System Service Provision

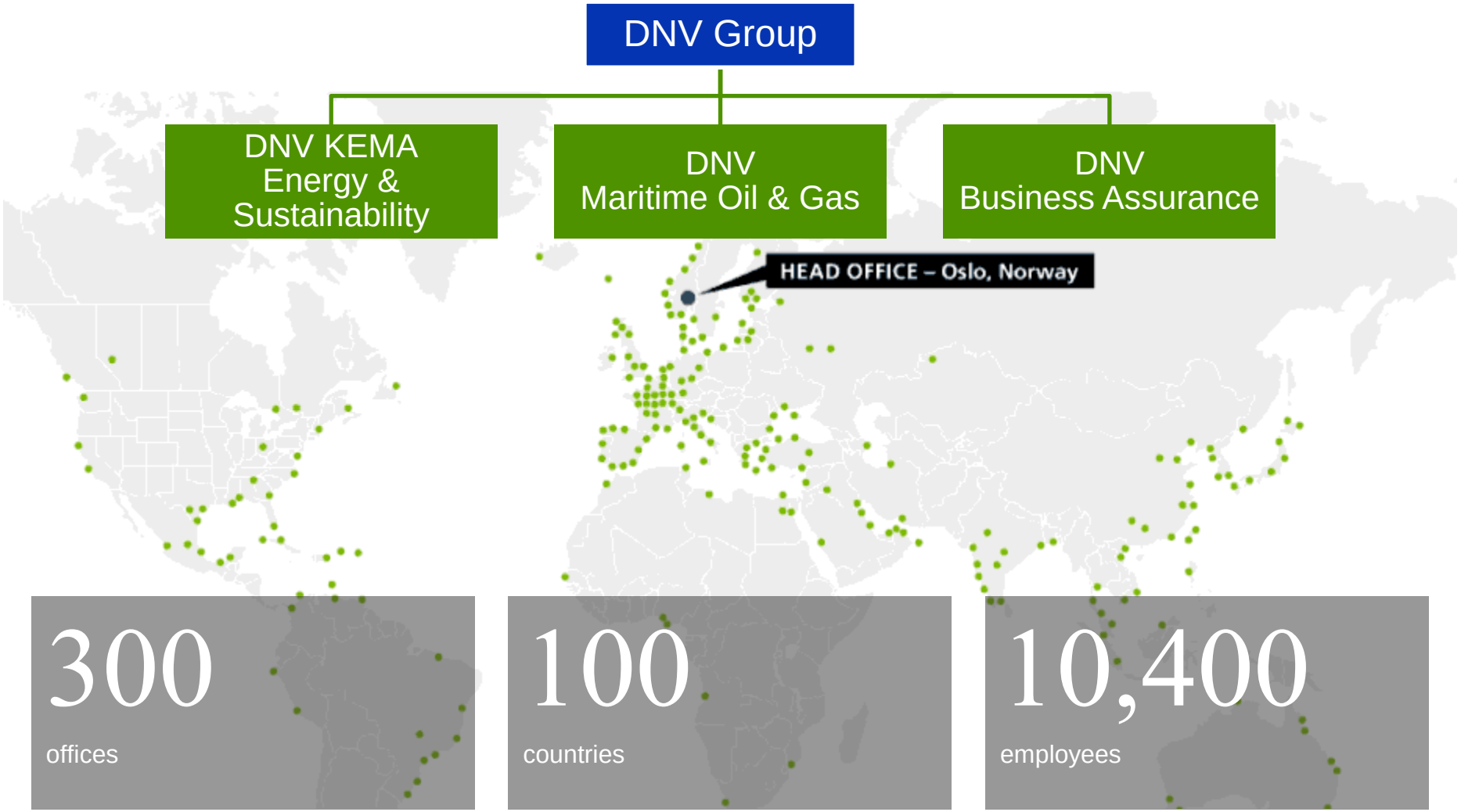
An independent view on the likely costs incurred by potential System Service Providers in delivering additional and enhanced System Services

Willem Uijlings, 2013, Belfast

Agenda

1. DNV KEMA
2. Introduction of the Fundamental changes to the power system
3. Technologies
4. Methods to comply with System Generation Services
5. Methods to comply with System Network Services
6. Summery of Costs
7. Project Results

The DNV Group



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- KEMA and DNV combined: a heritage of nearly 150 years
- Headquartered in Arnhem, the Netherlands
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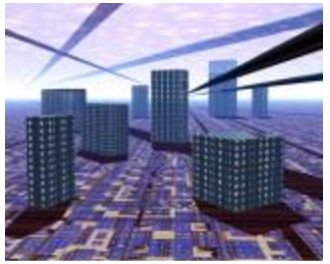

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- Energy
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- Founded 1867
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- Renewables

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Introduction

To achieve the government renewable energy policy objectives for renewable energy, the need for sufficient system services have been identified in the DS3 programme.

- TSOs have asked DNV KEMA to identify what additional capital investments are needed to meet proposed new system service requirements for a range of Generation and Network technologies. The TSOs developed two principle areas of asset upgrades:

1. A Generation Solution, including Wind, CCGT, OCGT and Coal fired power plants
2. A Network Solution, including Flywheel, STATCOM, Synchronous condensers and Batteries.

- The costs calculated in the study represent the general technical enhancement for each technology which enables/ allows compliance with the proposed new system service provisions.

Introduction

To achieve the government renewable energy policy objectives will require a transformational change in plant portfolio and operational policies.

- Needed capabilities identified in the DS3 programme:
  - Enhanced fault ride through for renewable energy (with focus on Wind)
  - Enhanced voltage control for renewable energy (with focus on Wind)

- System services identified in the DS3 programme:
  - Reduction of the technical minimum load
  - Inertia enhancement
  - Enhanced frequency response
  - Reduction in ramp-up time of the technology

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Technologies

Where the Generator solutions can not provide all services proposed, additional Network solutions are needed to deliver a safe and sustainable energy supply

DNV KEMA was asked to provide a cost indication for the following technologies

- Generation technologies :
  - Additional capabilities for **Wind Farms**
  - Additional ancillary services through **CCGT** (new and existing)
  - Additional ancillary services through **OCGT** (new and existing)
  - Additional ancillary services through **Thermal power plant** (Coal fired power plants)

- Network technologies:
  - Ancillary services through **Flywheel**
  - Ancillary services through **STATCOMs**
  - Ancillary services through **Synchronous condensers**
  - Ancillary services through **Batteries**.

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Methods to comply with System Generation Services

Fault ride through installation replacements/ enhancements

1.1 – Voltage dip
- No enhancement required

1.2 – Active Power
- Software control upgrade
- STATCOM

1.3 – Reactive Power Response
- STATCOM

Voltage control installation replacements/ enhancements

2.1 – Voltage regulation
- No enhancement required

2.2 – Reactive power range
- Shunt reactor

Wind

Enhanced fault ride through
Enhanced voltage control

Costs

Wind				
	Capacity	2 [MW]		
	Normalised built cost	Total	4,249,500 [EUR]	2,125 [EUR/kW]
	Enhanced cost	Total	277,000 [EUR]	139 [EUR/kW]

		A Current Grid Code	B Proposed GC modifications	C Enhanced Standard (proposed products)
Fault Ride Through	Voltage Dip	15% retained voltage for 625ms at connection point	15% retained voltage for 625ms at HV terminals of Grid Transformer	*Not relevant*
	Active Power (post fault)	90% of available active power within 1 second of voltage recovering to normal range	90% of available active power within 500 ms of voltage recovering to 90% of nominal where fault is cleared within 140 ms and within 1 second for longer duration faults.	90% of available active power within 250 ms of voltage recovering to 90% of nominal where fault is cleared within 140 ms
	Reactive Response	Maximise reactive current until the voltage recovers or for at least 600 ms. *Response time not defined.*	The reactive current response shall attempt to control the Voltage back towards the nominal Voltage. The reactive current response shall be supplied within the rating of the Controllable WFPS, with a Rise Time no greater than 100ms and a Settling Time no greater than 300ms.	The reactive current response shall be supplied within the rating of the Controllable WFPS, with a Rise Time no greater than 40ms and a Settling Time no greater than 300ms.
Voltage Control	Voltage Regulation	Three control modes: Voltage Regulation, constant PF, constant Q	*no change proposed*	*Not relevant*
	Reactive Power Range	Q = ±33% of registered capacity (0.95 pf at reg cap) for active power outputs from 100% down to 50% of reg cap, decreasing linearly from 50% to zero.	Q = ±33% of registered capacity (0.95 pf at reg cap) for active power outputs from 100% down to 12% of reg cap. Below 12% of reg. cap the reactive power is to be supplied as technically as much as possible down to cut-in speed of the turbines.	Q provided over as wide a range as possible (including at zero MW output)

Wind

Enhanced fault ride through
Enhanced voltage control

Methods to comply with System Generation Services

Installation replacements/ enhancements

A - Reduced minimal load (NOx, Stability)

- New burners
- Selective Catalytic Reduction (SCR)
- C inspection for preparedness
- Lost opportunity outage

B - More inertia

- No general technical solution feasible found at present

C - Frequency response enhancement (Controls and installation limitations)

- DCS upgrade
- I&C upgrade
- Lost opportunity outage

D - Ramp time improvement (Thermal stress, Process limitations)

- Auxiliary boiler

CCGT, OCGT, Thermal (Coal)
Enhanced Ancillary Services

Costs

CCGT (new)	Capacity	450	[MW]			
	Normalised built cost			Total	360,000,000 [EUR]	800 [EUR/kW]
	Enhanced cost			Total	13,446,172 [EUR]	30 [EUR/kW]
CCGT (existing)	Capacity	450	[MW]			
	Normalised built cost			Total	360,000,000 [EUR]	800 [EUR/kW]
	Enhanced cost			Total	54,690,497 [EUR]	122 [EUR/kW]
OCGT (new)	Capacity	50	[MW]			
	Normalised built cost			Total	32,500,000 [EUR]	650 [EUR/kW]
	Enhanced cost			Total	3,699,440 [EUR]	74 [EUR/kW]
OCGT (existing)	Capacity	50	[MW]			
	Normalised built cost			Total	32,500,000 [EUR]	650 [EUR/kW]
	Enhanced cost			Total	7,163,575 [EUR]	143 [EUR/kW]

Enhancements:
(A)Reduced minimal load; (B)More inertia; (C)Frequency response; (D)Ramp time improvement

CCGT, OCGT, Thermal (Coal)
Enhanced Ancillary Services

Costs

Thermal (Existing)						
Capacity	650	[MW]				
Normalised built cost			Total	845,000,000	[EUR]	1,300 [EUR/kW]
Enhanced cost			Total	53,663,920	[EUR]	83 [EUR/kW]

Enhancements:
(A)Reduced minimal load; (B)More inertia; (C)Frequency response; (D)Ramp time improvement

CCGT, OCGT, Thermal (Coal)
Enhanced Ancillary Services

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Methods to comply with System Network Services

Flywheel (highly impulsive generation/ consumption)

- Fast Frequency Response
- Virtual inertia
- Ramp time improvement

STATCOM (support critical loads)

- Voltage regulation
- Transient stability providing power oscillation damping

Synchronous condenser (local support of power quality for energy import from distant areas)

- Reactive power consumption or generator
- Short circuit power
- Inertia response
- Voltage control

Battery (renewable energy curtailment/ utilisation)

- Frequency response
- Peak shaving
- Energy storage

Flywheel
STATCOMs
Synchronous condensers
Batteries

Enhanced Ancillary Services

Costs

Flywheel	Capacity	20 [MW]				
	Normalised built cost		Total	14,000,000 [EUR]		
	Auxiliary equipment		Total	1,328,000 [EUR]	66	[EUR/kW]
STATCOM	Capacity	50 [MVAR]				
	Normalised built cost		Total	4,500,000 [EUR]		
	Auxiliary equipment		Total	928,000 [EUR]	19	[EUR/kVAR]
Synchr. condenser	Capacity	75 [MVA]				
	Normalised built cost		Total	2,000,000 [EUR]		
	Auxiliary equipment		Total	2,726,500 [EUR]	36	[EUR/kVA]
Batteries 40 MW	Normalised built cost NaS		Total	90,000,000 [EUR]		
	Normalised built cost Li-ion		Total	30,000,000 [EUR]		
	Auxiliary equipment		Total	3,170,500 [EUR]	79	[EUR/kW]

Ancillary services:
More inertia; Frequency response; Ramp time improvement; Voltage regulation; Reactive power consumption and generation; Short circuit power; Peak shaving; Energy Storage

Flywheel
STATCOMs
Synchronous condensers
Batteries

Enhanced Ancillary Services

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Summery of Costs

It is important to note that the costs of technologies provided in the table cannot be directly compared to each other without considering the context of the types of services and the volumes provided. For example, after enhancements, the provided system service by Wind technology is different to e.g. the CCGT technology.

Summary			
Generation Technologies	Units Size	Base Case	Enhanced
[Name]	[MW]	[Normalised Cost, EUR/kW]	
Wind	2	2,125	139
CCGT_new	450	800	30
CCGT_existing	450	800	122
OCGT_new	50	650	74
OCGT_existing	50	650	143
Thermal (Coal)	650	1,300	83[2]
Network Technologies	Units Size	Total Cost	
[Name]	[MW or MVA or MVAR]	[EUR]	[EUR/kW, EUR/kVA, EUR/kVAR]
Flywheel (5 MWh)	20	15,328,000	766
STATCOM	50	5,428,000	109
Synchronous Condenser	75	4,726,500[2]	63[2]
Batteries (10 MWh)	40	33,170,000	829

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Project Results

Without detailed investigations on each specific asset in Ireland and Northern Ireland it is not possible to cover all local issues with regards to specific modifications and the accompanied costs. In the time available for the study there was no scope for such detail. Though the project delivered an overview of the possibilities and constraints for the different required ancillary services for each technology and provide a generic cost for such modification.

Enhancement Generation Solutions Wind

- Enhanced fault ride through:
  - Voltage dip ride-through
    - No investment needed for proposed capability
  - Active power availability after fault
    - Investment for Software upgrade and STATCOM
  - Reactive current response
    - Investment for STATCOM
- Enhanced voltage control:
  - Voltage regulation
    - No investment needed for proposed capability
  - Reactive Power range improvement
    - Investment for shunt reactor if STATCOM is not already installed

Project Results

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Enhancement Generation Solutions CCGT, OCGT, Thermal (Coal)

- Reduced technical minimal load:
  - Investment for NOx
  - Investment for stability
- Inertia enhancement:
  - Not feasible for existing plants
- Enhanced frequency response:
  - Investment for controls
  - Investment for installation limits
- Reduction in ramp-up time of the technology:
  - Investment for thermal stress
  - Investment for process limitations
  - Investment for chest warming

Project Results

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Ancillary Network Solutions

- Providing some inertia
- Providing frequency response
- Providing ramp time improvement
- Providing voltage regulation
- Providing reactive power consumption and generation
- Providing short circuit power
- Providing peak shaving
- Providing energy storage

Thank you for your attention

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