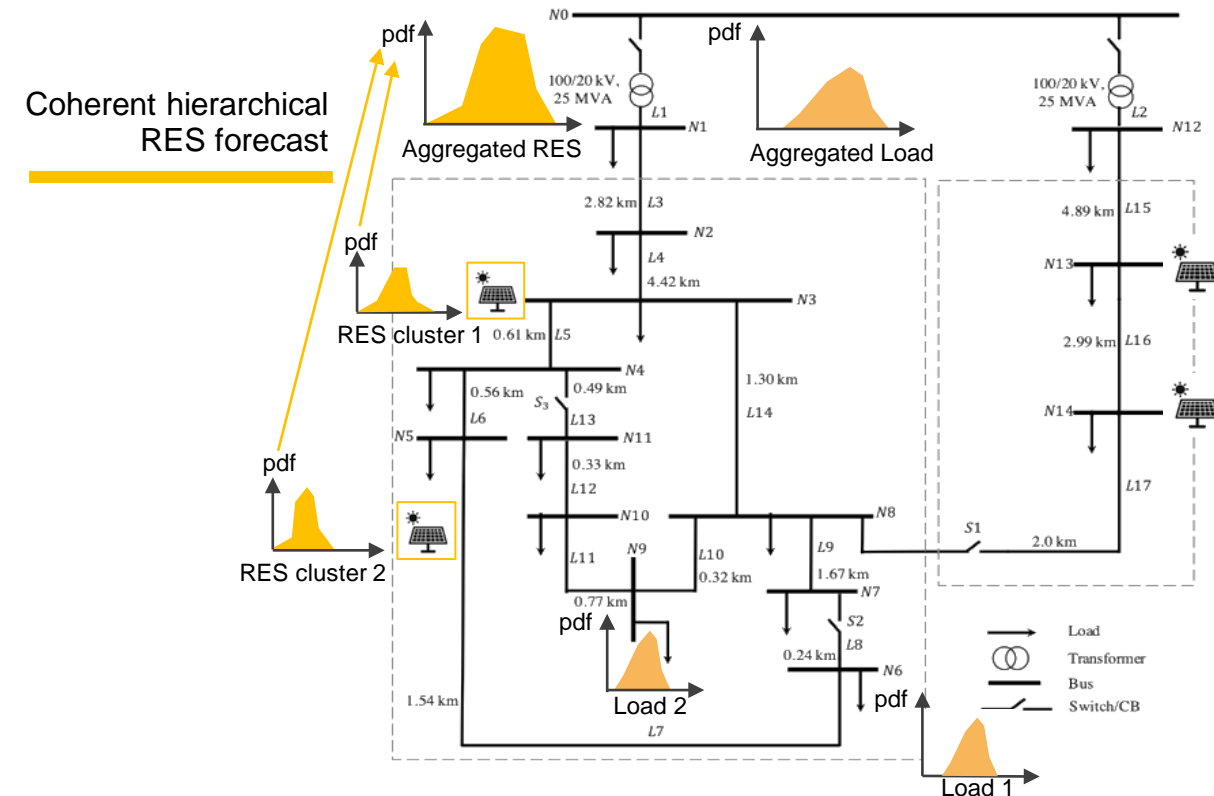
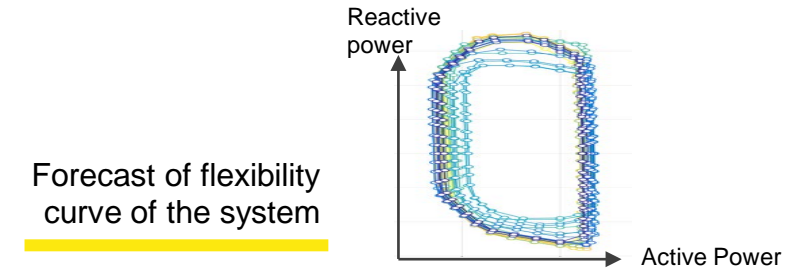


Gaps & bottlenecks (example app)

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



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!**



THANK YOU !





APPENDIX

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Smart4RES project: “Next Generation Modelling and Forecasting of Variable Renewable Generation for Large-scale Integration in Energy Systems and Markets”

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⇒ Newsletter: subscribe at www.smart4res.eu



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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**



Early interactions with future end-users

The Smart4RES Consortium has gathered 17 end-users (industrial members) forming a Reference group that will contribute by providing the consortium with:

- Advice on forecasting requirements in terms of models and applications, end-user challenges and issues and on the exploitation of results;
- Detailed measurements from RES power plants for the evaluation of the Smart4RES models and contribute to their scalability and replicability .