Capabilities and costs for ancillary services provision by wind power plants

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REserviceS
ECONOMIC GRID SUPPORT FROM VARIABLE RENEWABLES

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SUMMARY

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Objective	To establish a reference basis and policy recommendations for future network codes and market design in the area of ancillary services from variable renewables.
Output	Needs for and costs of ancillary services provided by wind and solar PV.
Background	• Future high shares of variable renewables in electricity consumption • Electricity market liberalisation
Target groups	System operators, energy regulators, policy makers, RES-E generators and power industry in general.
Consortium	Coordinator: EWEA Partners: EPIA, 3E, VTT, Fraunhofer IWES, Acciona, UCD NUID, DTU Wind Energy, EDSO4SG, Mainstream, SMA, GE

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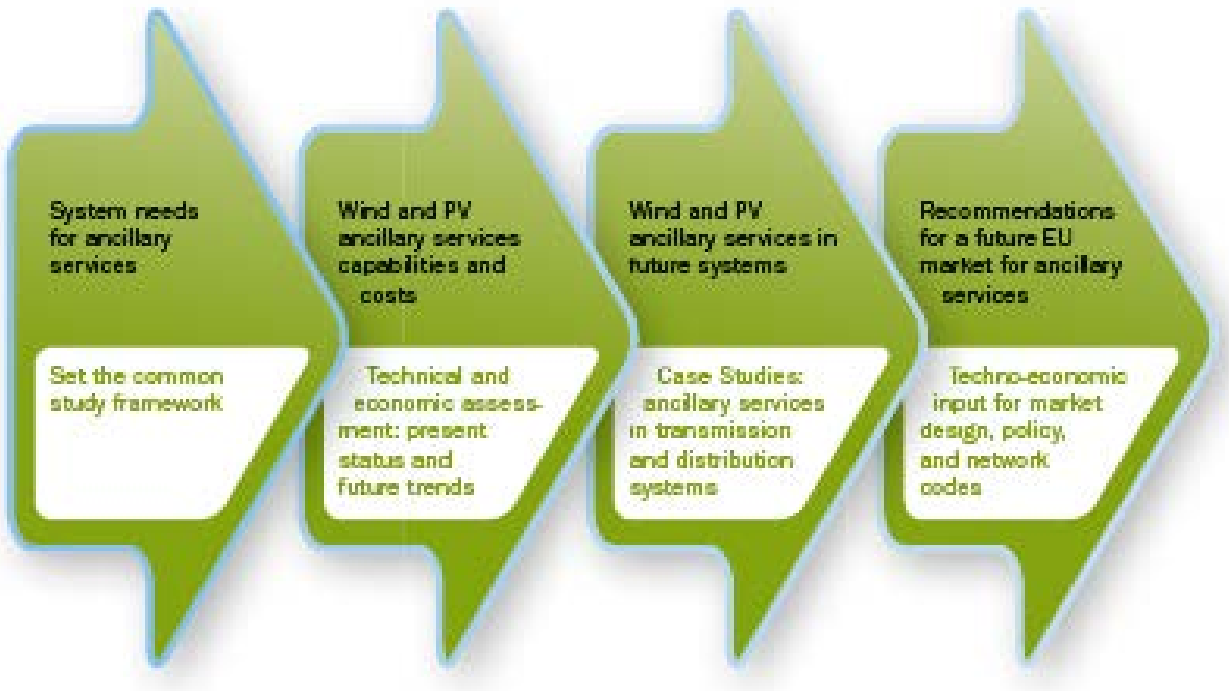
Project plan of actions



Methodology

System needs for AS

- List of services
- Impacts in services at wind large wind energy penetrations
- Cost structure definition
- Procurement survey
- Costs from conventional generation

Capabilities and Costs

- Literature survey
- Questionnaires – detailed on technical functionalities
- Interviews – focused on services

Case studies

- Simulation of service provision at
- Verification of capabilities and costs
- Assessment at transmission and distribution level

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Table for AS categories

Frequency support	Voltage support	System restoration
Frequency Containment Reserve FCR (<5, 10 or 30 sec) Frequency Restoration Reserve FRR (<15 min) Replacement Reserve RR (15 min to hours)	Normal Operation: control of power factor, reactive power or voltage	Black start
Fast frequency response (synthetic inertia) (< 2s) Ramping margin (1, 3, 8 hours ahead)	Fast reactive current injection	Islanding

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Cost structure

Ability / capability	Readiness / holding / availability	Utilisation / response
• investment cost related to providing the capability	• cost for capacity reserved, opportunity cost loosing energy that cannot be sold • link to other markets	• actual provision of the service, like energy as used with fuel cost • increased maintenance costs (wear and tear)

FoF – Frequency related services

Type of functionality	Functionality name	Ancillary Service FCR	FRR	RR	FFR	RM	Implementation level
Technical	Active Power Control	X	X	X		X	WT/WF
	Active Power Delta Control Mode	+	+	+			WT/WF
	Active Power Limitation Control Mode	+	+	+		X	WT/WF
	Active Power Gradient Control Mode	+	+	+		+	WT/WF
	Frequency Sensing	X	X		X		WT/WF
	Frequency Sensitivity Mode (or Droop Control)	+	+				WT/WF
	Active Power Setpoint Processing	X	X	X	X	X	WT/WF
	Setpoint Priority Management	-	-	-	-	-	WF
	Temporary Active Power Increase				-		WT
Operational	Ability to Calculate Actual Active Power Production	+	+				WT
	Power production forecast		+	+		+	WF
	Communication and Control Interface	X	X	X	X	X	WT/WF
	Communication and Control Interface with the SO	X	X	X	X	X	WF
	Wind Power Plant Management System	+	+	+		+	WF

References:

X Functionality required and today generally available

\+ Functionality required but not always available or optionally available

\- Functionality rarely available/ not implemented but implementable/ programmable

O Functionality required and NOT available

WT Functionality considered at Wind Turbine level

WF Functionality considered at Wind Farm (controller) level

FoF – Frequency related services

State-of-the-art / Limitations

- Control functionalities for active power control generally available
- The extent of frequency related services is limited

Challenges

- Clear specifications for active power control modes
- Impact assessment of service provision in turbine life time
- Forecast accuracy
- Impact of fast active power boost delivery followed by decrease in active power

FoF – Voltage related services

Type of functionality	Functionality name	Ancillary Service SSVC	Ancillary Service FRCI	Implementation level
Technical	Reactive Power Setpoint Processing	X		WT/WF
	Reactive Power Control Scheme	X		WT/WF
	Reactive Power Control	X		WT/WF
	Voltage Control	X		WT/WF
	Power Factor Control	X		WT/WF
	Reactive Power Provision	+		WT/WF
	Fast Possitive Sequence Reactive Current Injection Capability		+	WT
	Fast Active Current Reduction Capability		+	WT
	Fast Negative Sequence Current Provision		-	WT
Operational	Communication and Control Interface	X	X	WT/WF
	Communication and Control Interface with the SO	X	X	WF

References:

- X Functionality required and today generally available
- \+ Functionality required but not always available or optionally available
- \- Functionality rarely available/ not implemented but implementable/ programmable
- O Functionality required and NOT available
- WT Functionality considered at Wind Turbine level
- WF Functionality considered at Wind Farm (controller) level

FoF – Voltage related services

State-of-the-art/Limitations

- Functionalities for voltage control generally available
- The extent of those capabilities depend on the conversion system

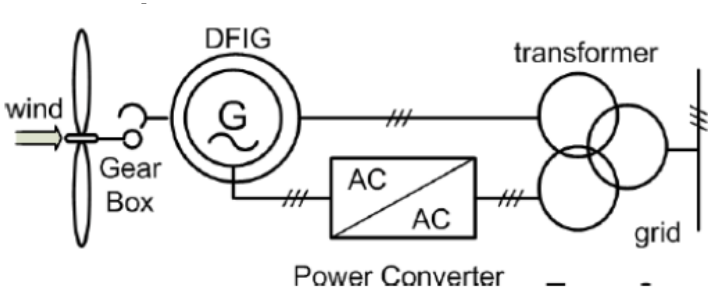


Figure 1: diagram of a Type 3 WT.

Challenges

- Economical challenges for the extending reactive power capability range (i.e. at zero active power)
- Specification of FRCI

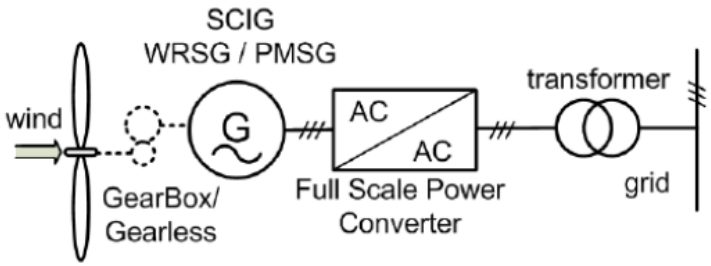
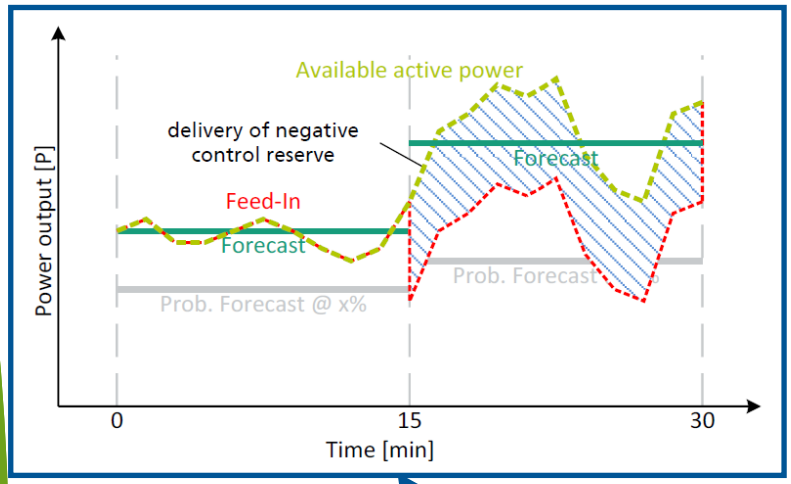
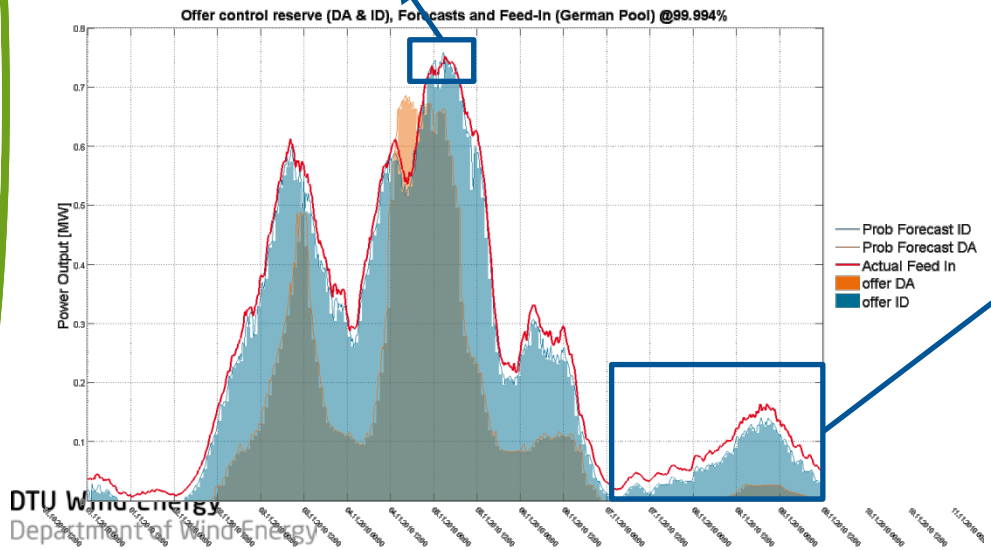
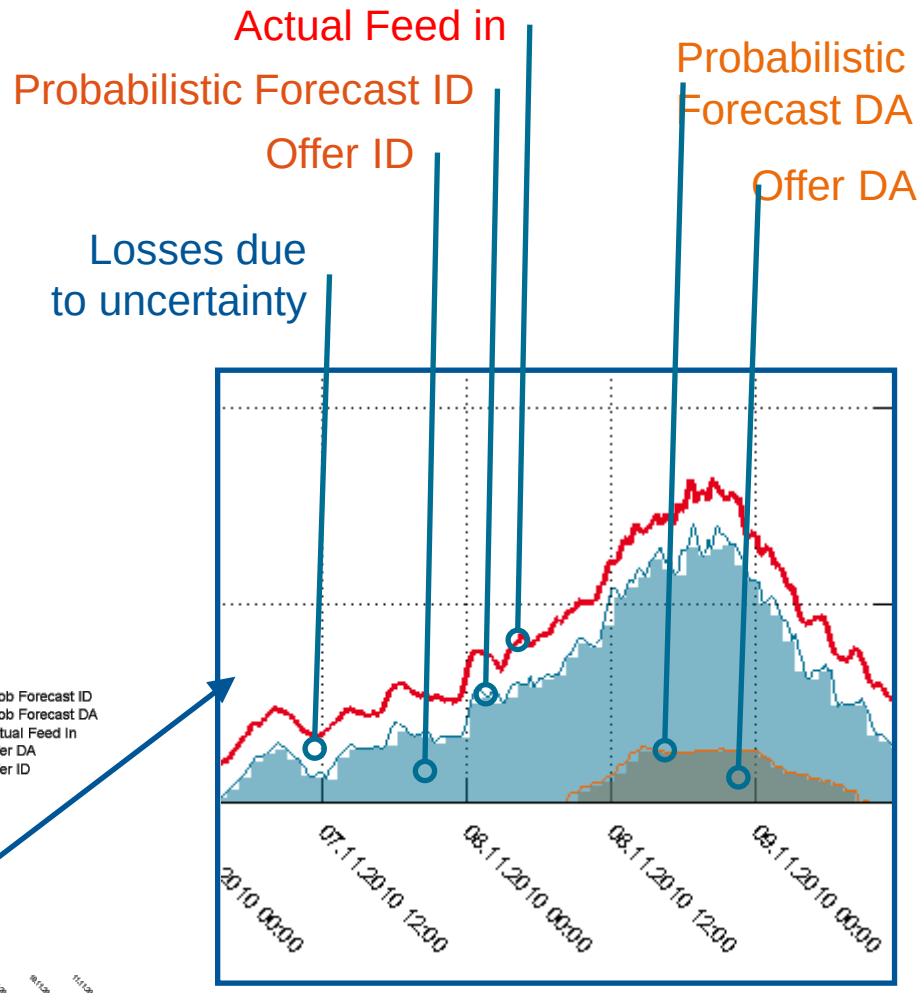


Figure 2: diagram of a Type 4 WT.

Variability and predictability - Forecast method



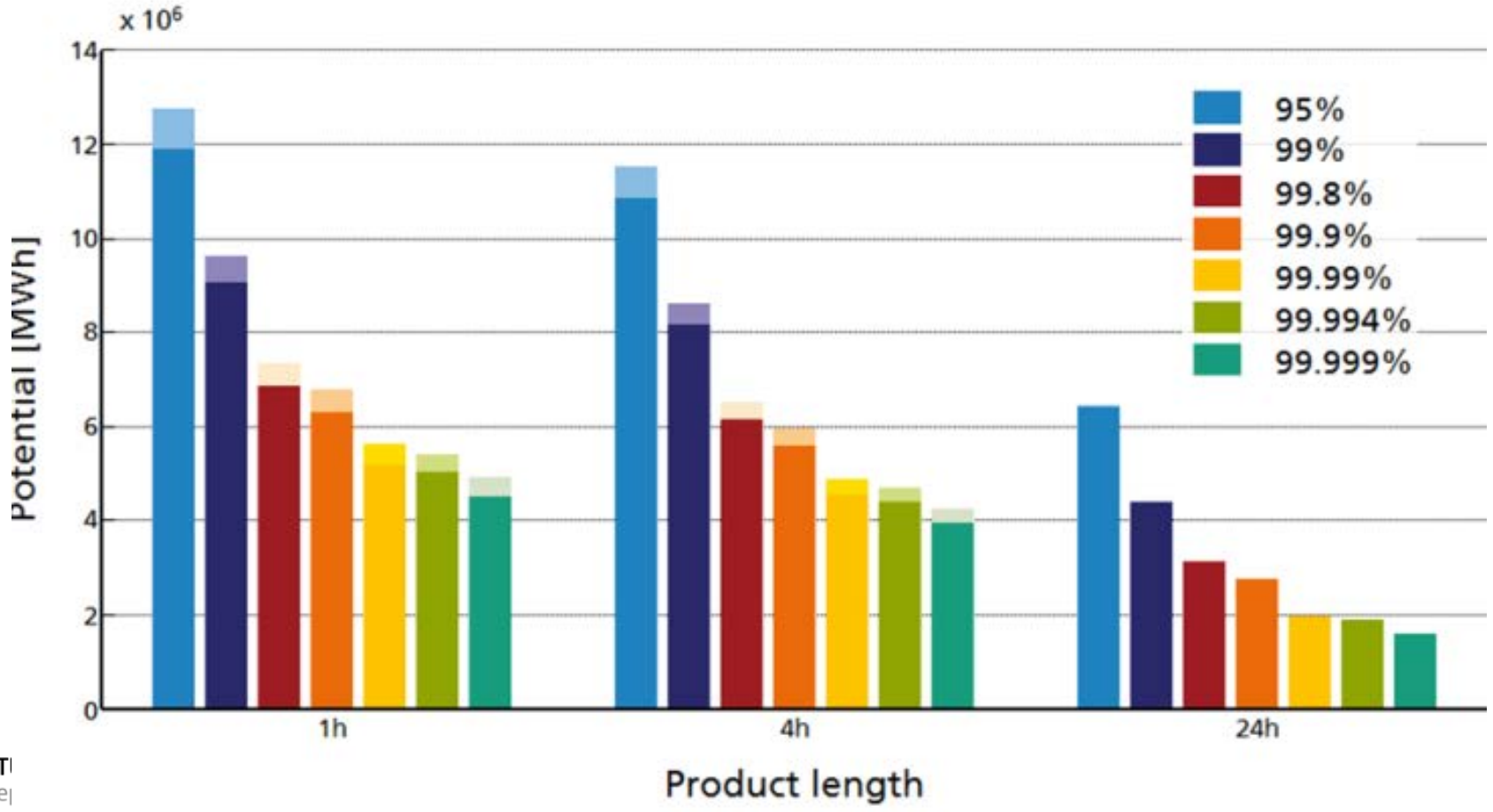




Source: Jansen, 2013. Wind turbine participation in control reserve markets. *Fraunhofer IWES*

Variability and predictability
Effect of product length in potential of service provision

30 GW in Germany



Source: Jansen, 2013. Wind turbine participation in control reserve markets. *Fraunhofer IWES*

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Gap Analysis

- Technology
  - Time constraints for the fast services (communication and control)
  - “Tear & Wear” costs need further investigation
- Requirements
  - Grid codes – a lack of clear specifications
  - Required performances might have an adverse reaction
- Operational
  - Service acquiring method (procurement and pre-qualification)

Conclusions

- Wind power technologies have adequate control capabilities to provide ancillary services, but these are not widely used
- The main challenges are related to incorporating the stochastic nature of wind
  - Forecast accuracy
  - Available active power calculation method
  - Improvement of communication and control capabilities
- Other challenge is the absence of a clear specifications to
  - Define response and delivery of the service for ‘very fast’ services (FFR, FCRI)
  - allow accurate assessment of impacts in the lifetime of the technology
  - enable participation in the market (procurement, prequalification)

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