

“Wind power forecasting, overview, history and future”



 **cener**
centro nacional de energías renovables



A brief history of STP



A brief history of STP



🌀 The initial steps. Before 1990:

- ❑ References on MOS, Kalman filtering, ARMA models...
- ❑ Mainly theoretical works but not many practical cases.

🌀 Beginning of the operational models. Between 1990 and 2000:

- ❑ References on models for physical downscaling, MOS, conditional parametric models, neural networks...
- ❑ Some practical cases mainly in Denmark.
- ❑ STP begins to appear in the EU calls for R&D projects.



A brief history of STP



🌀 Extensive use of STP. Since 2000:

- ❑ More work on mesoscale NWP, probabilistic forecasts, combination of forecasts, meteorological ensembles, multi-model ensembles, ...
- ❑ EU projects: ANEMOS, Honeymoon, POW'WOW, ANEMOS.plus, SafeWind.
- ❑ R&D projects at national level (Spain, Denmark, Germany, United Kingdom, Australia, US,...)
- ❑ Benchmarking national project in Spain (AEE).
- ❑ Lots of practical cases in Denmark, Spain, Germany, US,...





The Spanish case



The Spanish case



- 🌀 Before 2000 there were some attempts to develop STP models with some utilities. At that time there was no obligation of selling the energy in the market. The conclusion was that the accuracy of the STP models was not enough to be useful.
- 🌀 In year 2004, the regulation changed and wind energy producers were asked to participate in the market with advantageous conditions but with the necessity of using STP.
- 🌀 It was proved that state of the art STP models, were able to produce useful information to help promoters to improve their economic results in the market. This situation jointly with the very advantageous conditions of the law, made that the majority of the wind farms were quickly included in the electricity market.





🌀 Changes made in year 2004 in the regulatory conditions had two impacts:

- ❑ The progressive change from fixed tariff conditions to market operation of the wind farm owners.
- ❑ The extensive use of STP models by wind farms.
- ❑ The development of the STP market in Spain.

🌀 STP market in Spain is one of the most competitive worldwide:

- ❑ In years 2005 and 2006 new companies and university groups appeared on a monthly basis offering new STP models.
- ❑ Most of those companies/activities disappeared by 2007.
- ❑ Accuracy, reliability and quality of service are the key factors.





The value of wind power forecast



The value of wind power forecast



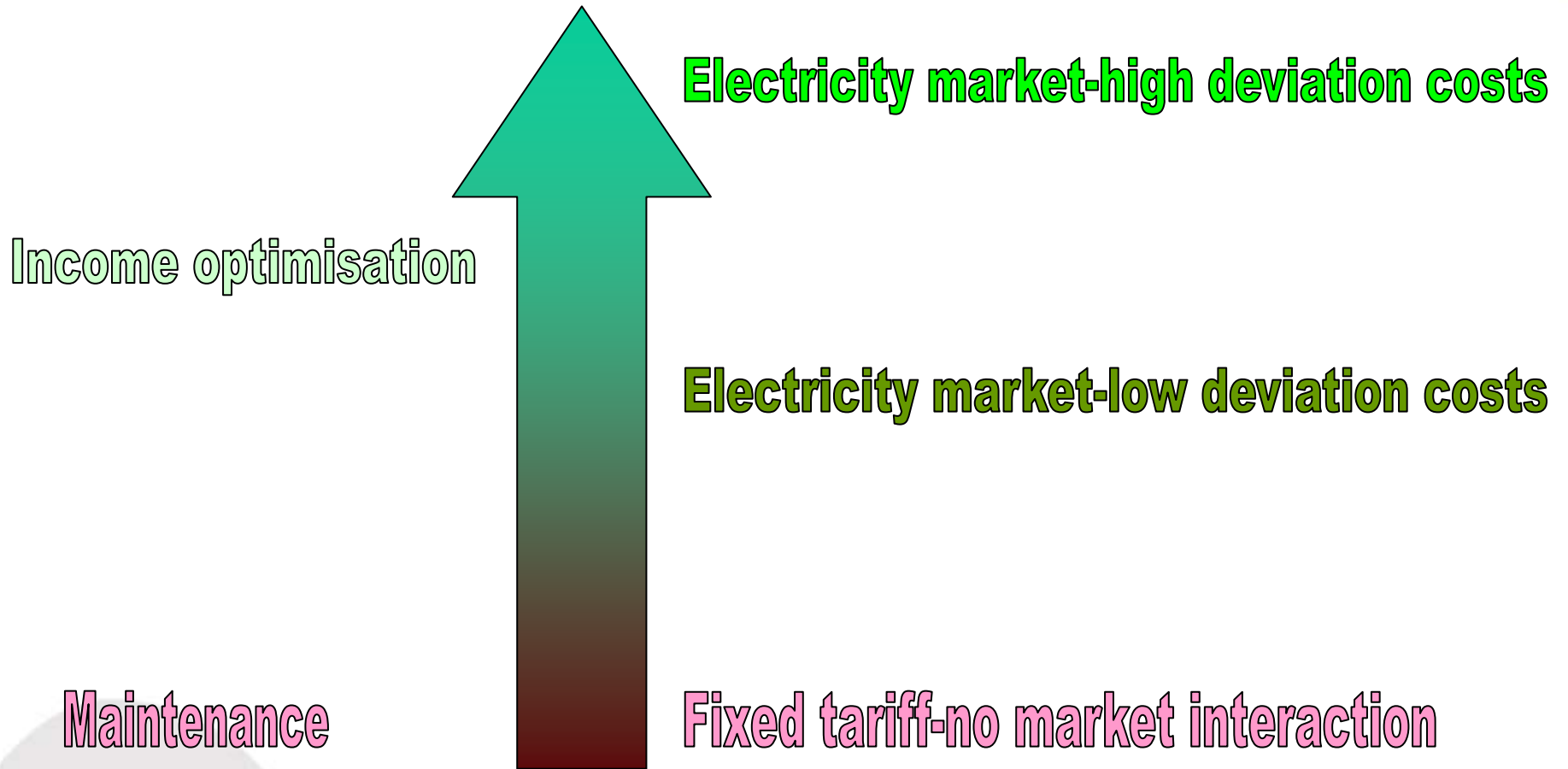
- 🌀 The value of the wind power forecast depends mainly on two factors:
 - ❑ Accuracy of the forecasting models.
 - ❑ Market rules and specific conditions for wind energy trading.

- 🌀 During the last 15 years there has been a significant improvement in the forecasting models.

- 🌀 However there is still, in general, a non optimal use of the full potential of forecasting by the end users.



The value of wind power forecast

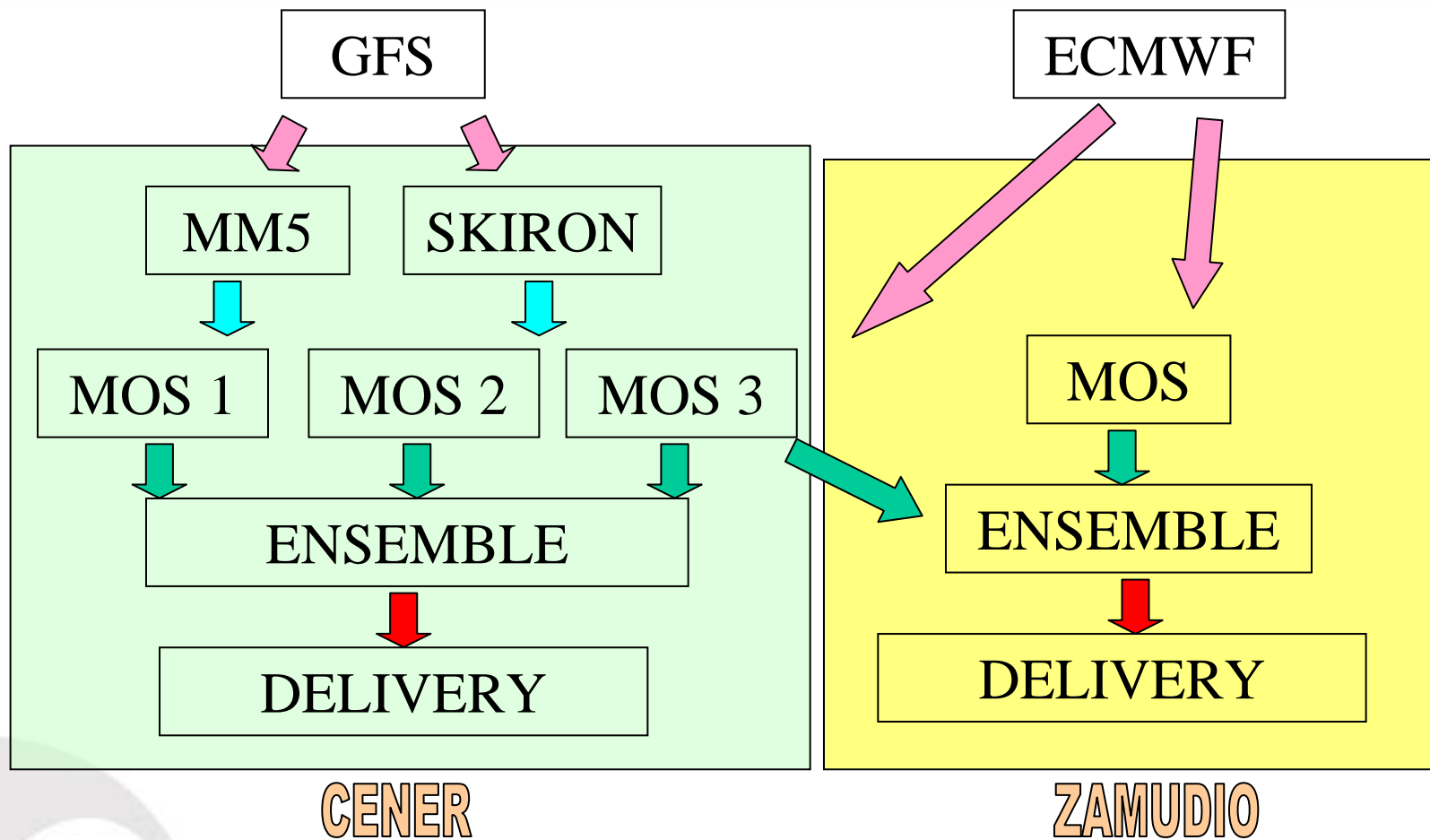




CENER forecasting system



CENER forecasting system: multi-model ensemble



Configurations for the daily and intra-daily markets





ANEMOS forecasting system



ANEMOS forecasting system



- 🌀 ANEMOS consortium was established in 2001 in the framework of a EU project.
- 🌀 An integrated forecasting system was developed, including a common shell and prediction models from different universities, R&D institutions and private EU companies.
- 🌀 ANEMOS consortium started commercial activities in 2006.
- 🌀 ANEMOS system is producing forecasts for utilities, TSOs and wind farm promoters in several EU countries and abroad.



anemos.cma.fr





The future



The future of STP according to TPWind



Knowing the geographic coordinates of the site (flat terrain, complex terrain or offshore), with or without measurements, **2030** techniques will provide estimations of:

- 🌀 Wind energy potential with an uncertainty $< 3\%$ ("**resource**").
- 🌀 Design wind characteristics with an uncertainty $< 3\%$ ("**design conditions**").
- 🌀 **Short-term forecasting** scheme for power production and wind conditions with an uncertainty $< 3\%$.

The 3% vision





Data analysis and new measurement techniques:

Use of **real time measurements** for very short-term forecast for safe grid operation,

} Short Term

Better integration of online wind measurements (masts, remote sensing, turbines) to improve average and extreme errors.

} Short Term





🌀 *Advanced models:*

- ❑ **Improved meteorological models.** Dedicated models for extreme events. Coupling of wind and wave models.
- ❑ Better characterization of **forecast uncertainty.**
- ❑ Integration of **wind farm data into NWP** models and wind power.

} **Medium Term**

} **Long Term**





Arcadio María Larraona 1, 2ª Planta
31008 Pamplona (España)

Tel. +34 948 25 28 00
Fax. +34 948 27 07 74
Email. info@cener.com

www.cener.com



 **cener**
centro nacional de energías renovables