Innovative AI contributions to renewable energy forecasting

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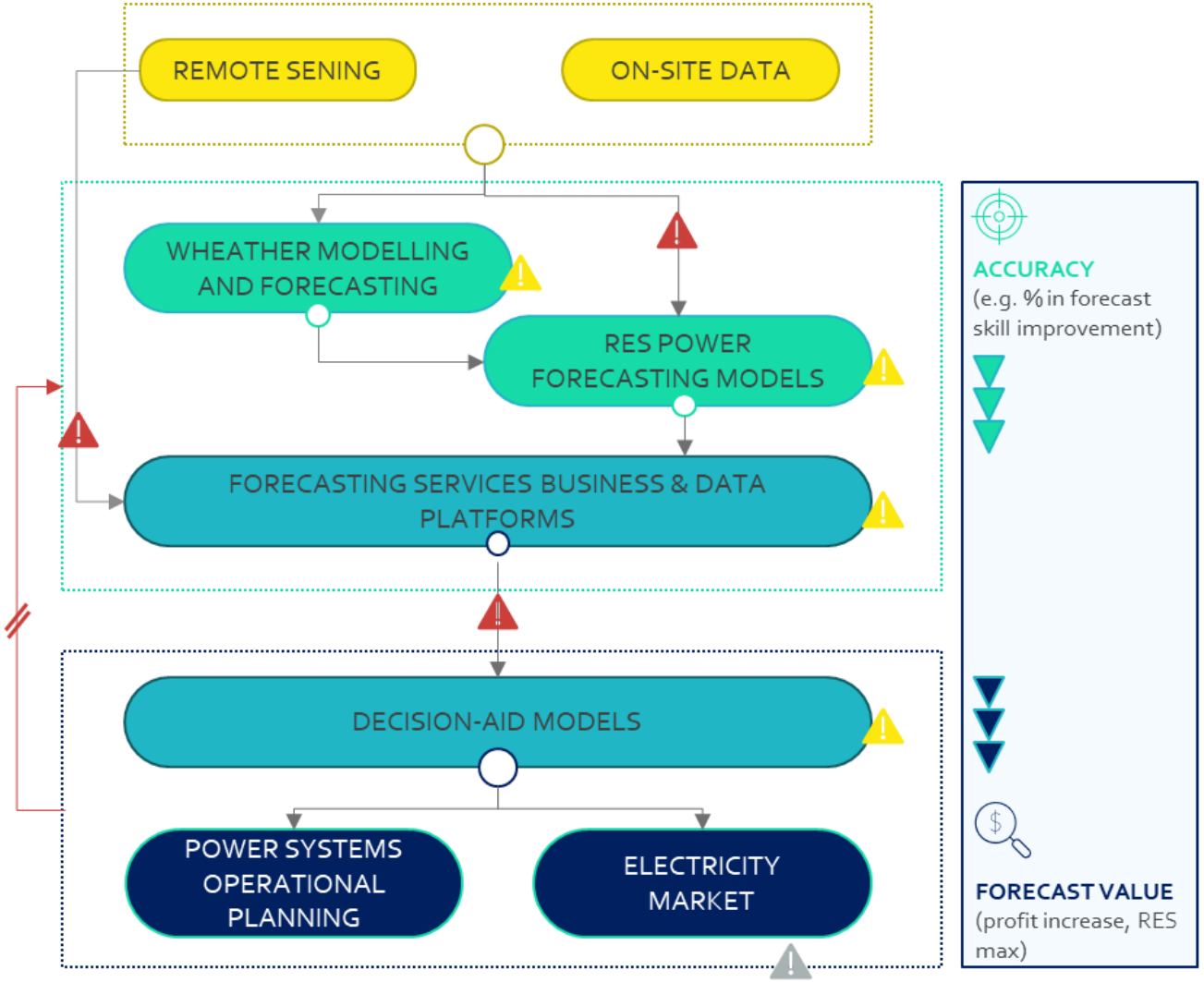
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864337

The « Forecast then Optimise » Model Chain

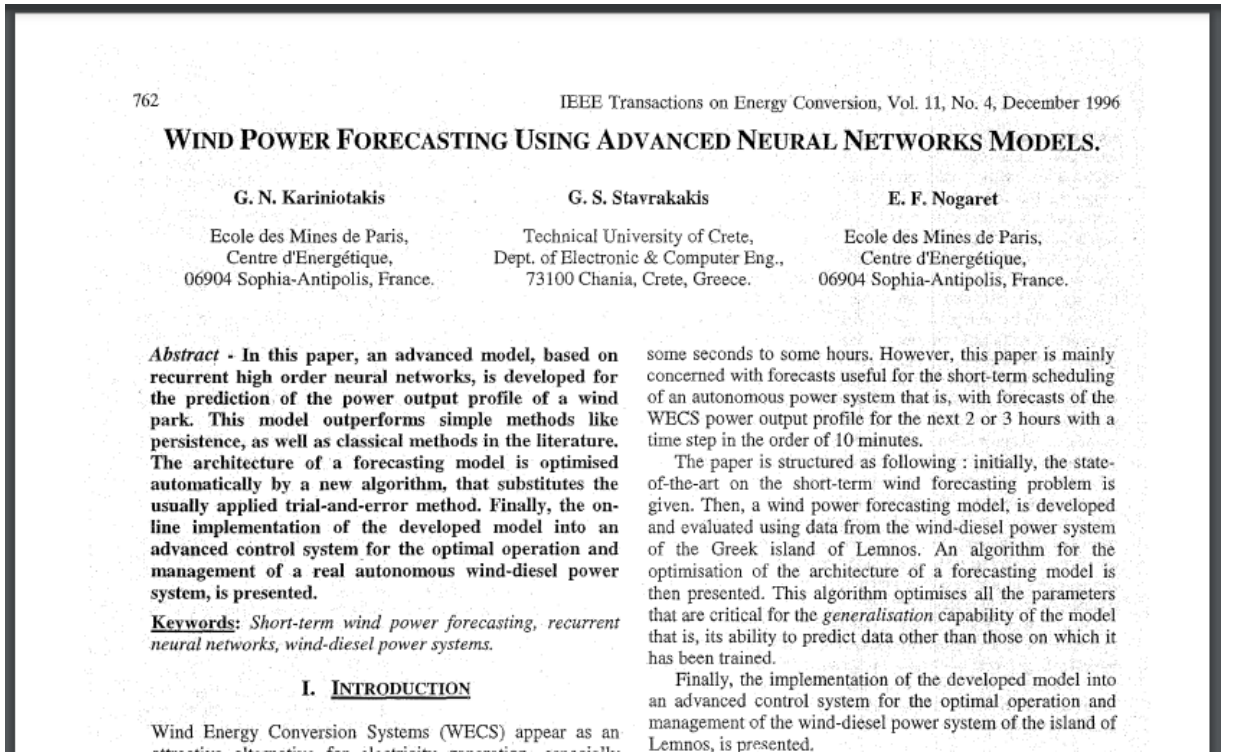
- Short-term forecasts (min-days ahead) of renewable (RES) generation are required for a safe and economic integration of RES into power systems and markets

- IA approaches can be present at each step of the model chain



IA and renewable energies

- First research works on IA methods applied on renewable energies appeared in mid '90s.
- The 1st ever journal paper, where IA was applied in the renewable energies field was published in 1996 (ANN for wind power forecasting).
- Since then there is an explosion of academic works (i.e. ~600-700 papers on wind/solar forecasting per year).



762 IEEE Transactions on Energy Conversion, Vol. 11, No. 4, December 1996

WIND POWER FORECASTING USING ADVANCED NEURAL NETWORKS MODELS.

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Abstract **- In this paper, an advanced model, based on recurrent high order neural networks, is developed for the prediction of the power output profile of a wind park. This model outperforms simple methods like persistence, as well as classical methods in the literature. The architecture of a forecasting model is optimised automatically by a new algorithm, that substitutes the usually applied trial-and-error method. Finally, the on-line implementation of the developed model into an advanced control system for the optimal operation and management of a real autonomous wind-diesel power system, is presented.**

Keywords: *Short-term wind power forecasting, recurrent neural networks, wind-diesel power systems.*

I. INTRODUCTION

Wind Energy Conversion Systems (WECS) appear as an

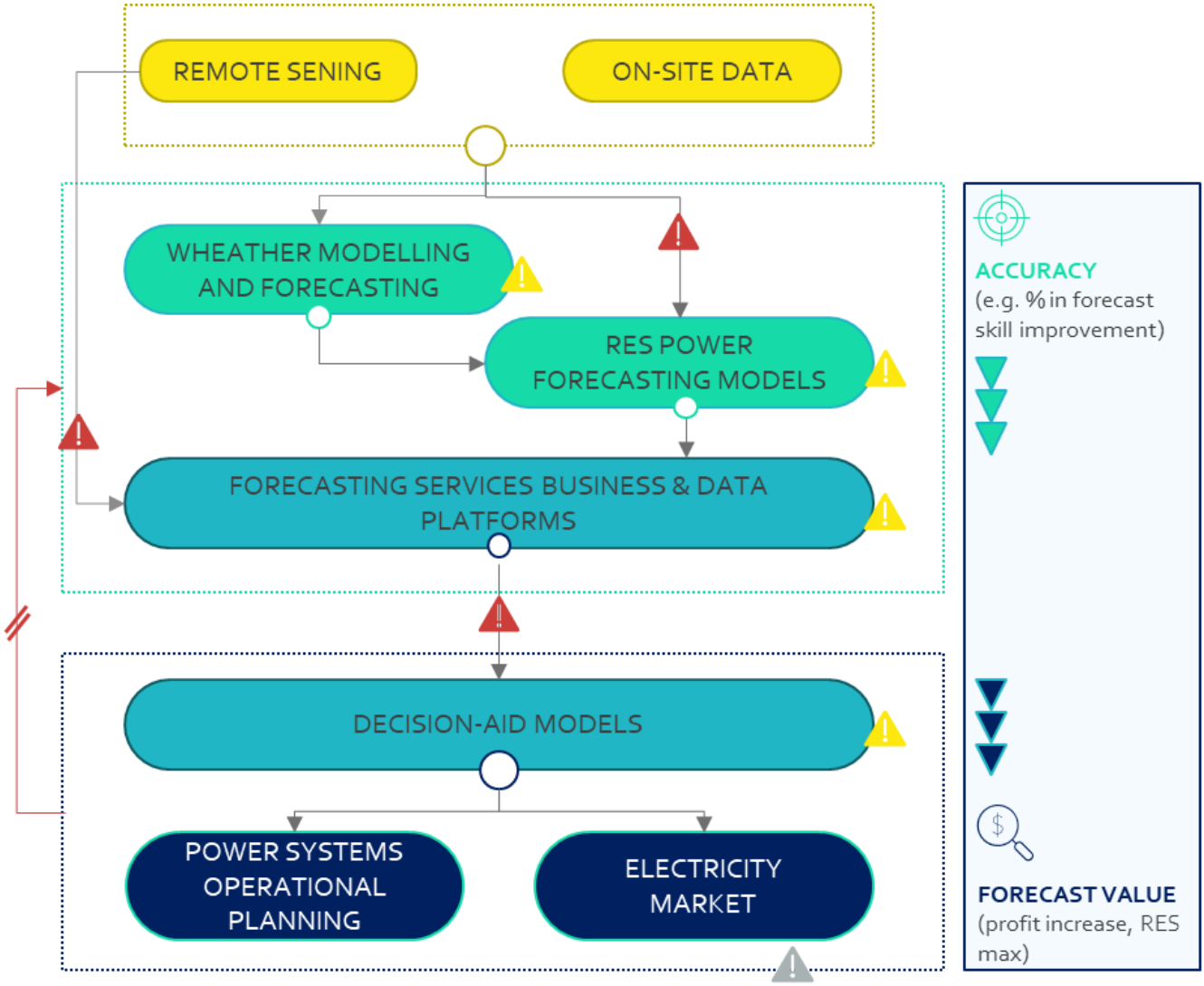
some seconds to some hours. However, this paper is mainly concerned with forecasts useful for the short-term scheduling of an autonomous power system that is, with forecasts of the WECS power output profile for the next 2 or 3 hours with a time step in the order of 10 minutes.

The paper is structured as following : initially, the state-of-the-art on the short-term wind forecasting problem is given. Then, a wind power forecasting model, is developed and evaluated using data from the wind-diesel power system of the Greek island of Lemnos. An algorithm for the optimisation of the architecture of a forecasting model is then presented. This algorithm optimises all the parameters that are critical for the *generalisation* capability of the model that is, its ability to predict data other than those on which it has been trained.

Finally, the implementation of the developed model into an advanced control system for the optimal operation and management of the wind-diesel power system of the island of Lemnos, is presented.

The « Forecast then Optimise » Model Chain

- Short-term forecasts (min-days ahead) of renewable (RES) generation are required for a safe and economic integration of RES into power systems and markets
- IA approaches can be present at each step of the model chain
- IA gives opportunities to think out of the box.



Beyond classical RES forecasting: Seamless forecasting

Example Use-Case: Optimisation of VPP participation in day-ahead (DA) + Intraday (ID) + Ancillary Service (AS) markets:
(in parenthesis the number of models: 11 in total)

Data on RES, storage, markets

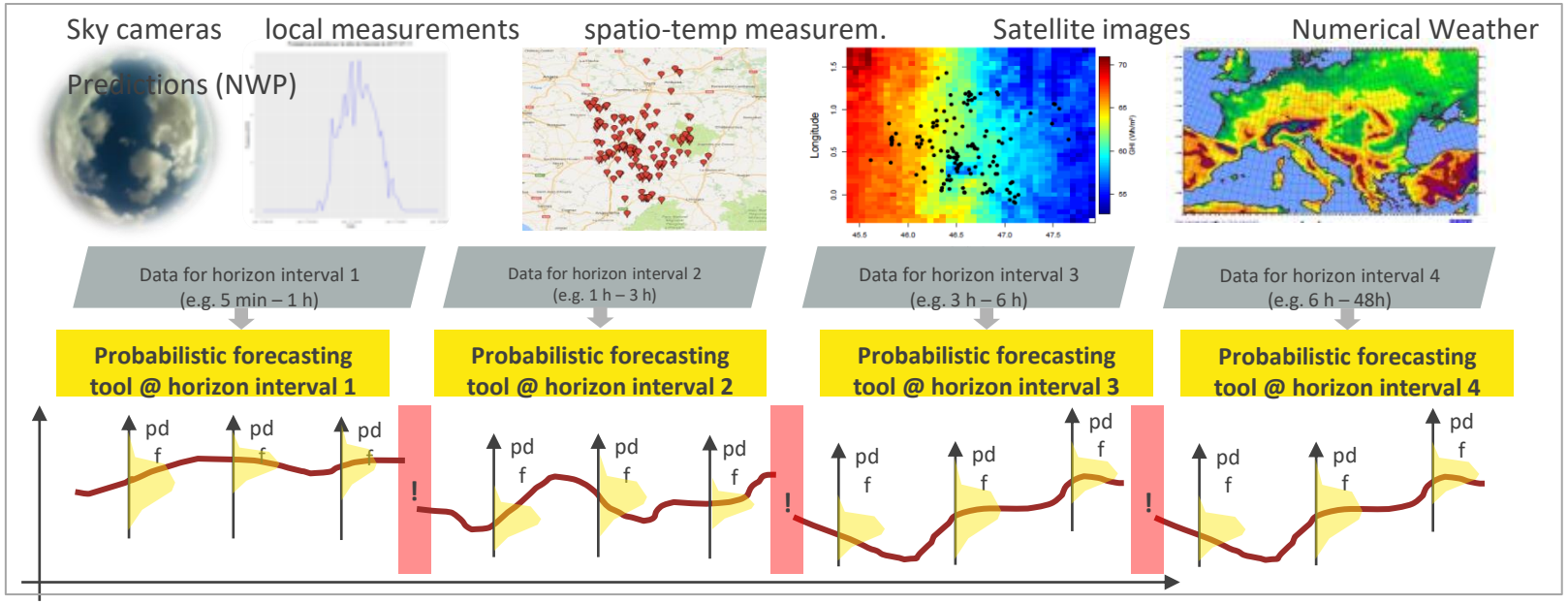
Forecast aggregated RES production (1)

Forecast DA/ID energy market quantities (prices, imbalances) (3)

Forecast AS market quantities (prices, volumes, activation probabilities) (6)

Stochastic optimisation for trading decisions (1)

Bids on energy + AS markets



The usual RES forecasting consists in separate models for different time frames

Seamless approach: Develop a single probabilistic model able to cover all time frames, all available data input and applicable to all technologies (wind/solar/combinations…). Have at least same level of performance as existing dedicated models.

Beyond classical RES forecasting: Value-oriented forecasting

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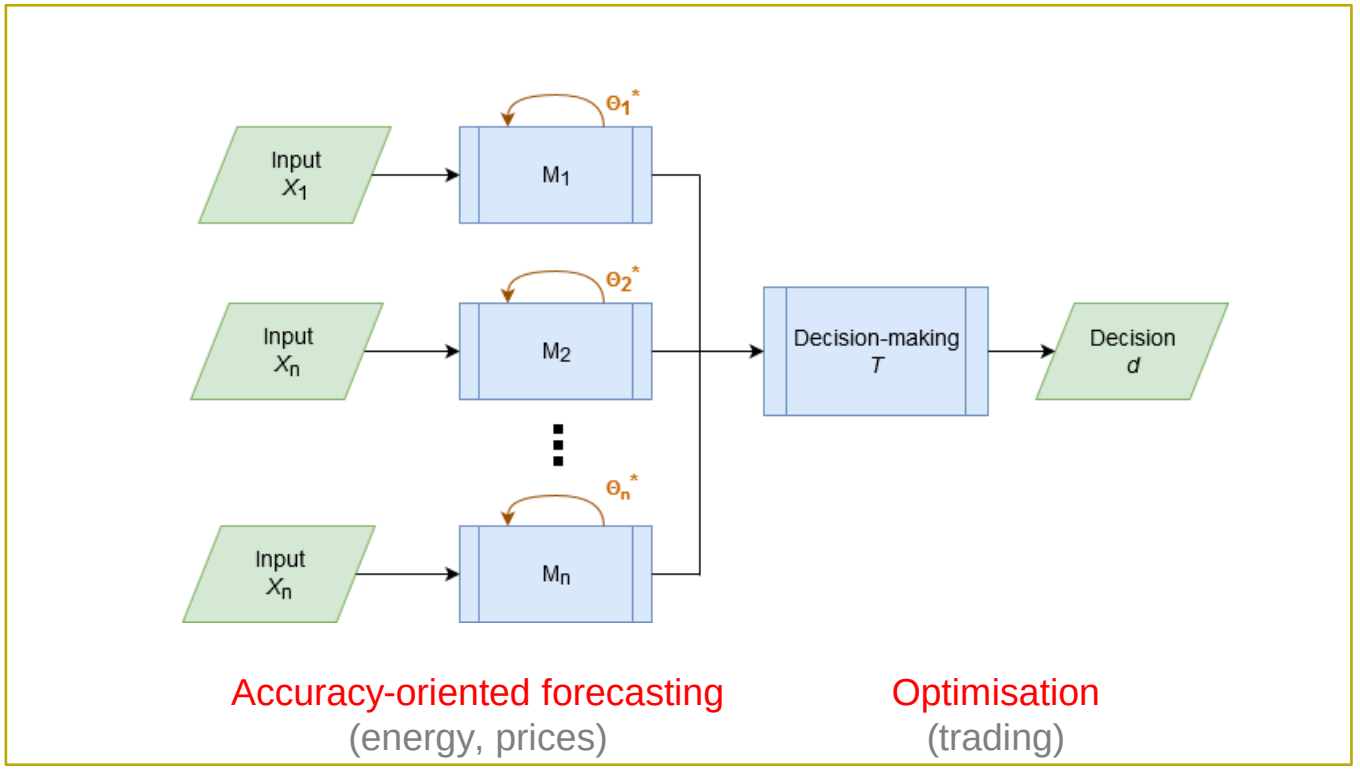
The classic approach:

FORECAST THEN OPTIMISE



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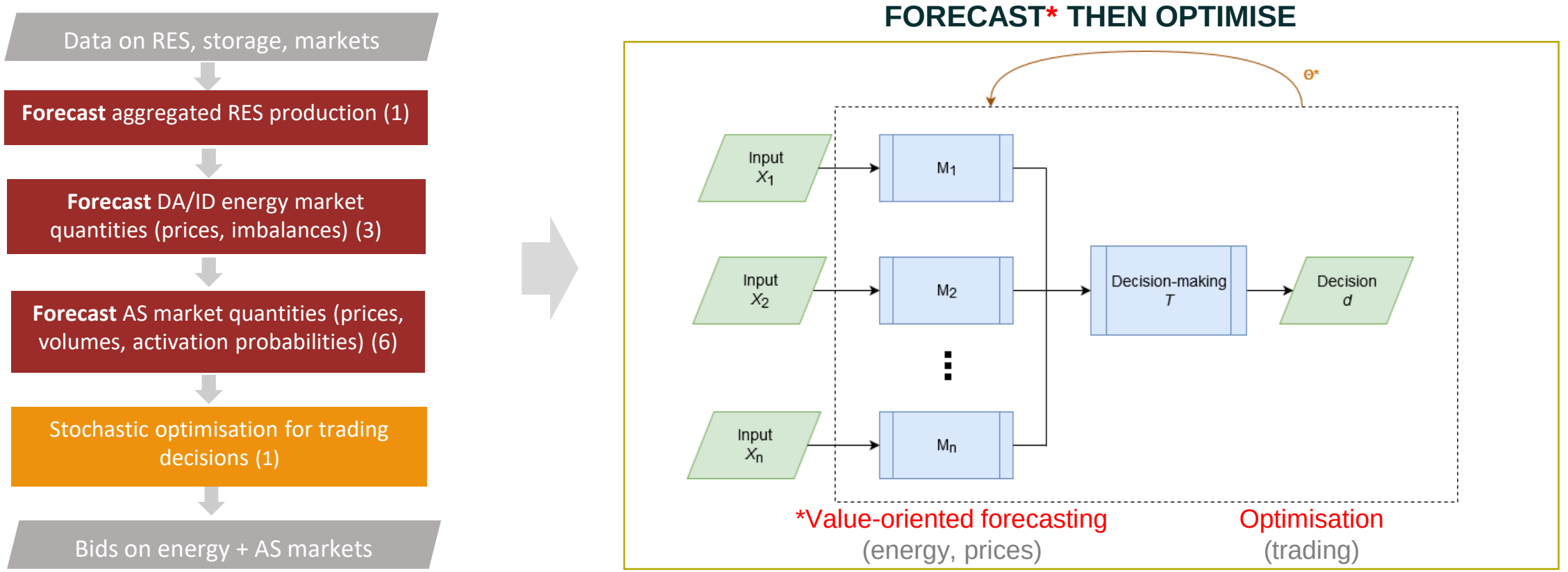

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Beyond classical RES forecasting: Prescriptive analytics

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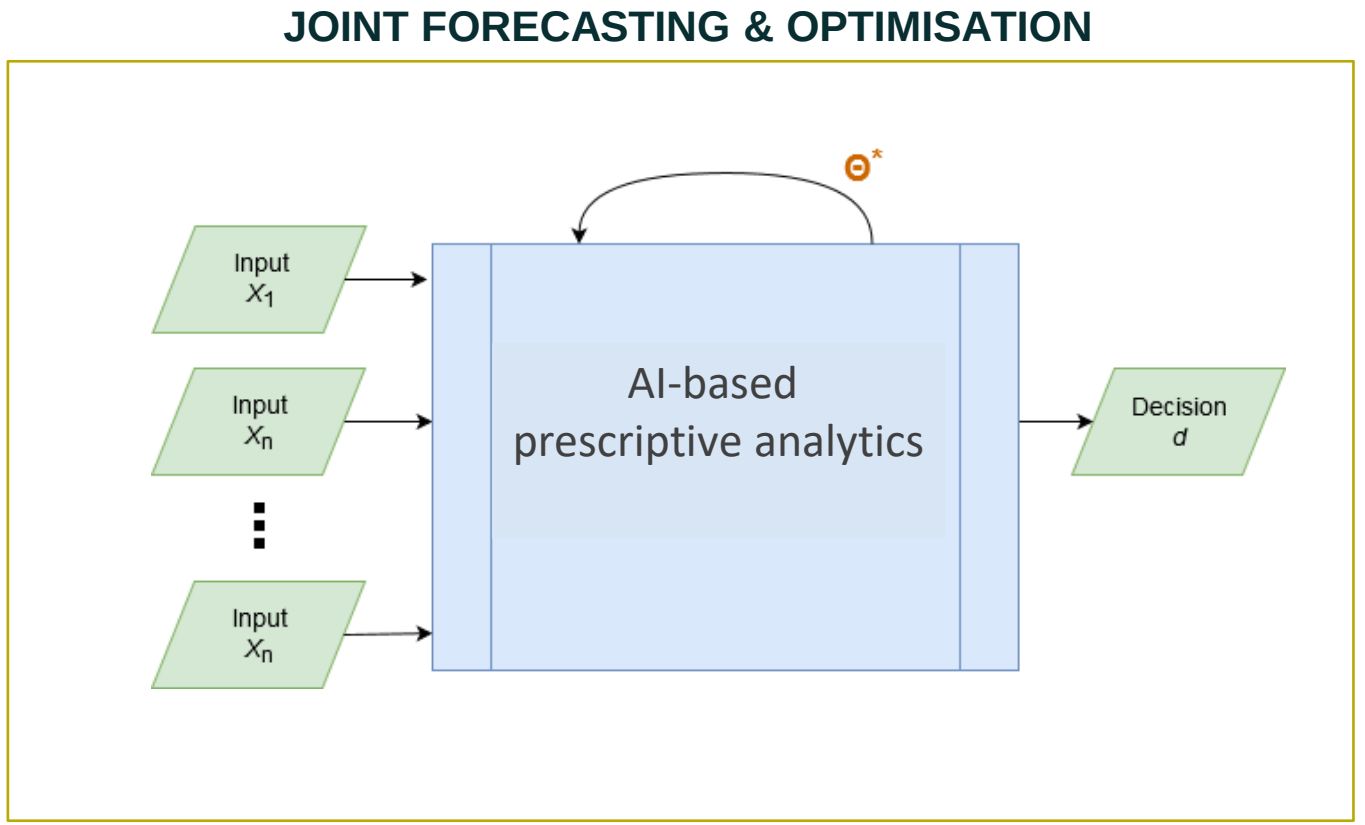
Stochastic optimisation for trading decisions (1)

Bids on energy + AS markets



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...and beyond the presciptive approach

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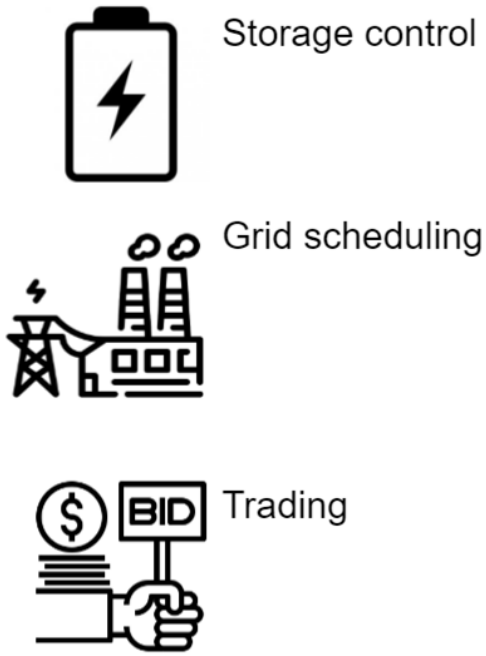
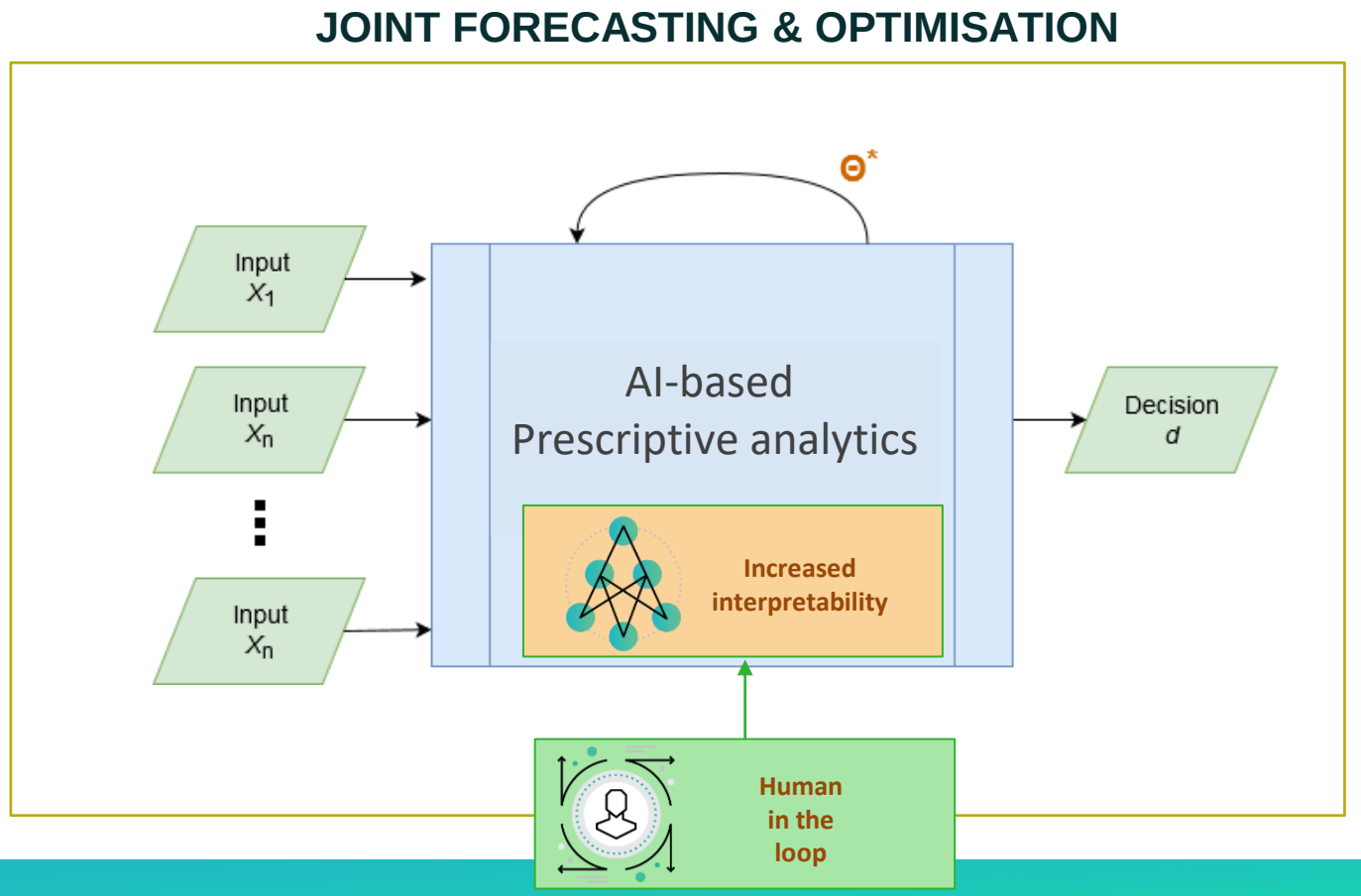
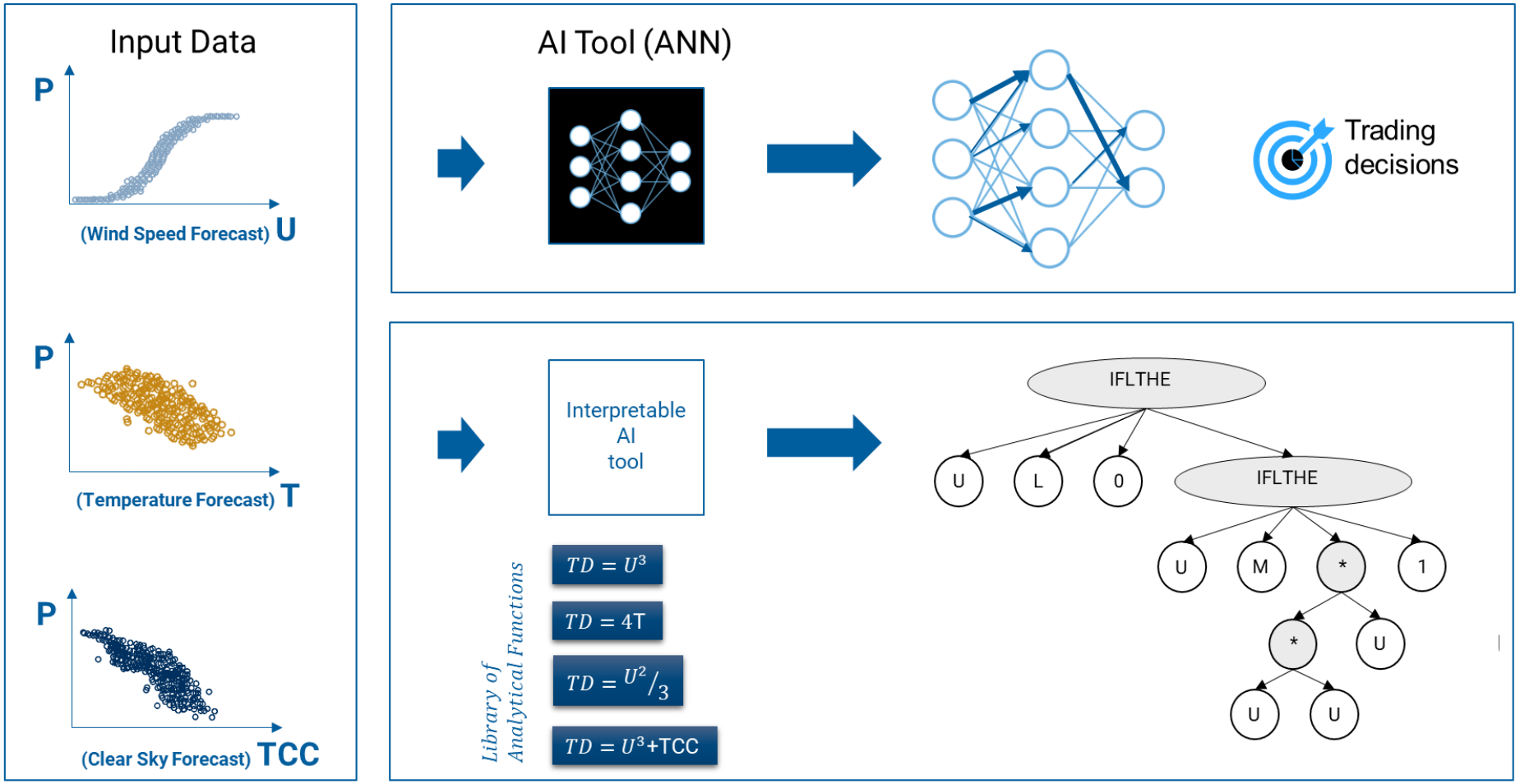




...and beyond the presciptive approach

Example Use-Case: Wind power trading using the Genetic Programming approach (natural language processing).



Smart4RES

THANK YOU !

https://www.smart4res.eu/

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We have 5 PhD positions open in this area : contact me if interested.