Rabat

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Grid codes for renewable energy integration

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Work Package leader for grid integration activities in the EuroSunMed project

Outline

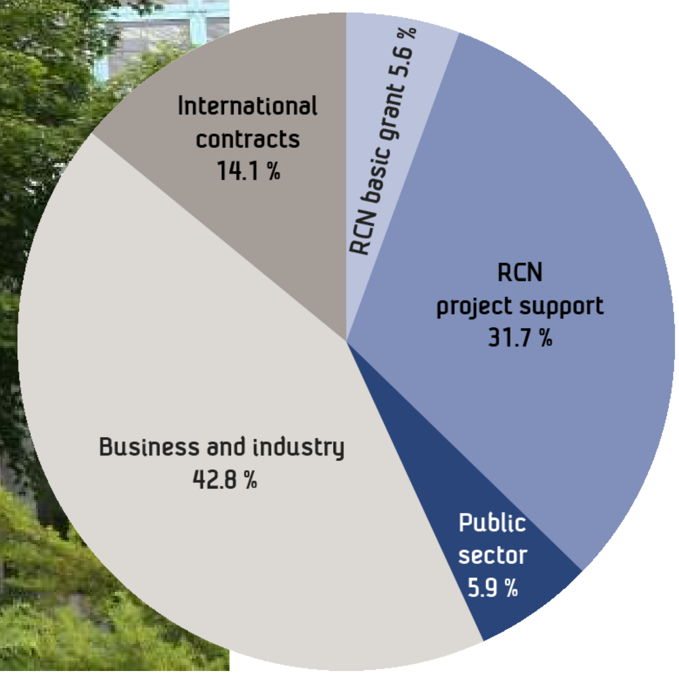
- EuroSunMed project – grid integration activities
- Grid codes and renewables
- European grid code harmonisation – ENTSO-E Network Codes

SINTEF Energy Research part of the SINTEF Group

Independent research institute

Contract-based research

Not-for profit



EuroSunMed project

Euro-Mediterranean cooperation on research and training in sun-based renewable energy

2013 – 2017 (4 years)

Funded via the EU 7th framework programme

http://www.eurosunmed.eu


Norway
• Sintef Energi AS, SINTEF E
• Stiftelsen Sintef, SINTEF
Belgium
• The Association of European Renewable Energy Research Centres, EUREC
France
• Centre National de la Recherche Scientifique, CNRS
• European Materials Research Society, EMRS
Spain
• IK4-Tekniker, IK4
• National Renewable Energy Center, CENER
Italy
• TURBODEN
Morocco
• Al Akhawayn University, AUI
• Centre National de l'Energie des Sciences et Techniques Nucléaires, CNESTEN
• Centre National pour la Recherche Scientifique et Technique, CNRST
• Moroccan Foundation for Advanced Sciences, Innovation and Research, MAScIR
• Moroccan Agency for Solar Energy, MASEN
• University Mohammed-V, UM5a
Egypt
• Alexandria University, AU
• Helwan University, HU
• Nile Valley Engineering, NVE

EuroSunMed – main objectives

- Developing new technologies in
  - photovoltaic solar power (PV)
  - concentrated solar power (CSP)
  - grid integration
- Establishing a strong network between European and North African countries through exchange of researchers
- Disseminating knowledge and project results through summer schools, workshops and conferences

EuroSunMed – grid integration

SINTEF Energy Research (Norway)
CENER (Spain)

Al Akhawayn University in Ifrane (Morocco)
Helwan University (Egypt)

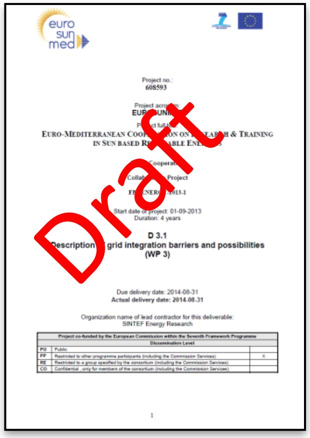
Identify the potential for and barriers against large scale integration of renewable energy in North Africa. Suggest strategies for realising this potential:

Grid codes – how to develop/adapt grid codes for large renewable energy penetration?

Power balance – how to deal with increased variability in power production?

Grid stability – how to ensure a stable power system?

Grid codes



Draft

Project no.:
608593

Project acro[illegible]:
EUR[illegible]

P[illegible]ct full t[illegible]:
EURO-MEDITERRANEAN COO[illegible] ON [illegible]EAR[illegible]H & TRAINING IN SUN BASED R[illegible]ABLE ENE[illegible]

[illegible] Cooperati[illegible]

Collab[illegible] Project

FP[illegible]ENER[illegible]-2013-1

Start date o[illegible] project: 01-09-2013
Duration: 4 years

D 3.1
Description [illegible] grid integration barriers and possibilities (WP 3)

Due delivery date: 2014-08-31
Actual delivery date: 2014-08-31

Organization name of lead contractor for this deliverable:
SINTEF Energy Research

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	X
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential , only for members of the consortium (including the Commission Services)	

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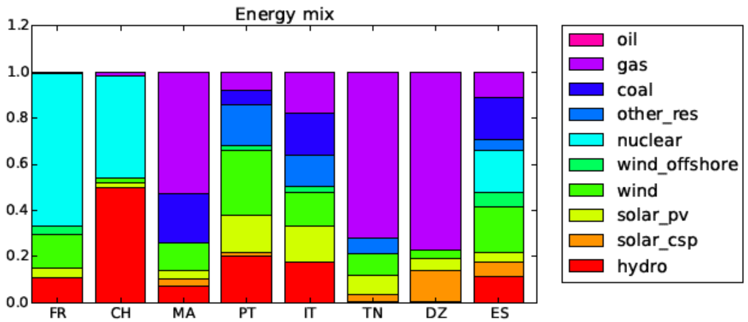
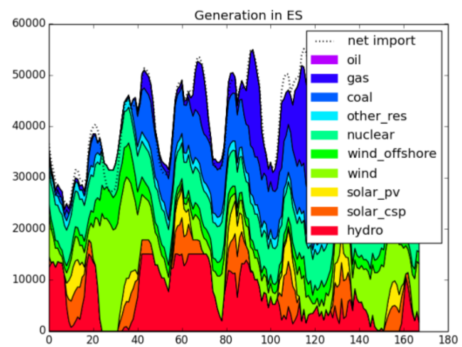
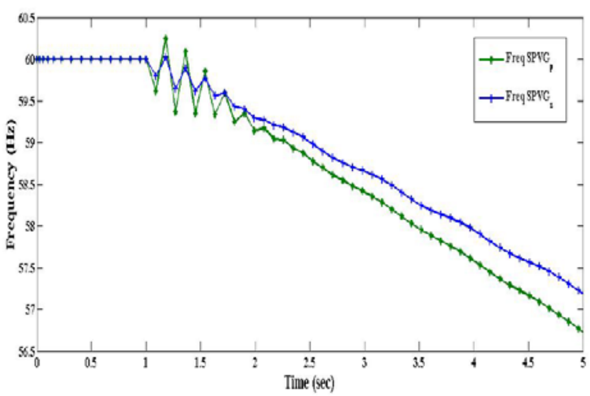
- ✓ Collection of information about grid code status
- ✓ Today's workshop
- ✓ Report with summary of status and recommendations for grid code development

Today's workshop gives input to the report.

Power balancing

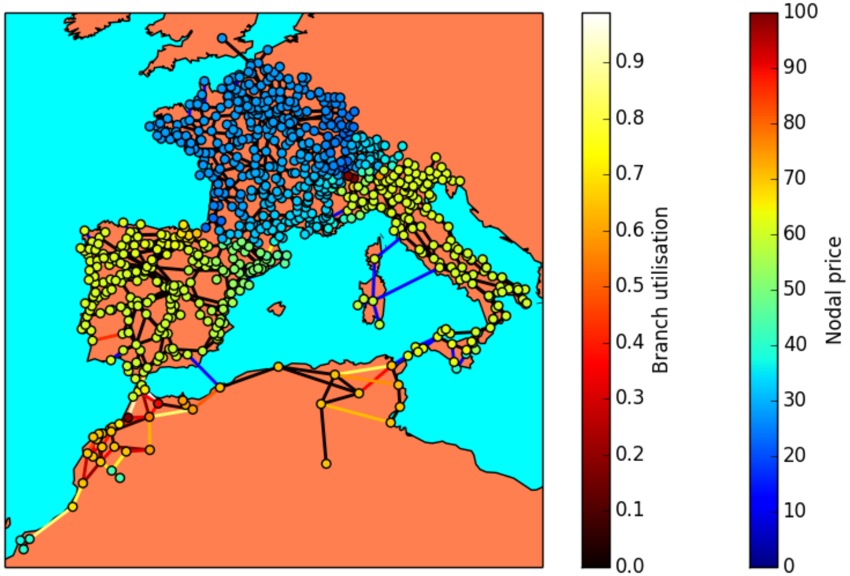


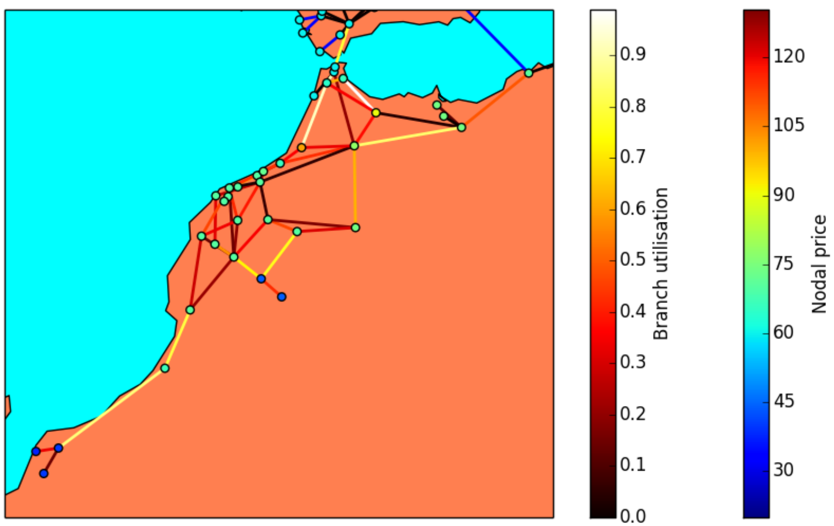




- **power exchange**: Western Mediterranean 2030 case study analysis
- **energy storage:** modelling and analysis of storage strategies in Morocco
- **spinning reserve**: analysis of PV and spinning reserve requirements (Egypt)
- **load shedding**: analysis of influence by wind and PV (Egypt)

Power balancing – power exchange





PowerGAMA
Grid And Market Analysis

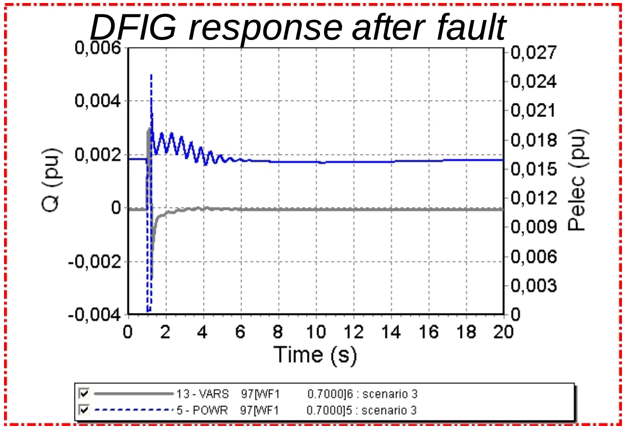
powergama – open source analysis tool (project output)

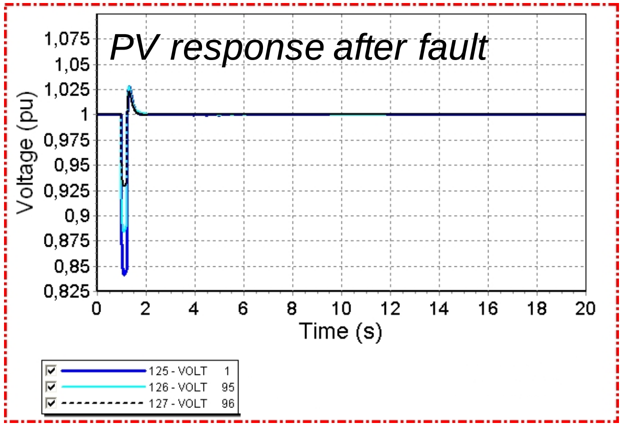
hour-by-hour simulations, with grid impedance and capacity constraints

plot showing annual average nodal prices for 2030 case study

- identify grid bottlenecks and value of grid reinforcements
- variations in cost of supply

System stability





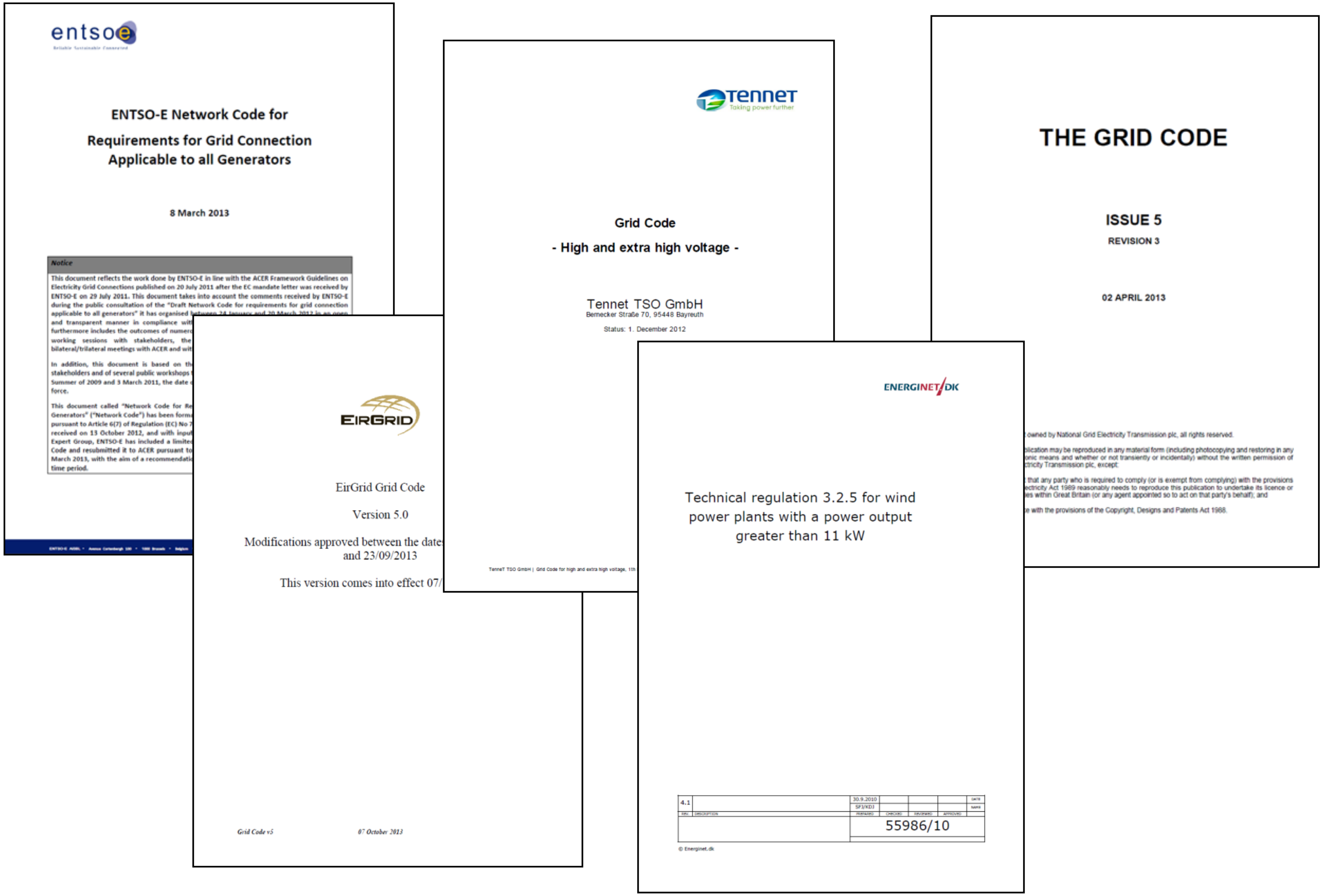
Morocco case studies

- ✓ PSSE model simulations of Moroccan grid; validation of model
- ✓ Static and dynamic analysis for PV and wind integration cases
- ✓ Identify potential stability problems and develop schemes to avoid them

Egypt case studies

- ✓ Developed suitable models for Egypt (in several simulation environments)
- ✓ Suitable siting / grid connection points for solar power plants
- ✓ Voltage stability analysis

Grid codes


entsoe
ENTSO-E Network Code for
Requirements for Grid Connection Applicable to all Generators
8 March 2013
Notice
Tennet
Taking power further
Grid Code
- High and extra high voltage -
Tennet TSO GmbH
Bernecker Straße 70, 95448 Bayreuth
Status: 1. December 2012
THE GRID CODE
ISSUE 5
REVISION 3
02 APRIL 2013
EIRGRID
EirGrid Grid Code
Version 5.0
Modifications approved between the date
and 23/09/2013
This version comes into effect 07/
Grid Code v5
07 October 2013
ENERGINET DK
Technical regulation 3.2.5 for wind power plants with a power output greater than 11 kW
55986/10

Grid codes

Technical requirements that everything connected to the electricity network has to satisfy

general rules that are written down and apply to all

purpose:

to ensure that the electricity network works in a safe, secure and economic way

Grid codes for renewables

- Technical requirements for **generators**
  - Wind power plants
  - Solar Photovoltaic (PV) plants
  - Concentrated Solar Power (CSP) plants
  - Distributed generation
- Power **markets**
  - future market (days, weeks, months)
  - spot market (intra-day)
  - ancillary services

Challenges with renewables

- Renewable generation is becoming important for system stability
- Different behaviour from conventional power plants, new technical capabilities and limitations
  - new problems and new solutions
- Often small units, distributed throughout the grid, rather than big centralised plants
- Many more power plants: Need for streamlined grid connection approval process
- Grid codes should not unnecessarily increase the cost of grid connection of renewables
  - safe and secure, but also economic grid
- Cost-effective standard technology solutions possible with standard requirements
  - important for supply industry

Different perspectives

Transmission system operators

- responsible for reliable power system operation
- favours strict requirements for connection; conservative attitude

Power plant owners

- not too strict requirements
- take into account special characteristics of renewable power generation

Supply industry

- predictable and standardised requirements
- alignment between requirements and technology capabilities

Ancillary services

Ancillary services are help the power system buys from generators and consumers to support power system stability

Grid codes **impose** minimum requirements for generators by law

↕

Ancillary services enable power plants to support the grid on a **paid-for** basis through a market, being an extra source of potential revenue

Examples:

Active and reactive power reserve

Black start capability (after blackout)

ENTSO-E Network Codes – background

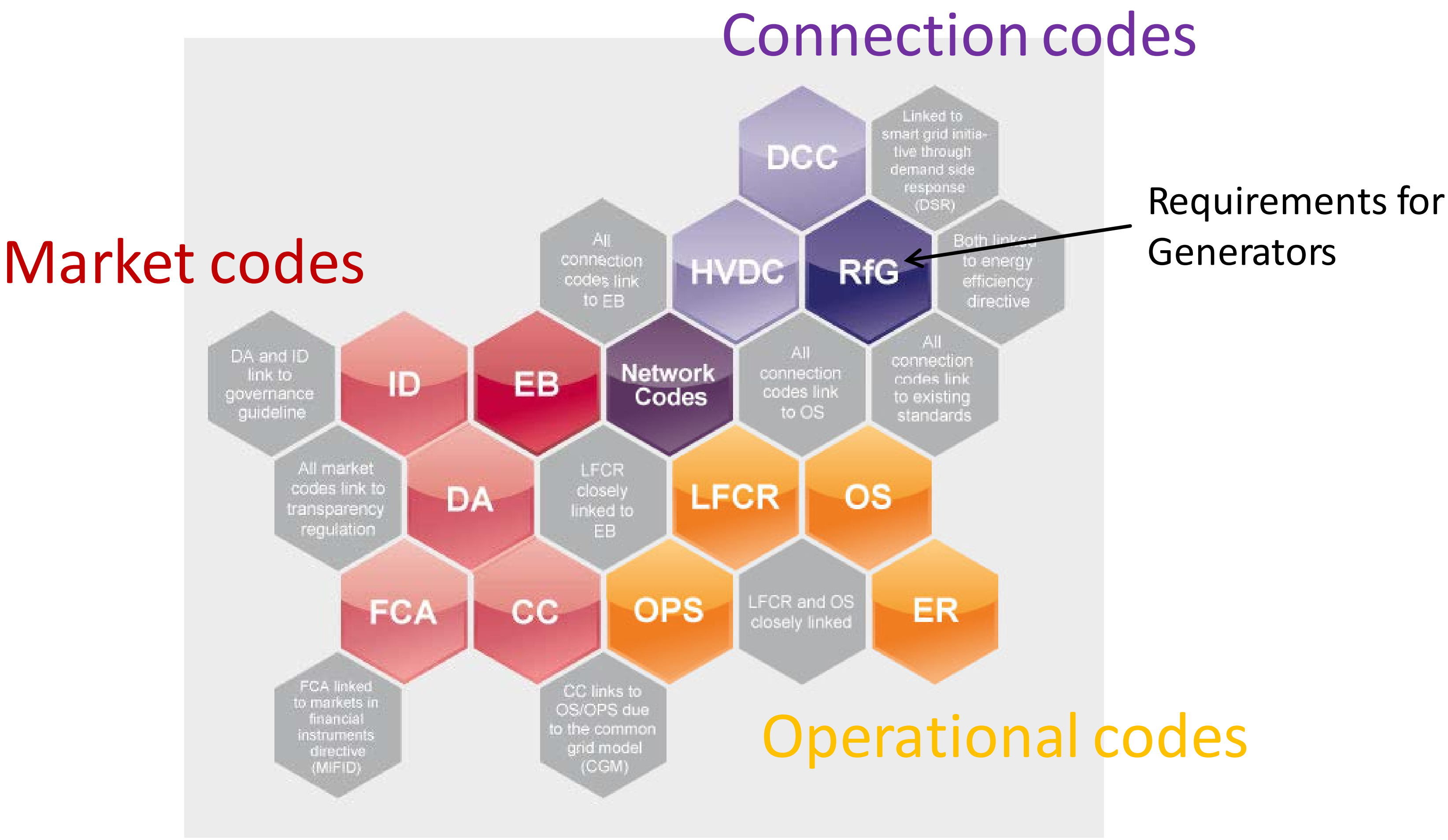
The electricity sector in Europe is undergoing radical change

- changing electricity generation and consumption patterns
- rising fossil fuel prices
- greater interconnection of electricity markets

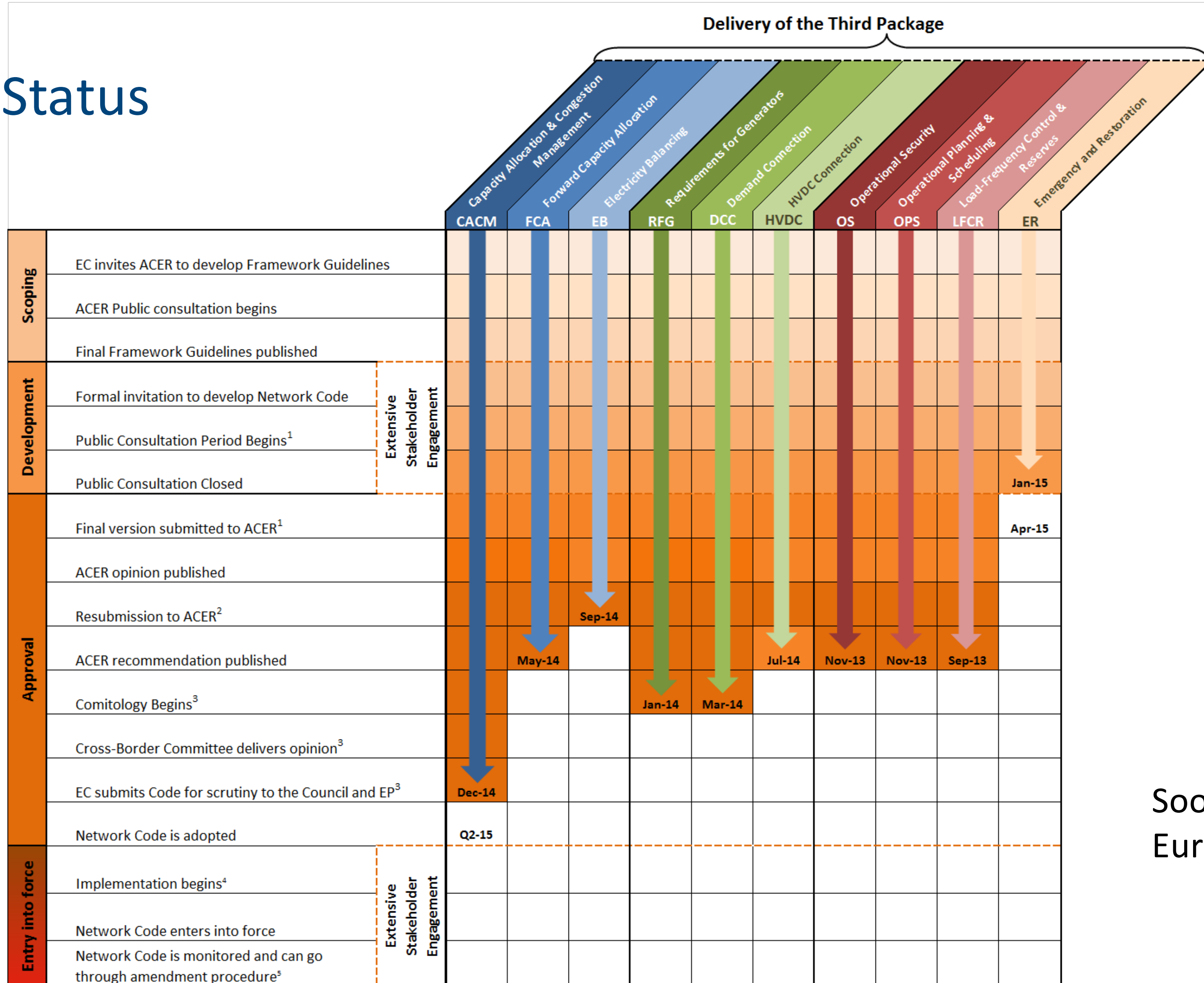
In 2007, the EU started development of an internal gas and electricity market, seeing a need for common rules to be put in place for these markets to operate effectively

When these rules, or network codes, become law, they will have the same status as any other European regulation and will govern all electricity market transactions with a cross-border impact.

ENTSO-E Network Codes



Status



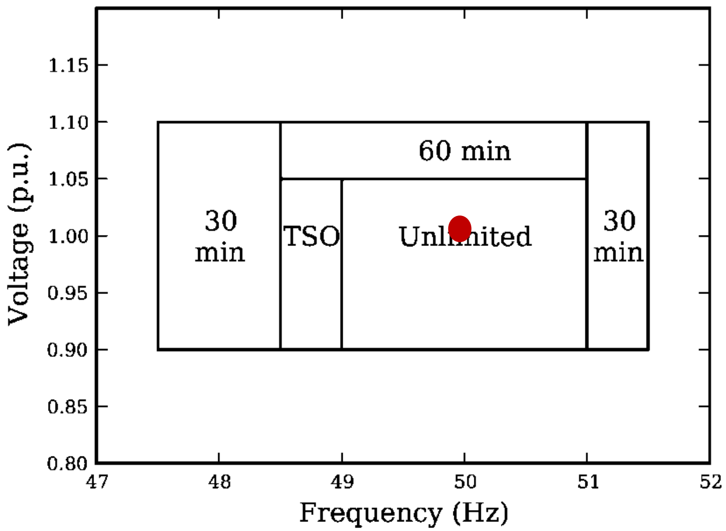
Soon to become European law

Requirements for Generators

- Distinguishes generators by size (power rating) and voltage level at grid connection point – stricter rules for larger plants
- The following slides relates to large power plants (e.g. 100 MW)

Requirements for Generators

- Voltage and frequency operational range

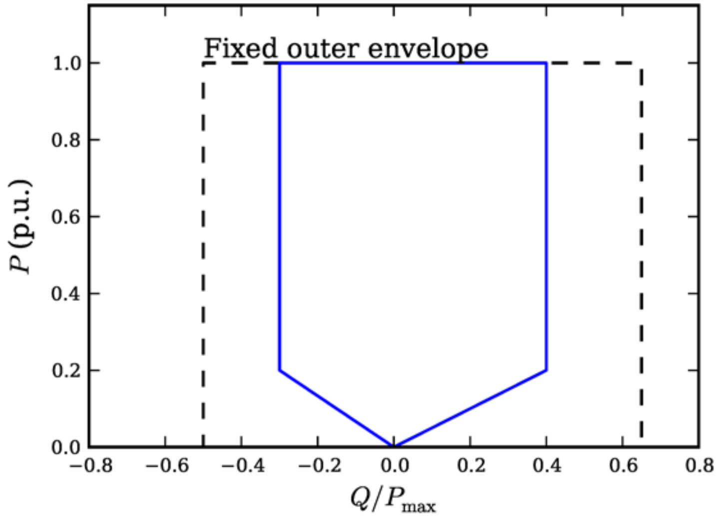


Time before generator is allowed to disconnection during a voltage/frequency deviation

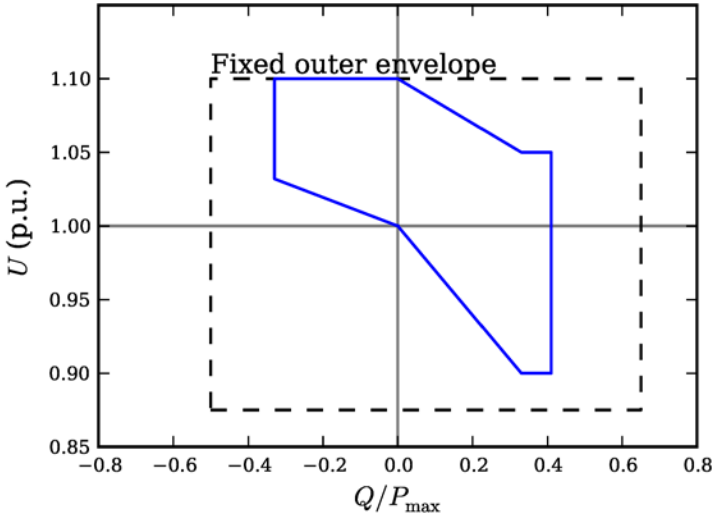
● = Nominal value

Requirements for Generators

- Voltage stability support



below maximum capacity



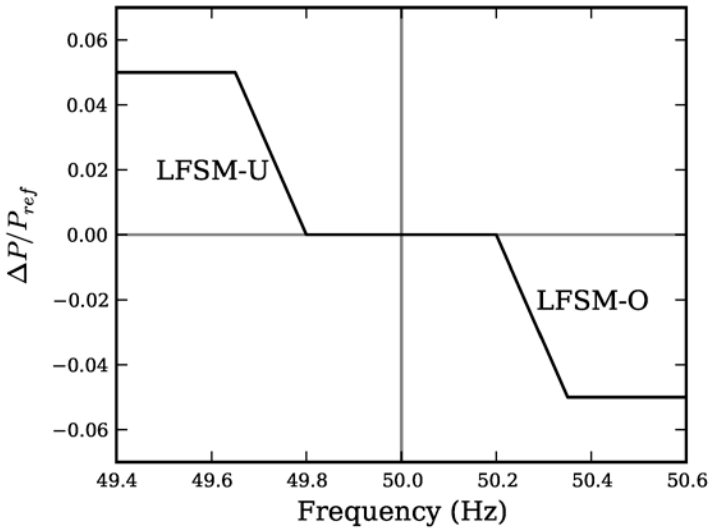
at maximum capacity

— = example

Reactive power capability
Generator may be required to provide reactive power (Q) to support grid voltage. The amount depends on active power output (P) and voltage (U)

Requirements for Generators

- Frequency stability support



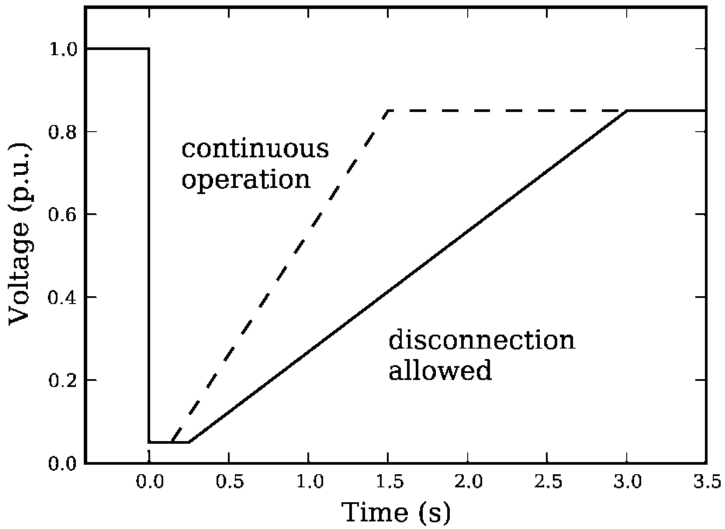
= example

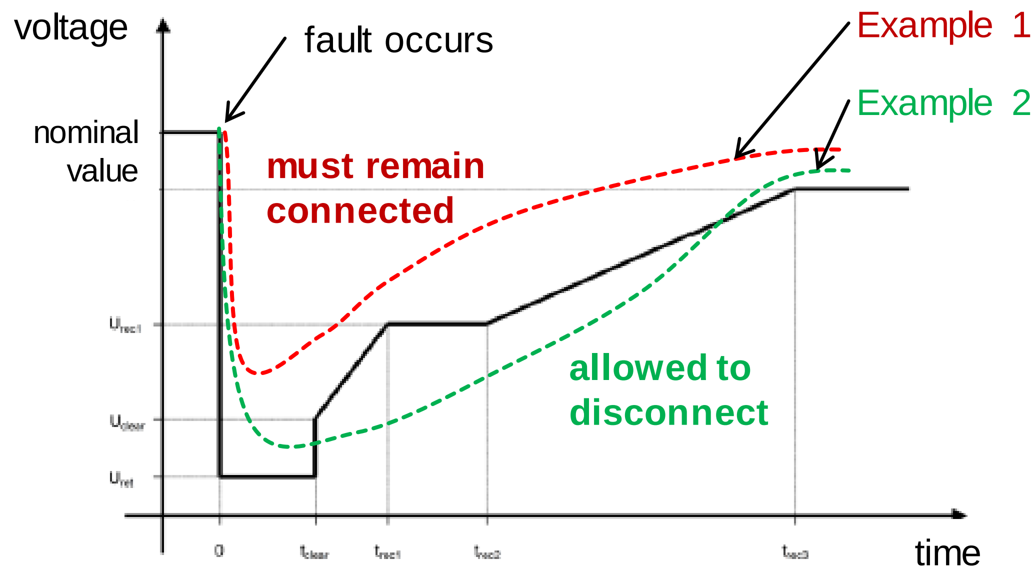
(L)FSM = (Limited) Frequency Sensitivity Mode

Frequency response capability
Generator may be required to automatically adjust power output (P) to support grid frequency – increasing power at under-frequency (U), and/or reducing power at over-frequency (O)

Requirements for Generators

- Fault ride-through capability





Fault ride-through capability
Generators are required to remain in operation during short voltage dips (due e.g. to a short-circuit fault in the grid). Requires a system to dissipate or absorb excess energy

Summary

EuroSunMed project – overview of project and grid integration activities

- dedicated tasks on grid codes, power balancing, and grid stability analyses

Grid codes

- The special characteristics of renewable power generation should be taken into account when specifying grid standardised grid codes
- Standardised grid codes and predictable requirements are important for planning, and for renewable energy supply industry
- ENTSO-E process in Europe – market integration and harmonisation of grid codes

We should strive for regulations that are ultimately good for society

SINTEF

Technology for a better society

ENTSO-E Network Codes – abbreviations

Connection Codes

- RfG = Requirements for Generators
- DCC = Demand Connection Code
- HVDC = High Voltage Direct Current Connections

Operational Codes

- OS = Operational Security
- OPS = Operational Planning and Scheduling
- LFCR = Load Frequency Control and Reserves

Market Codes

- ID = Intra-day
- DA = Day-ahead
- CC = Capacity Calculation

(ID, DA and CC:) CACM = Capacity Allocation and Congestion Management

- FCA = Forward Capacity Allocation
- EB = Electricity Balancing