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Future European Energy Networks

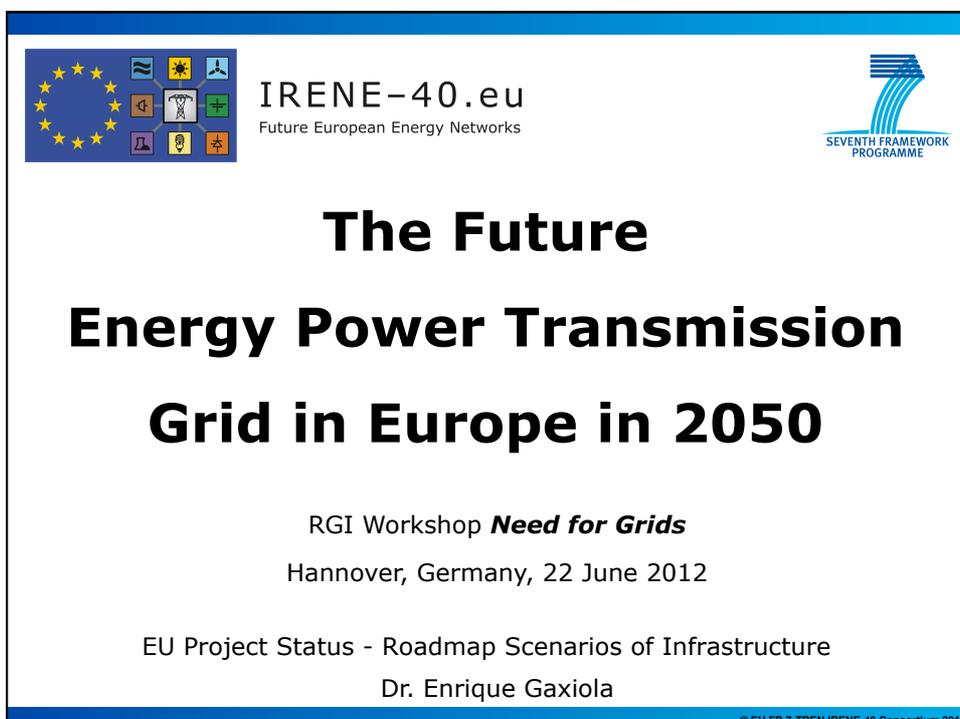
 SEVENTH FRAMEWORK PROGRAMME

The Future Energy Power Transmission Grid in Europe in 2050

RGI Workshop *Need for Grids*
Hannover, Germany, 22 June 2012

EU Project Status - Roadmap Scenarios of Infrastructure
Dr. Enrique Gaxiola

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 IRENE-40.eu Future European Energy Networks	<h2>1. Main driver(s) for developments as described</h2>	 SEVENTH FRAMEWORK PROGRAMME
<u>Background / motivation:</u>		
.... renewable generation (RES)		
.... meeting EU 20-20-20 targets 		
→ Transmission capacity increase		
(= network development)		
“multi-GW flow inter-country overlay power network”		
(= “electricity highway” / supergrid)		
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Upgrading & Modernizing Power Systems



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In advanced electricity networks: (To fulfill EU set boundaries)

- What will network infrastructure look like?
- What type of transmission technology to use?

To enable large active power exchange → Combined HVDC and AC power systems

- *What bottlenecks?*
- *How will high penetration of renewables and distributed generation influence the networks?*
- *Optimized minimum needed invest against security of supply?*

←

The Past: 1900 - 2010

The Future: 2020 - 2050

→

DC 1900

AC 1950

AC 1960

AC 2010

2012

HVDC

HVDC

HVDC

HVDC

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2. Example I European Wind Integration Study (EWIS)



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input into ENTSO-E TYNDP*

Base Case

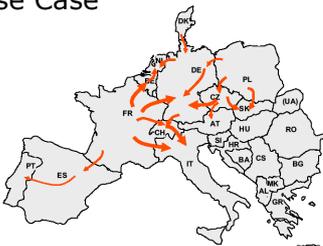


Figure 23: Main corridors of electrical power transmission in the Base Case

South Wind

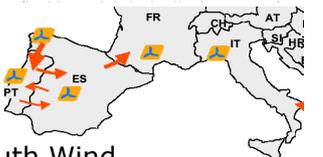


Figure 25: Changes of electrical power transmission in UCTE S

North Wind

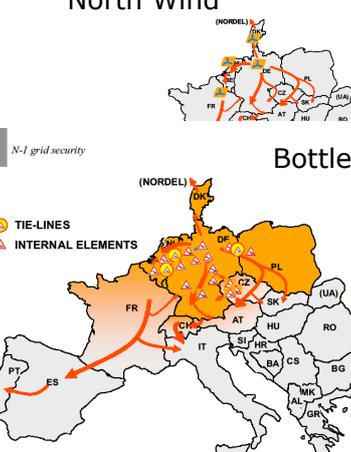


Figure 26: Detected bottlenecks during N-1 conditions of UCTE Scenario North

*: European Network of Transmission System Operators for Electricity - Ten Year Network Development Plan

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Example II From Studies to Realistic Implementation?



Technische Dimension für das Netz

NorNed-Kabel (Statnett - TenneT)
 Länge: 580 km,
 Technologie: +/- 450 kV DC-Kabel
 Übertragungsleistung: 0,7 GW
 Kosten: 600 Mio. Euro

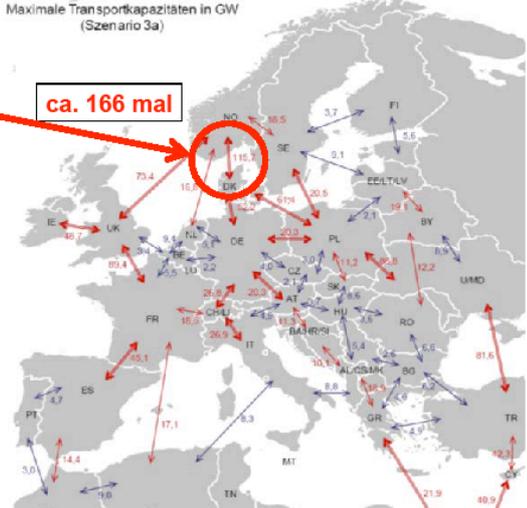


Quelle: ABB



Quelle: ABB

Maximale Transportkapazitäten in GW (Szenario 3a)





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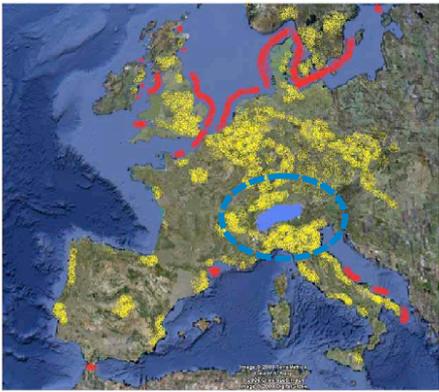
Example III Generation Surplus Renewables – Load Deficit Areas – and a Role for Storage



„battery“ & smart grid

Energy Consumption
3022 TWh

Load
max 400 GW
min 160 GW



● „swiss battery“

BKW

Installed Capacity
800 GW

2015 Offshore
25 GW

n-1 Reserve
3 GW

Itol energy

→ Extreme large power transmission corridor flows

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So
What is (Now) Underway to Face Such?



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Available:

- Priority Interconnection (PIP) EU DG Transp. & Energy
- TYNDP ENTSO-E, 38 to 138 b€
- DENA 1+2, Netzplan up to 2022, 20 b€ in GER

Investment: 4b€/y By whom?

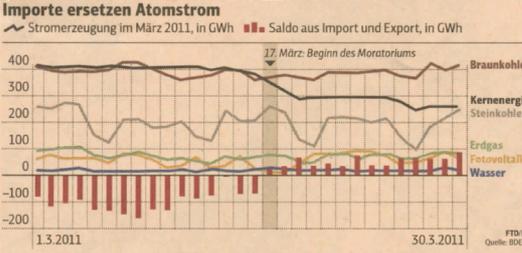
Further Studies & Proposals:
Mediterranean- / Baltic- /
North-Sea-Ring (underway) / ..
Desertec / Iceland-link /



TRANS-EUROPEAN NETWORKS
PRIORITY PROJECTS
FOR ELECTRICITY

Electricity Priority Projects
in the European Union and
in neighbouring Countries

02/2004

Our Answer: Pan-European Electricity Transmission Grid Project



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Project – Mission Statement



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“Identify **strategies for future power transmission grids** for investors and regulators (i.e. stakeholders) in the European electricity system”

- The mature and ageing EU electricity transmission and electrical power system infrastructure is starting to show decreased security margins
- The European Commission acknowledges and foresees a need for active innovative solutions implementation to cope with this and address such

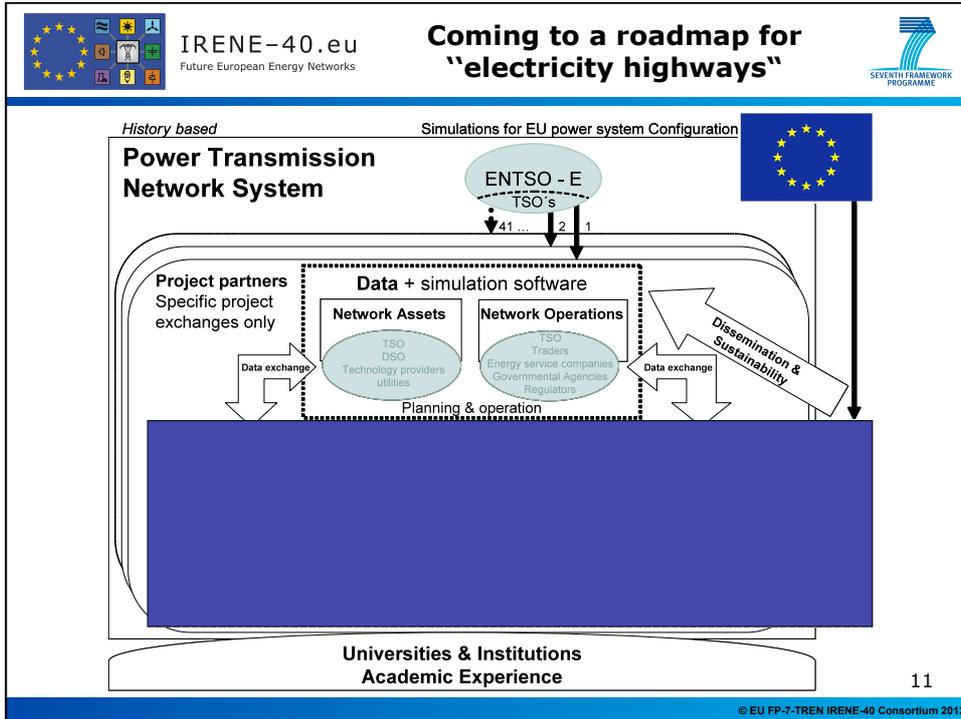
- Roads towards a sustainable, secure and cost efficient future power grid are impacted by today's actions; i.e. investment decisions made now define system aspects in the next 40 years

The left hand image symbolizes this: network invest €'s „tumble down“ and lack of confidence for investment makes „for a reduced amount of €'s to have a fully developed and healthy market meeting its overall objectives“

IRENE-40 roadmap

2012
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Key Objectives

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What should the European Electricity Grid look like? 2020 → .. → 2050

Needed:

- Databank** Transmission Network Technologies (incl. HVDC, FACTS,...)
- Scenarios** for Infrastructure Development
- Tools** Development to Research the Infrastructure Development
- Roadmap to Optimized Grid Network in 2050
- Research of Roles of Dominant Network **Stakeholders**

Staged Approach

- ✓ O1.2: Method to **determine weak network points**
- ✓ O2.1: Strategies to **deployment of upcoming technologies**
- ✓ O3.2: **Develop infrastructure scenarios**
- ✓ O4.2: Identify **investment strategies**

Toolbox → Roadmap

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3. Results – Deliverables

www.irene-40.eu



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Milestones Project Reports:

Investigation WP1

D1.1
Framework for
Scenarios-Development

D1.2
Application Guide
Work Points

Analysis WP2

D2.1
Methodology for Placement
New Network Elements

D2.2
Technology Development
and Forecast

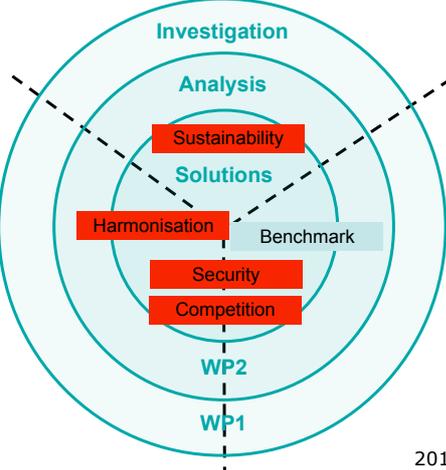
Solutions WP3 (available in July 2012)

D3.1
Application Guide for the Improvement of
Ecological Sustainability, Security and
Competitiveness by Infrastructural Changes

D3.2
Scenario Benchmark

**Delivered,
Approved,
and Publicly
Available**

System analysis



Scenarios

2012

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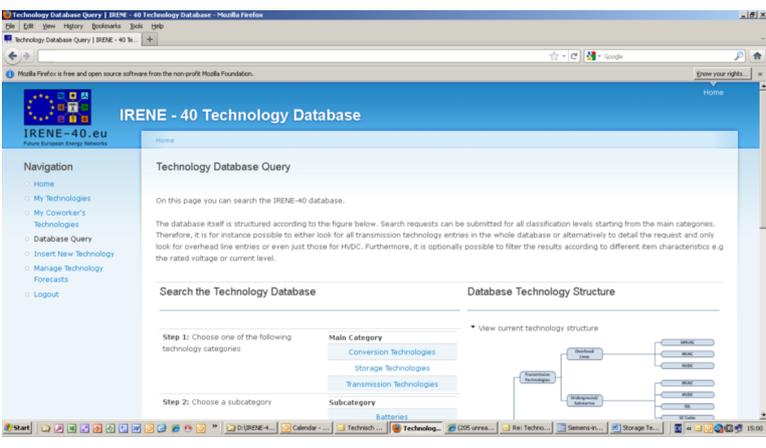


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- Technology Database -



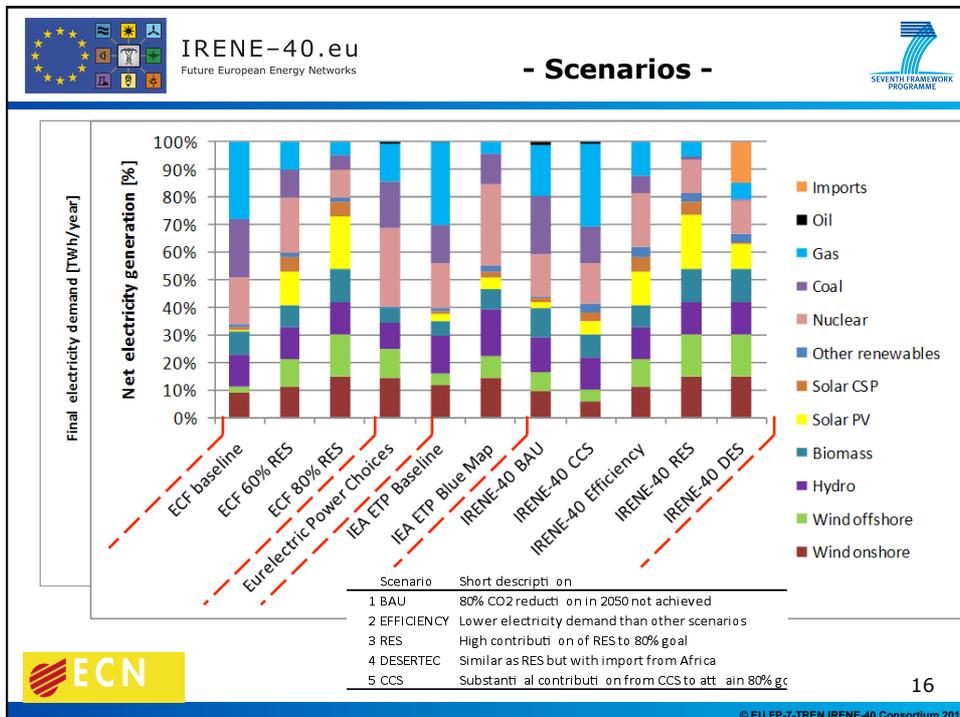
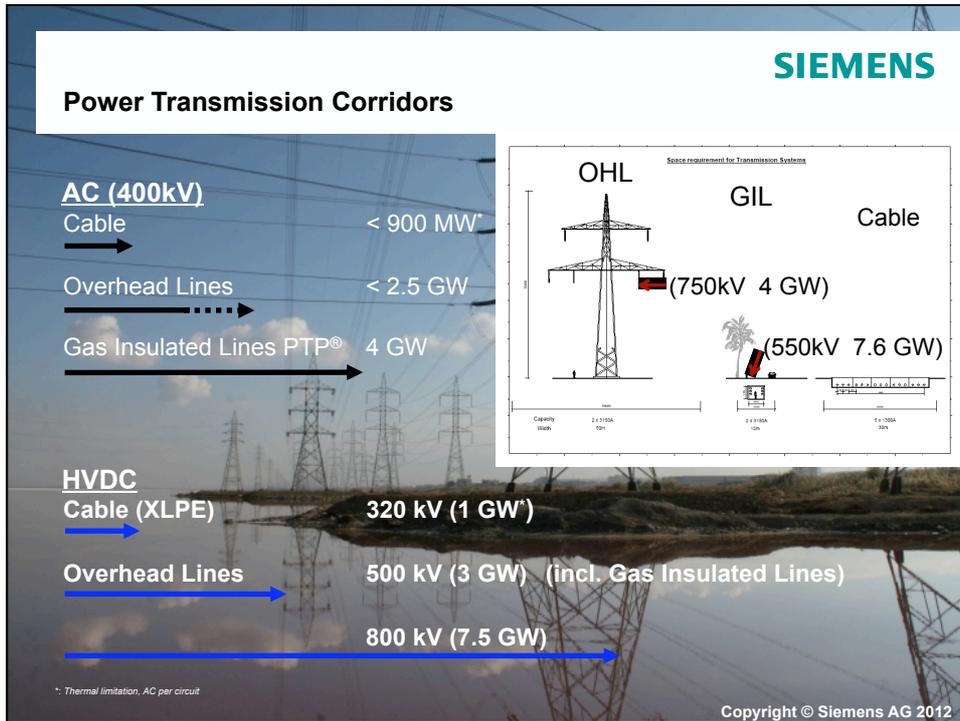
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**Harmonization and Coordination
among National Networks**



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**European Energy Markets Study/Analysis
– 4 Variants of Capacity Market Unification Level**

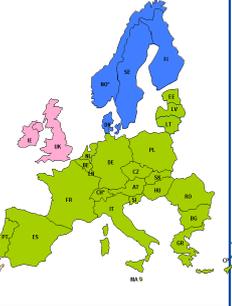
■ 27 Nations



■ 7 Clusters



■ 3 Regions



■ 1 EU Market



* Note: Although Norway and Switzerland are not official EU member states, they are nonetheless integrated into the RENE scenario definition and thus included in the capacity market variant analysis



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**TSO exchanges
Statements / Remarks / Advice**



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Focus on three technologies:

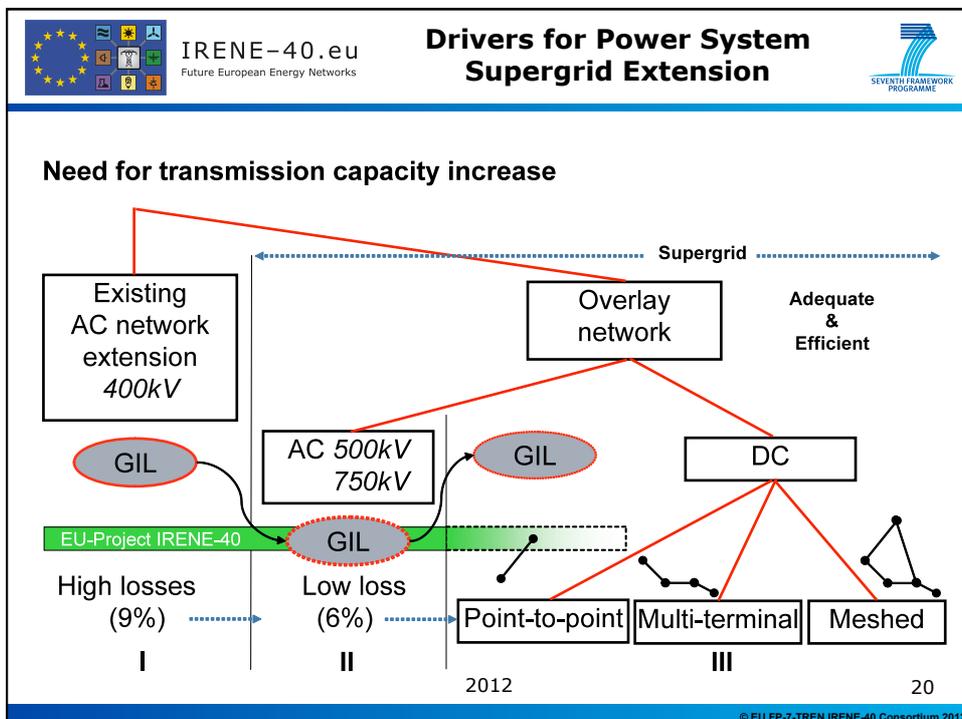
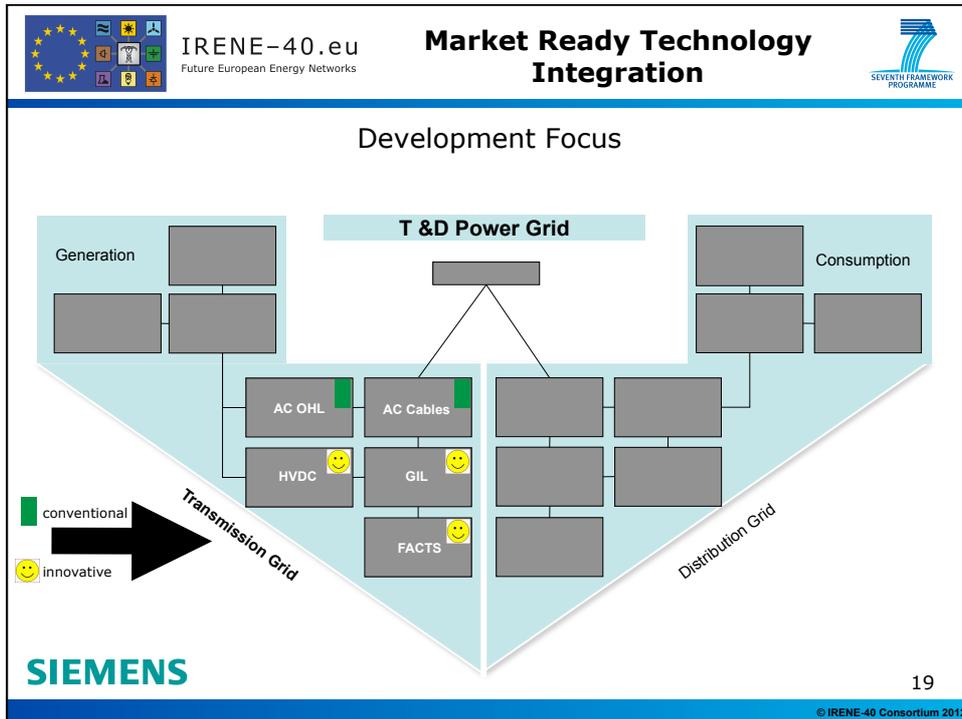
- 1.) 400kV AC
- 2.) 750kV AC
- 3.) HVDC (500-800kV; HVDC LCC classic – VSC)



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Infrastructure solutions for increased competitiveness



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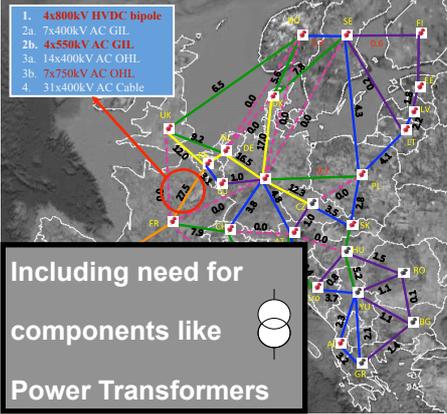
Proposed network capacity to facilitate the RES2050

Quantified outcomes of:

- The **additional infrastructure developments** required in the European transmission network to accommodate various levels of renewable energy sources.
- Demand side flexibility and storage facilities as **alternative options** to generation capacity and transmission interconnections infrastructure build-up.
- Proposing present and **feasible future transmission technology solutions** to respond to the required secure and cost-optimal levels of investment in the future European transmission network infrastructure.

Renewable scenario: year 2050

- 1. 4x800kV HVDC bipole
- 2a. 7x400kV AC GHL
- 2b. 4x550kV AC GHL
- 3a. 14x400kV AC OHL
- 3b. 7x750kV AC OHL
- 4. 31x400kV AC Cable



Including need for components like  Power Transformers

Imperial College London *: Base case ENTSO-E TYNDP 2010 2012

Capacity [GW]	0.1	2	5	10	20	30	> 30
Colour code							

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- 2050 - Summary of system characteristics



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Scenario	Total CO ₂ [28 g/kWh = 100%]	Peak demand* [579 GW = 100%]	Generation surplus [Generation "firm" capacity / Peak demand]	Capacity of the main EU transmission corridors [89 TW-km = 100%]	Additional transmission corridors capacity [as % of main capacity]	RES [Annual contribution to total generation]
BAU	668 %	129 %	1.7	54 %	+23%	50 %
RES	126 %	151 %	1.4	183 %	+79%	80 %
DES	93 %	141 %	1.5	211 %	+78%	80 %
CCS	129 %	140 %	1.7	48 %	+21%	40 %
EFF	100 %	100 %	1.8	100 %	+60%	60 %

Scenarios (except BAU): Low CO₂ emissions

BAU scenario: Extreme (unsustainable) high levels of CO₂ emissions

CCS scenario:

- High "firm" generation capacity invest

EFF scenario:

- Significantly reduced demand
- Moderate transmission infrastructure invest

Renewable scenarios needs: Significant transmission infrastructure invest.

Imperial College London *: Electricity demand: 3,691 TWh 22

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- 2050 -
Summary of cost characteristics

Scenario	Additional generation capacity cost [1.5*10 ³ b€ = 100%]	Additional transmission capacity cost [70 b€ = 100%]	Annual operating cost [82 b€/Yr = 100%]
BAU	87 %	26 %	230 %
RES	133 %	217 %	129 %
DES	201 %	263 %	104 %
CCS	115 %	13 %	360 %
EFF	100 %	100 %	100 %

CCS scenario: Extreme annual operating costs
 EFF scenario: Lowest annual operating cost due to:

- energy efficiency improvements decrease energy demand
- significant levels of renewable energy sources

 Renewable scenarios needs:

- More transmission infrastructure invest
- More generation infrastructure more invest
- Low annual operating cost; not being reliant on fossil fuel.

Imperial College London

*: Additional generation capacity cost (adequacy of supply) < 1%

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-Security of supply -
Significant cost savings
by dedicated measures

HVAC-400kV

10 AC lines + 9 submarine HVDCs

Cost = 95.29 billion Euros

UHVAC-750kV

10 AC lines + 9 submarine HVDCs

Cost = 94.01 billion Euros

HVDC

19 HVDC lines

Cost = 88.74 billion Euros

Reduction = 10.3%

Reduction = 11.5%

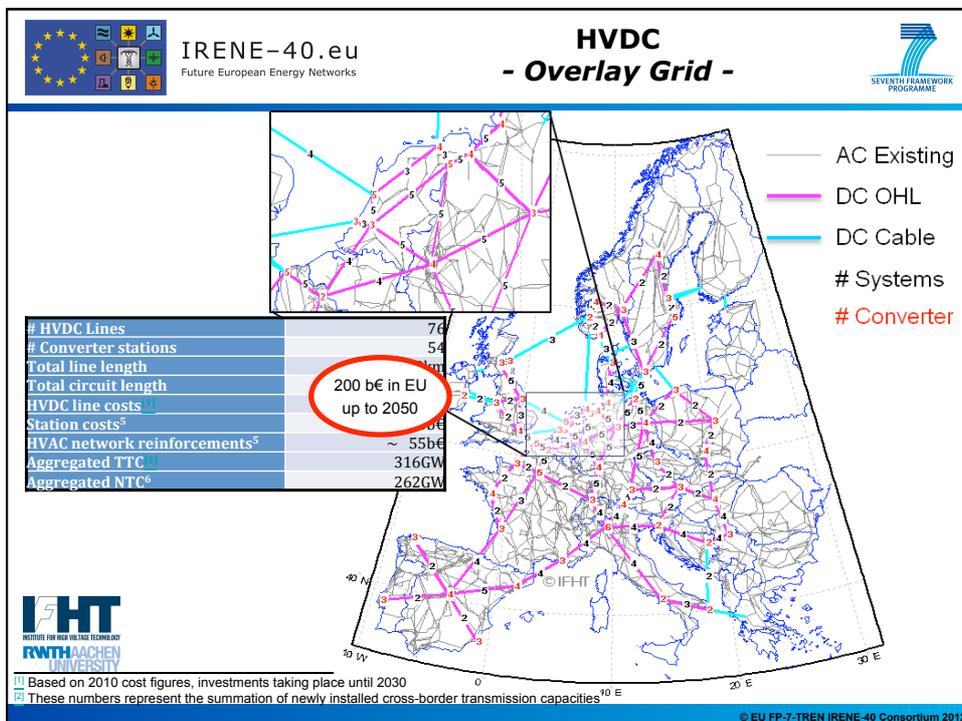
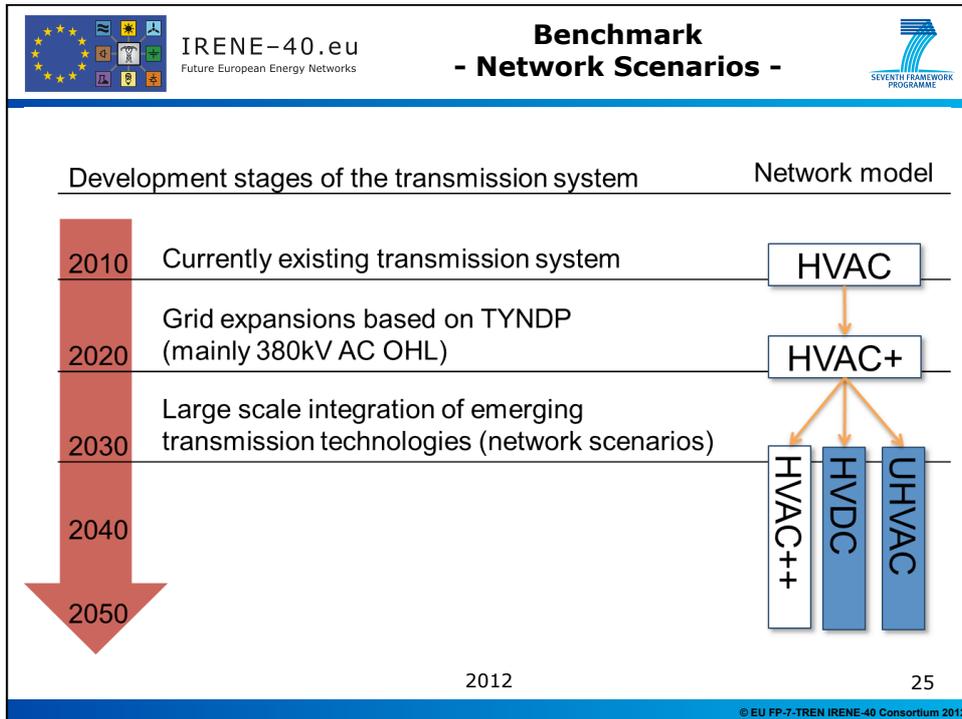
Reduction = 16.5%

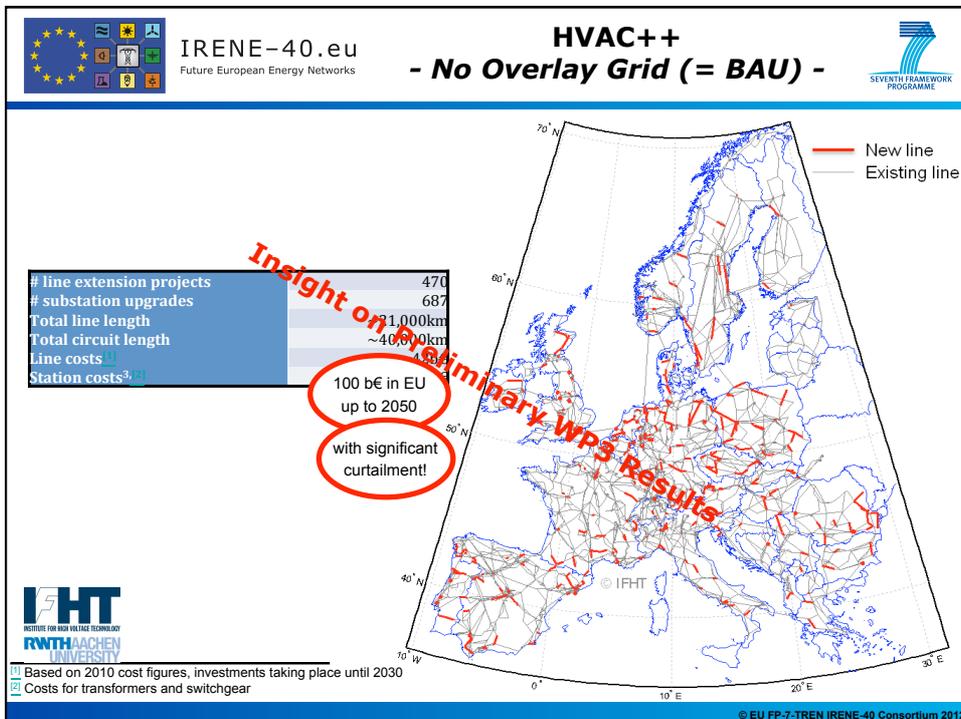
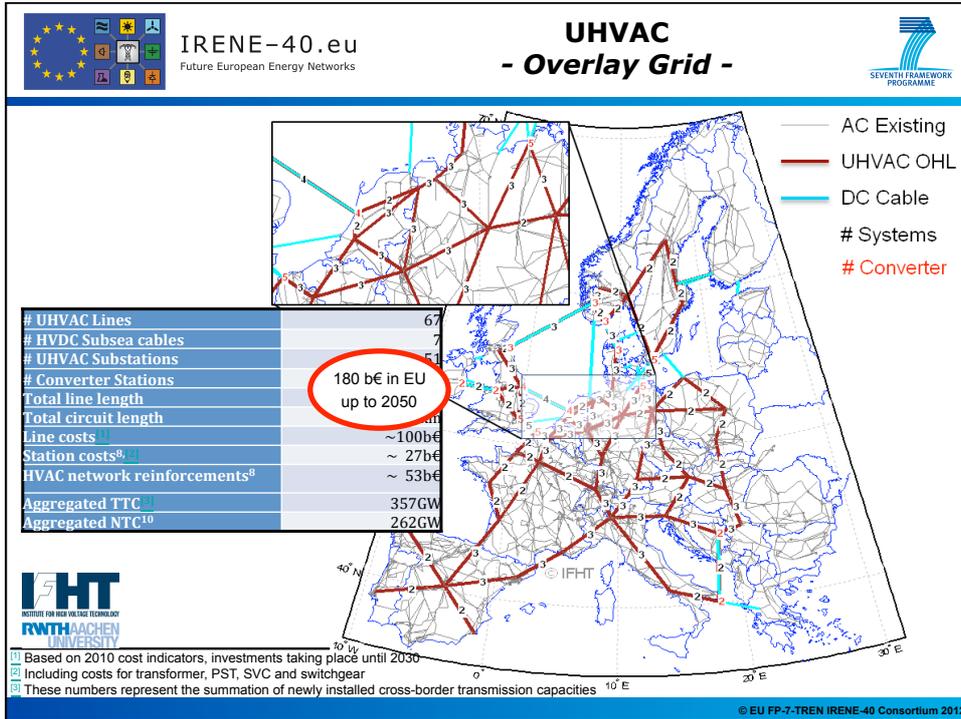
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Minimum Expansion: Cost = 106.31 billion Euros

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**- Unique Selling Proposition-
Pro IRENE-40**



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- Good plan on the table how to come to:
A consistent credible **roadmap for 40 years, i.e. up to 2050**
 - No additional input from external (non-public) sources (except: grid data)
 - With respect to other EU projects: Exchanged relevant results*
 - Articulated differences in our approach - Complementary scenarios

Dissemination relevance: **Quantitative messages**

- **Technology assessment & modeling tasks** differentiator:
Clearly position project as from the works by the three key industrial major manufacturer players & universities team
- Unbiased independent **valuable complement** to ENTSO-E (TSO's) messages & TYNDP

*: N.B.: Not redoing work others already did.

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Sustainability of action



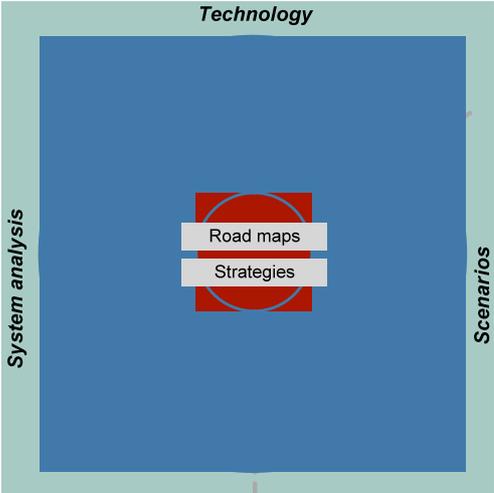
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“Support for other successor-projects” Informative source for stakeholders

Launch transfer of findings:

- Access to database
- Application survey infrastructure measures
- Price trends for electricity

.... updates on
"Energy Infrastructure Packages"
....



The diagram is a conceptual model with three axes: 'Technology' at the top, 'System analysis' on the left, and 'Scenarios' on the right. In the center, there is a red circle containing two white rectangular boxes labeled 'Road maps' and 'Strategies'.

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4. Expected end of project achievements - Sept 2012



- Agreement on **when and where** grid networks will need to evolve
- Answers to **which technologies** to be developed and deployed
 - Make of use relevant (published) tools & methods
 - Identified issues / barriers: proposed ways forward and know-how on where "disturbing events" are possible / plausible
 - Taking influence on the EU Energy Package

The Future Energy Power Transmission Grid in Europe in 2050

Transmission network extension is a good investment

2012

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Thank you for your attention





On behalf of the
IRENE-40 team

Key data:

Budget: 6 Mio. €

Duration: 2009 – 2012

- Project Coordinator: luis.costa@alstom.com
- Project Website: www.IRENE-40.eu
- Become a member of the project platform: enrique.gaxiola@siemens.com

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