The REALISEGRID technology roadmap

Rome meeting

1-st April 2011

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Technofi

Outline

- A reminder of the WP1 work flow
- Roadmap rationale: background and issues
- Assumptions for roadmap building
- The main roadmap components
- Conclusions

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Road map in the WP1 OBJECTIVES

- To scan the technology options that will be available to the European TSOs
- To identify their effectiveness and efficiency at guaranteeing reliability and controllability of the increasingly interconnected European Transmission system
- To infer the impacts of the use of such new technologies on the power system
- To analyze optimal method of synchronous and joint operation for the improvement of stability and reliability of the pan-EU power system
- **To develop a roadmap for the incorporation of new transmission technologies in the electricity grids *(a TSO-oriented roadmap)***

The roadmap objectives

- To build a technology integration roadmap for European TSOs at short/mid/ long-term horizons, starting from:
  - the 2020 horizon bounded by
    - EU energy policy targets for 2020;
    - European Electricity Grid Initiative (EEGI) vision at a 2020 time horizon;
    - ENTSO-E Ten-Year Network Development Plan (TYNDP) 2010-2020;
    - EC Communication on energy infrastructure priorities for 2020 and beyond;
    - SETIS high level roadmap for European Grids.
  - A list of candidate technologies for TSOs' integration
- To provide investment cost ranges for the selected technologies
- To define a list of potential benefits qualitatively validated by TSOs

The work flow to build D142

- Inputs for the Roadmap building (D142)
  - Inputs from WP1 tasks on critical technologies
    - Prysmian: D111, D112
    - JRC/TUDO: D121, D122, D133
  - Inputs from REALISEGRID TSOs : RTE-I, TenneT, Terna, Verbund APG
  - Inputs from REALISEGRID WP3 (D3.3.1, and D3.3.2) and WP2
  - Inputs from literature, research centres
  - Assumptions
- Outcomes: a technology TSO-oriented integration roadmap (D142)
  - After Year 1: list of technologies + rationale for selection
  - After Year 2: a final roadmap integrating:
    - The feedback from Irene 40 to update the Action Agendas (September 28th 2010)
    - The feedback from REALISEGRID Stakeholder Board (September 28th 2010) and WP1 Arnhem workshop (September 29th 2010)
    - The final chapters (Executive summary; Conclusions, …)
    - Submission to the EC in April 2011

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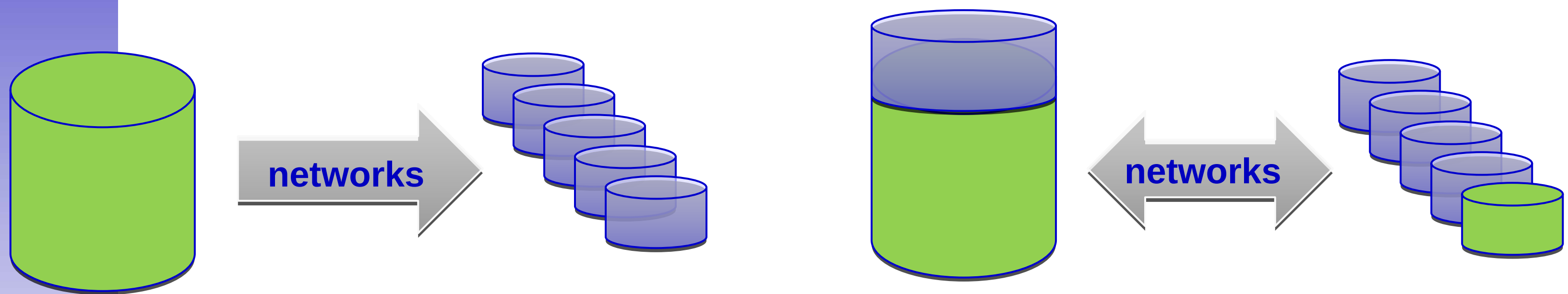
Electricity Networks in the 21-st century : change drivers

Assumptions for network design & operations are changing !



Central generation fully predictable

Consumption fully stochastic

Some generation is stochastic and dispersed (renewables)

Some consumption becomes controllable

20-th century
National electricity markets

21-st century
Single European electricity market

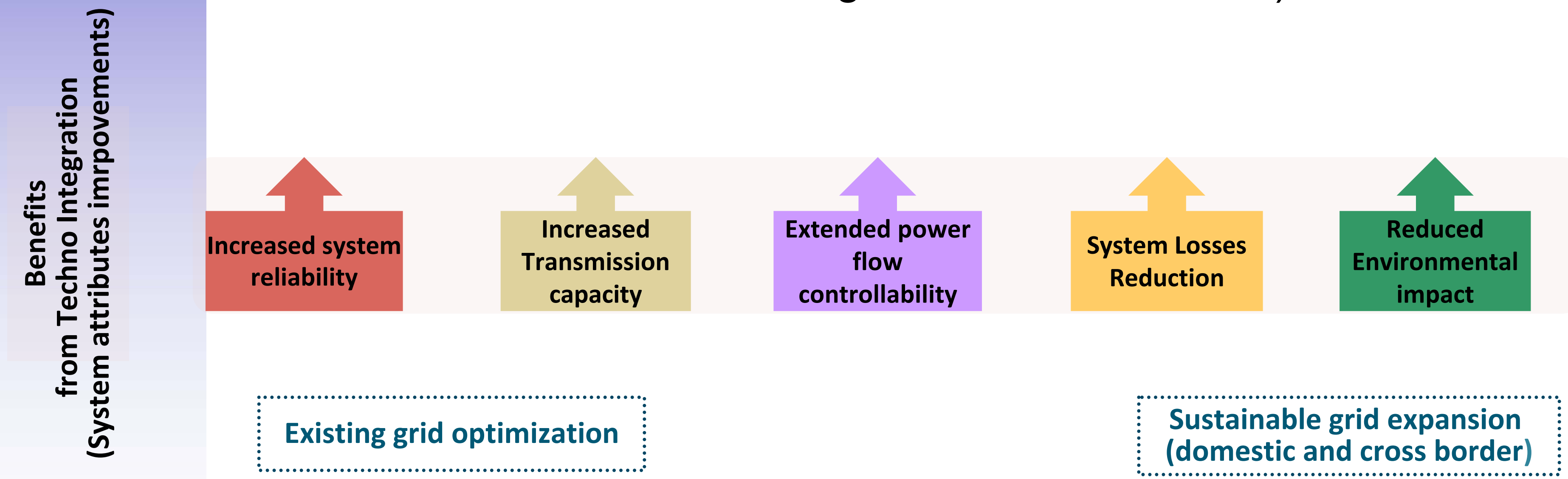
Roadmap rationale

A transition has started:

- Techno wise: which technologies?
- Time wise: at which time horizon?
- Economy wise: the TSOs/manufacturers' game

Road map rationale

- A "catalogue" of technology options available for TSO integration
- Control zone constraints impact the choice of one option against the others
- Cost/benefits analysis required for the final choice (more and more often involving cross border criteria)



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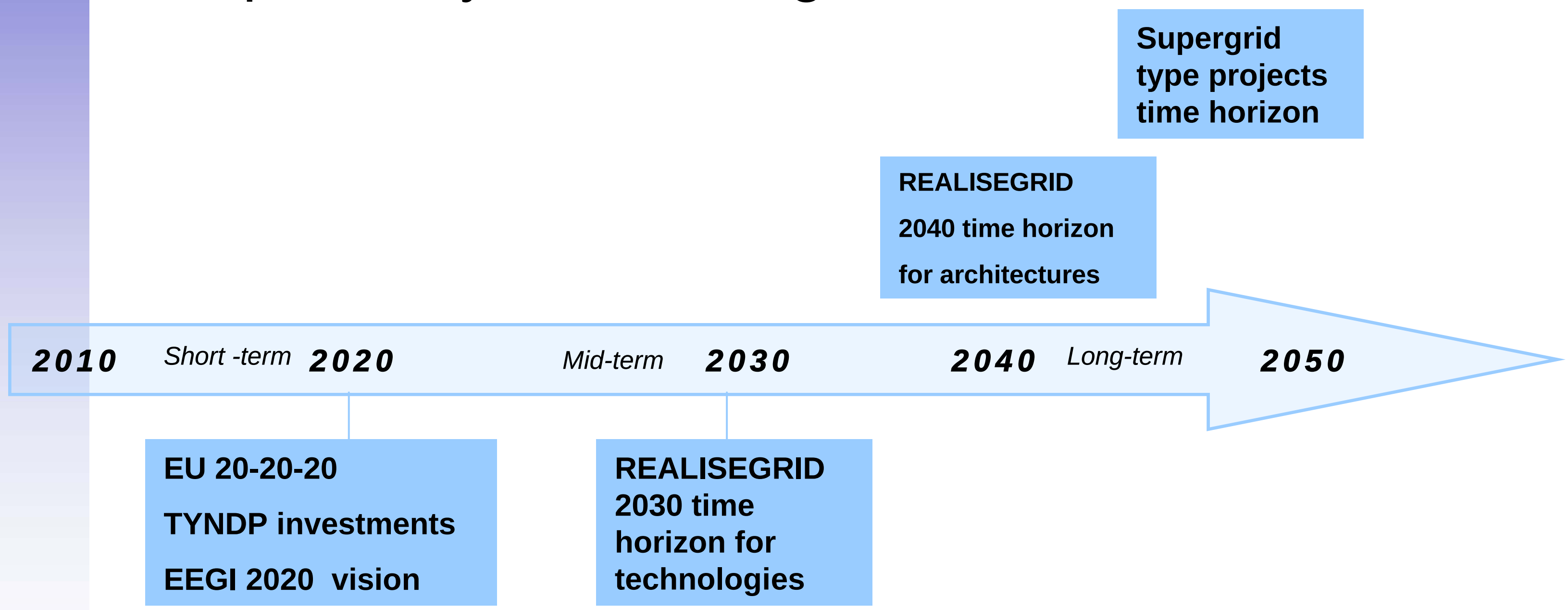
Time horizons

- Two overlapping time frames
  - for technology incorporation ending in 2030
  - for architecture and major evolutions of the EU power system ending in 2040



Technologies

- No coupling between technologies (loss of potential impacts)
- Some technologies impacting TSO operations
- Some technologies discarded
  - Extra high voltage (rather operating option)
  - Tools for real time decision making (EEGI roadmap)
  - Protective relays (revisit of N-1 rule required)
  - Emergency /Restoration (id)

The technological scope

Innovative technologies operated by TSOs

REAL-TIME TECHNOLOGIES

- RT1) Real-Time Thermal Monitoring (RTTR)
- RT2) Wide-Area Monitoring Systems (WAMS)

PASSIVE TECHNOLOGIES

- P1) XLPE underground cables
- P2) Gas Insulated Lines (GILs)
- P3) High Temperature Conductors
- P4) Superconducting cables
- P5) Innovative towers for HVAC lines

ACTIVE TECHNOLOGIES

- A1) Fault Current Limiters
- A2) Phase Shifting Transformers
- A3-4)High Voltage Direct Current (HVDC)
- A 15-12) Flexible Alternating Current Transmission System (FACTS)

Tecnologies Not operated by TSOs

EQUIPMENT IMPACTING ON TSO' s OPERATIONS (ITO)

- ITO1) Smart metering (impact of)
- ITO2) Wind powered pumped hydro storage
- ITO3) Compressed Air Energy Storage
- ITO4) Flywheel Energy Storage (FES)
- ITO5) Superconducting Magnetic Energy Storage (SMES)
- ITO6) Sodium-Sulfur (Na-S) batteries

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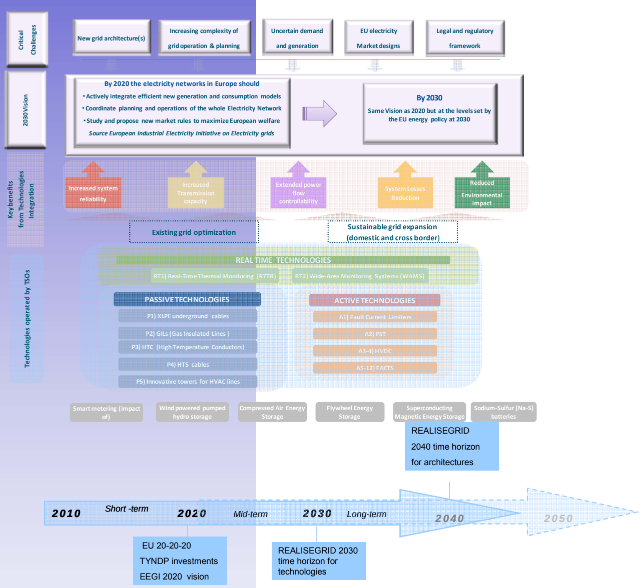
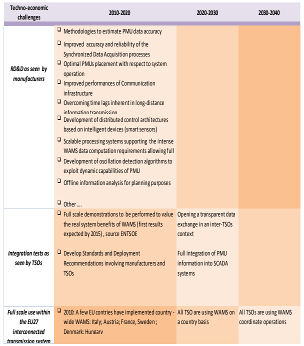
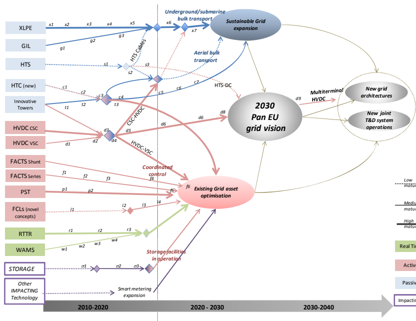
The roadmap components



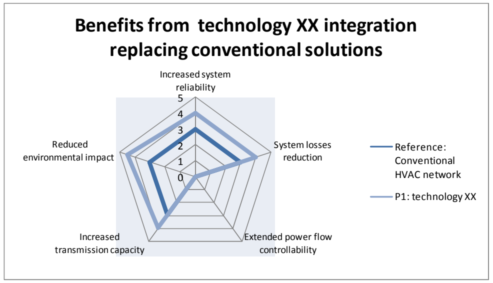
The techno portfolio in the TSO context at the 2030/2040 horizon

- A) Action agendas and synthetic view of key milestones



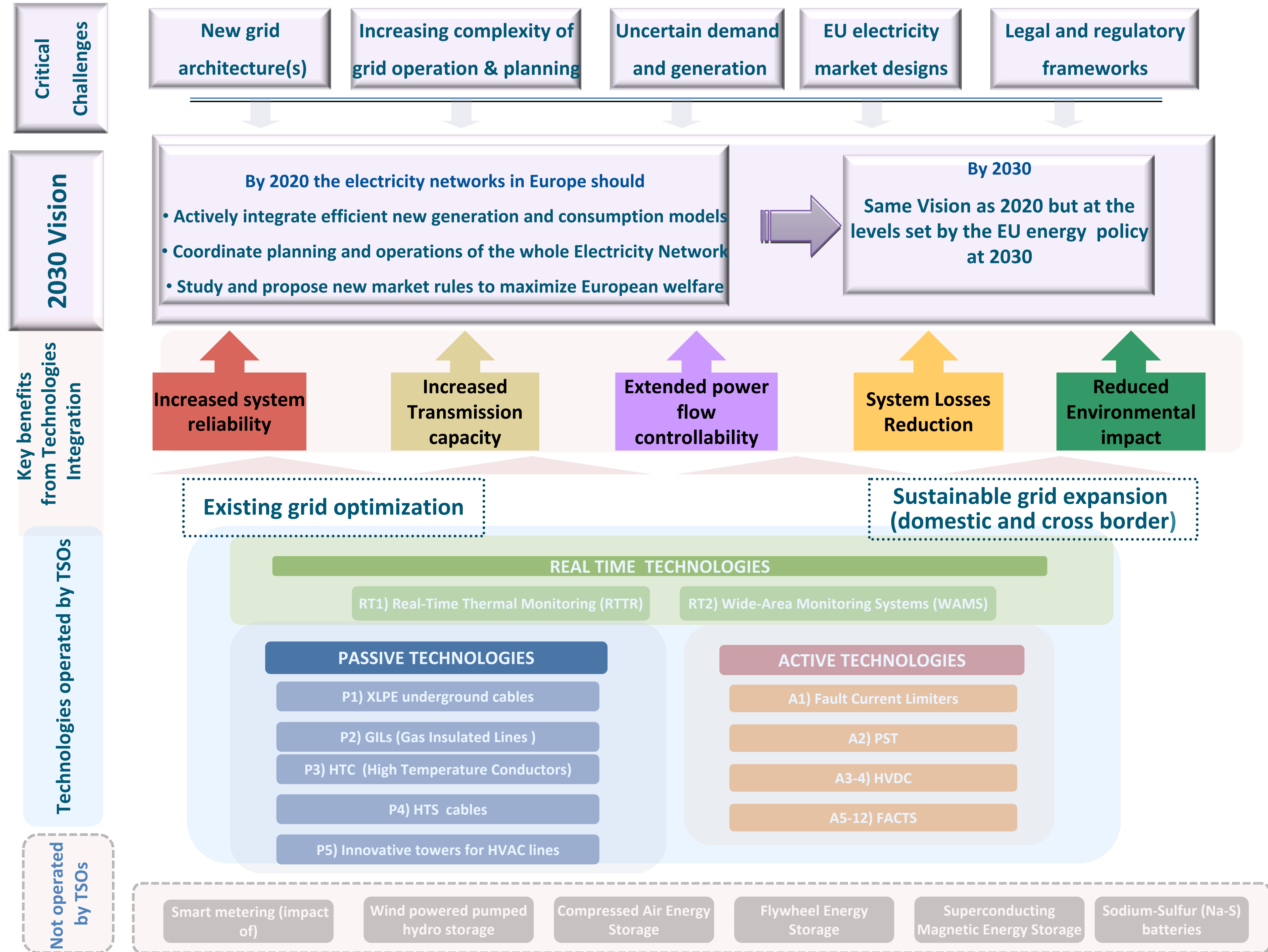


- B/C) Benefits/Costs



- D) Detailed techno cards

- E) Stakeholders' point of view (in case of discrepancies)


Critical Challenges
New grid architecture(s)
Increasing complexity of grid operation & planning
Uncertain demand and generation
EU electricity market designs
Legal and regulatory frameworks
2030 Vision
By 2020 the electricity networks in Europe should
• Actively integrate efficient new generation and consumption models
• Coordinate planning and operations of the whole Electricity Network
• Study and propose new market rules to maximize European welfare
By 2030
Same Vision as 2020 but at the levels set by the EU energy policy at 2030
Key benefits from Technologies Integration
Increased system reliability
Increased Transmission capacity
Extended power flow controllability
System Losses Reduction
Reduced Environmental impact
Existing grid optimization
Sustainable grid expansion (domestic and cross border)
Technologies operated by TSOs
REAL TIME TECHNOLOGIES
RT1) Real-Time Thermal Monitoring (RTTR)
RT2) Wide-Area Monitoring Systems (WAMS)
PASSIVE TECHNOLOGIES
P1) XLPE underground cables
P2) GILs (Gas Insulated Lines)
P3) HTC (High Temperature Conductors)
P4) HTS cables
P5) Innovative towers for HVAC lines
ACTIVE TECHNOLOGIES
A1) Fault Current Limiters
A2) PST
A3-4) HVDC
A5-12) FACTS
Not operated by TSOs
Smart metering (impact of)
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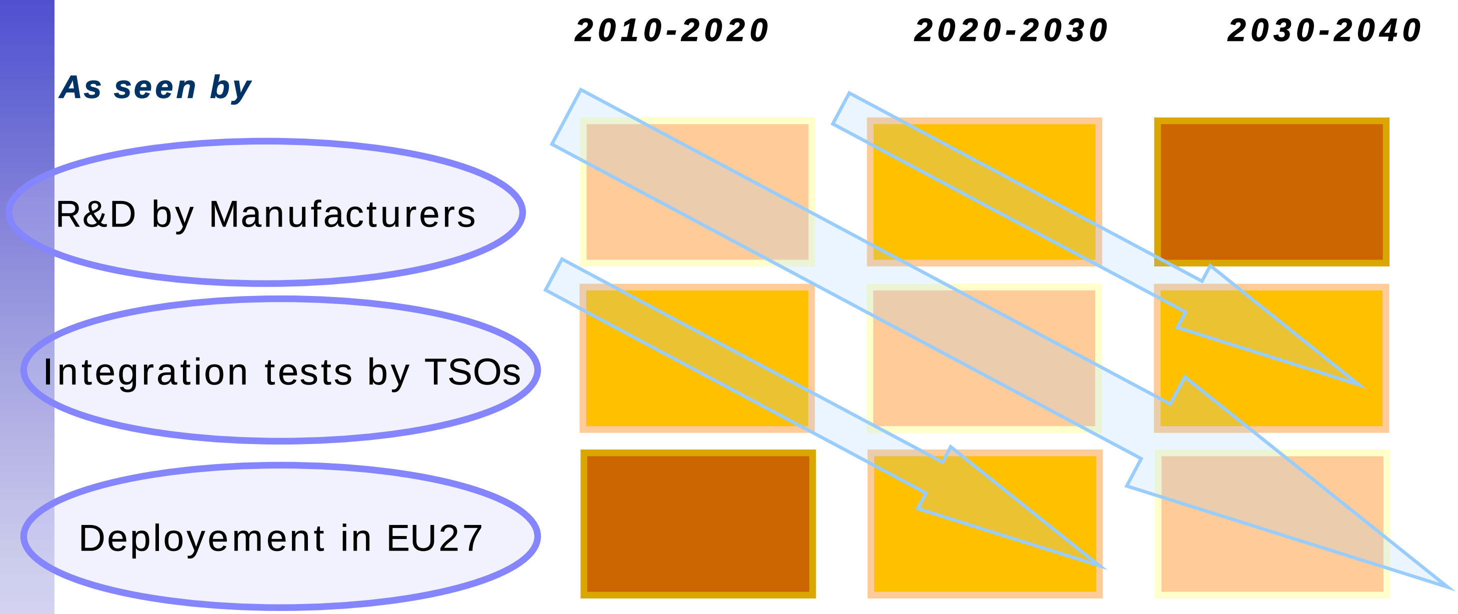
Flywheel Energy Storage
Superconducting Magnetic Energy Storage
Sodium-Sulfur (Na-S) batteries

Technology agendas



Legend	
N/C	No clear view in the development due to uncertainty at that the time horizon
	No evidence of consensus between the manufacturers
N/D	No Development are expected to occur due to the maturity stage of the technology

Techno-economic challenges	2010-2020	2020-2030	2030-2040
RD&D as seen by manufacturers	❑ Methodologies to estimate PMU data accuracy ❑ Improved accuracy and reliability of the Synchronized Data Acquisition processes ❑ Optimal PMUs placement with respect to system operation ❑ Improved performances of Communication infrastructure ❑ Overcoming time lags inherent in long-distance information transmission ❑ Development of distributed control architectures based on intelligent devices (smart sensors) ❑ Scalable processing systems supporting the intense WAMS data computation requirements allowing full ❑ Development of oscillation detection algorithms to exploit dynamic capabilities of PMU ❑ Offline information analysis for planning purposes ❑ Other		
Integration tests as seen by TSOs	❑ Full scale demonstrations to be performed to value the real system benefits of WAMS (first results expected by 2015) , source ENTSOE ❑ Develop Standards and Deployment Recommendations involving manufacturers and TSOs	Opening a transparent data exchange in an inter-TSOs context Full integration of PMU information into SCADA systems	
Full scale use within the EU27 interconnected transmission system	❑ 2010: A few EU contries have implemented country - wide WAMS: Italy; Austria; France, Sweden ; Denmark; Hungary	All TSO are using WAMS on a country basis	All TSOs are using WAMS coordinate operations

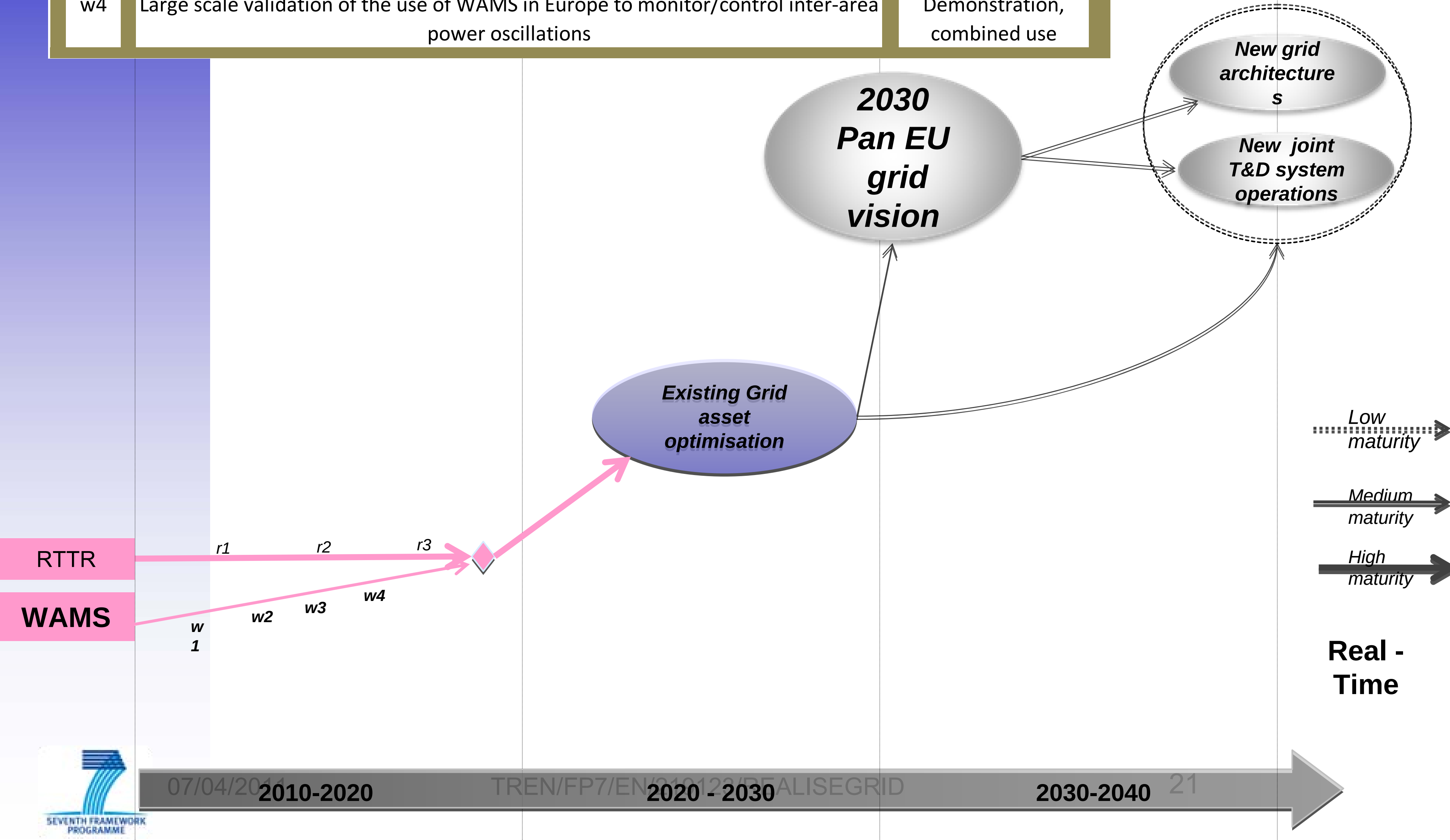
Action agenda for WAMS

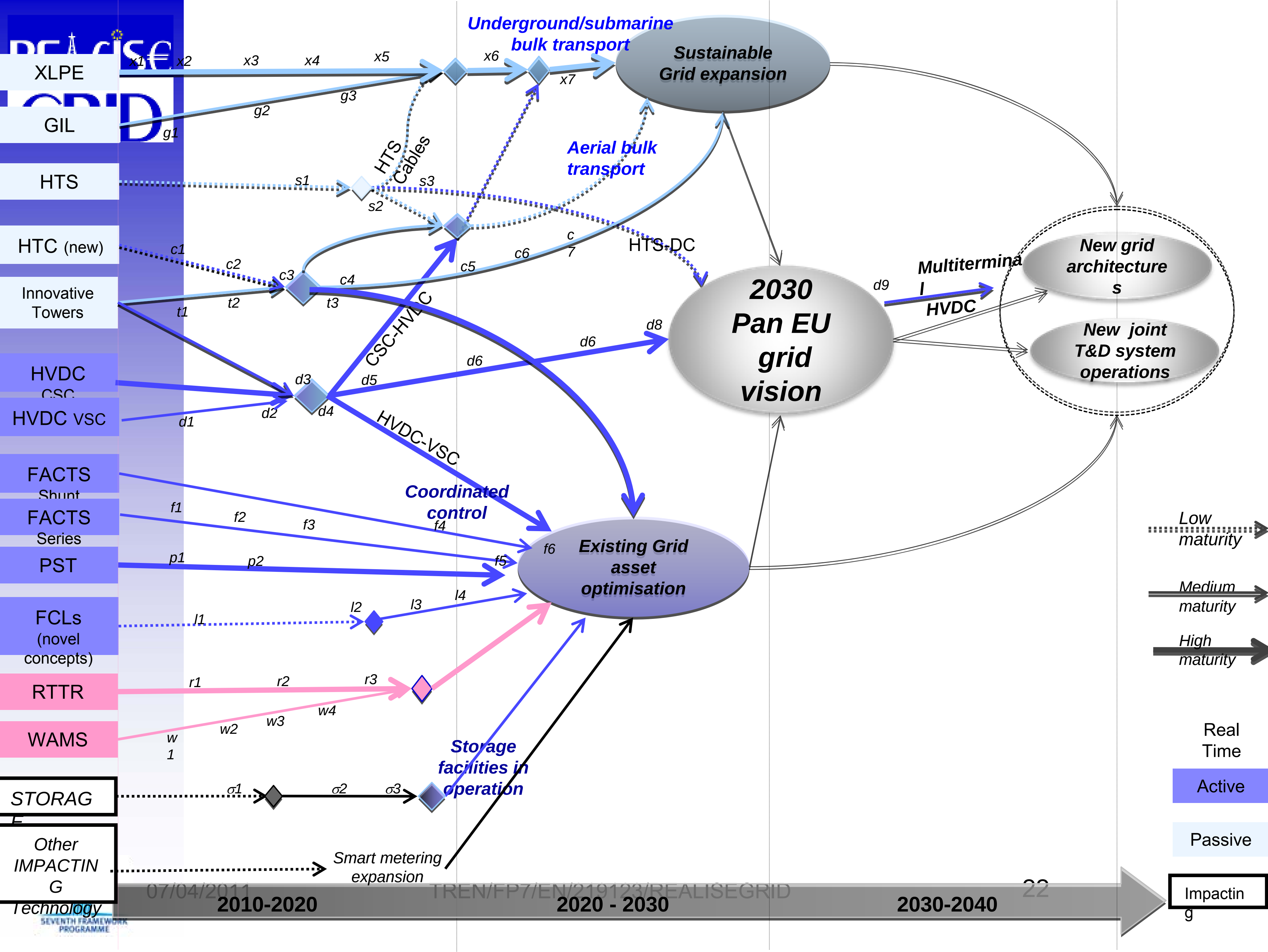
WAMS			
Techno-economic challenges	2010-2020	2020-2030	2030-2040
RD&D as seen by manufacturers	*Signal accuracy* ❑ Methodologies to estimate PMU data accuracy (standardisation) ❑ Improved accuracy and reliability of the Synchronized Data Acquisition processes (supercalibrator) *Communication or architectures and processing* ❑ Optimal PMUs placement with respect to system operation ❑ Improved performances of Communication infrastructure ❑ Overcoming time lags inherent in long-distance information transmission ❑ WACS development: distributed control architectures based on intelligent device (smart sensors) ❑ Scalable processing systems supporting the intense WAMS data computation requirements allowing full use of collected data *Algorithms* ❑ Development of standards for oscillation detection algorithms to exploit dynamic capabilities of PMU and models for interpretation ❑ Understandable link for operators between operational conditions and inter-area power oscillation damping thanks to correlations of synthetic measurements data such as generation patterns in Europe	❑ WACS/WAPS: Development of reliable turn-key systems combining data monitoring, control and protection schemes	N/C
Integration tests as seen by TSOs	❑ Full scale demonstrations to be performed to value the real system benefits of WAMS (first results expected by 2015) ❑ Development of standards on accuracy of data and deployment recommendations involving manufacturers and TSOs ❑ Integration and processing of accurate data at local level and tranmission of synthetic information at central level ❑ Integration test of non conventional sensors based on optical fibers	❑ Full integration of PMUs information into SCADA systems including special protection schemes and automation ❑ Opening a transparent data exchange in an inter-TSOs context	N/C
Full scale use within the EU27 interconnected transmission system	❑ 2010: a few EU contries have implemented country -wide WAMS: Italy; Austria; France, Sweden, Denmark, Hungary	❑ All European TSO are using WAMS in order to monitor/control inter-area power oscillations, ..	❑ WACS /WAPS : use of WAMS data for control and protection issues

Key technology integration challenges: WAMS

Id	Key technology integration challenges	Type of challenge
w1	Improved WAMS signal accuracy and standards development	Performances
w2	Development of standards for WAMS algorithms	Standards
w3	Evaluation of WAMS benefits based on full scale demonstrations by TSOs	Coordinated use
w4	Large scale validation of the use of WAMS in Europe to monitor/control inter-area power oscillations	Demonstration, combined use

Id	Key WAMS technology integration challenges	Type of challenge
w1	Improved WAMS signal accuracy and standards development	Performances
w2	Development of standards for WAMS algorithms	Standards
w3	Evaluation of WAMS benefits based on full scale demonstrations by TSOs	Coordinated use
w4	Large scale validation of the use of WAMS in Europe to monitor/control inter-area power oscillations	Demonstration, combined use




XLPE
GIL
HTS
HTC (new)
Innovative Towers
HVDC CSC
HVDC VSC
FACTS Shunt
FACTS Series
PST
FCLs (novel concepts)
RTTR
WAMS
STORAGE
Other IMPACTING Technology
x1 x2 x3 x4 x5 x6 x7
g1 g2 g3
s1 s2 s3
c1 c2 c3 c4 c5 c6 c7
t1 t2 t3
d1 d2 d3 d4 d5 d6 d8 d9
f1 f2 f3 f4 f5 f6
p1 p2
l1 l2 l3 l4
r1 r2 r3
w1 w2 w3 w4
σ1 σ2 σ3
Underground/submarine bulk transport
Sustainable Grid expansion
HTS Cables
Aerial bulk transport
HTS-DC
CSC-HVDC
HVDC-VSC
2030 Pan EU grid vision
Multiterminal HVDC
New grid architectures
New joint T&D system operations
Coordinated control
Existing Grid asset optimisation
Storage facilities in operation
Smart metering expansion
Low maturity
Medium maturity
High maturity
Real Time
Active
Passive
Impacting
2010-2020
2020 - 2030
2030-2040
SEVENTH FRAMEWORK PROGRAMME

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A dialogue tool

REALISEGRID

Project no.: 219123

Project acronym: REALISEGRID

Project title:

REseArch, methodoLogies and technologieS for the effective development of pan-European key GRID infrastructures to support the achievement of a reliable, competitive and sustainable electricity supply

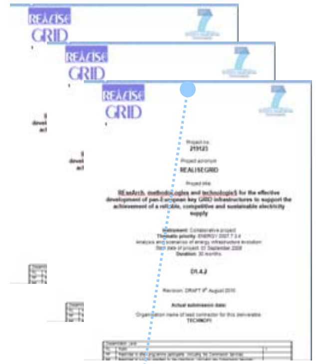
Instrument: Collaborative project
Thematic priority: ENERGY 2007.7.3.4
Analysis and scenarios of energy infrastructure evolution
Start date of project: 01 September 2008
Duration: 30 months

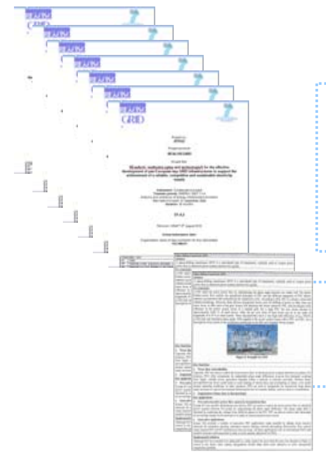
D1.4.2

Revision: DRAFT 9th August 2010

Actual submission date:

Organisation name of lead contractor for this deliverable: TECHNOFI





Annex I
15 technology cards

PASSIVE, ACTIVE, REAL TIME IMPACTING TECHNOLOGIES (Storage,…)

Chapters 1-5:
- Roadmap scope
- Background and Vision
- Methodological assumptions and Roadmap overview

The Three core components :

PASSIVE TECHNOLOGIES (Chapter 6)
ACTIVE TECHNOLOGIES (Chapter 7)
REAL TIME TECHNOLOGIES (Chapter 8)

PASSIVE: XLPE GIL HTC HTS Innovative Towers
ACTIVE: FCL, PST, HVDC, FACTS
REAL TIME : RTTR, WAMS,

Annex II
Rationale for technology portfolio selection

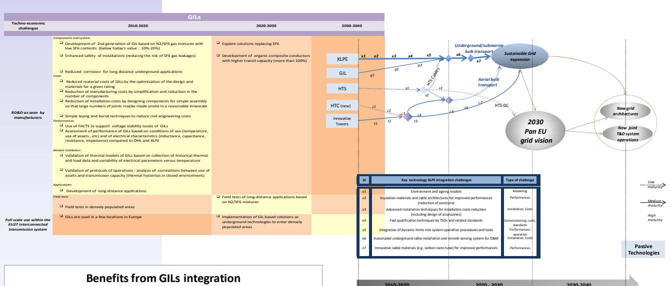
Chapters 12-15
- Non technical barriers,
- Scenarios considerations,
- Linking with ENTSO-E,
- Conclusions

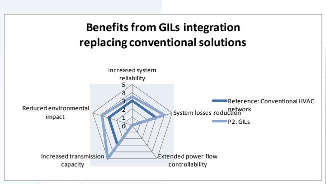
Chapters 9 , 10 , 11
- Combined use of technologies
- « Exotic technologies »
- Other Impacting technologies

Annex III
Stakeholders" and manufacturers' inputs

A dialogue tool

The same structure for each P.A.RT. technology





- Section *.1:
  Action agenda for technology integration in the system
  - For each technology detailed challenges are listed
  - Organized per decade
  - Organized per point of view: manufacturer or TSO
  - Critical challenges and maturity are represented graphically

- Section *. 2:
  Key expected benefits and typical Investment Costs ranges
  - 5 types of Benefits
  - Qualitative analysis of benefits on a relative scale
  - Cost ranges: Information on costs remains scarce

- Section *.3:
  Conclusion
  - On the maturity/applicability
  - Discrepancies between TSOs and manufacturers

- Annex I:
  Detailed description of the considered technology
  - Definitions
  - Key technologies
  - Functions
  - Applications
  - Implemented solutions

Conclusions

- # 1: The **re-engineering of the pan-European power transmission system has started thanks to market and technology pushes**

- # 2: Several **Passive technology options** co-exist to address **network expansion needs and/ or existing asset optimisation**

- # 3: **Active technologies**, allowing network expansion and/or existing grid assets optimization, will become **crucial for the future integration of RES** into the pan-European power transmission system

Conclusions

- # 4: The **combined use of passive/active technologies and real-time equipment** allows **further optimising** the use of the existing increasingly congested European grid assets

- # 5: **Large scale experiments (system innovation) at European level** are needed to validate costs and benefits under different boundary conditions

- # 6: **Simulations of the combined use of active and real-time equipment** in coupled power systems are required to better assess the expected benefits of the technology options

Conclusions

- # 7: **Impacting Technologies** (smart metering, storage, smart substations) **are expected to significantly ease TSOs' operations** provided that operational rules and procedures are revisited collectively

- # 8: The REALISEGRID roadmap provides timelines for technology adoption: it can be used as an input to the **ENTSO-E 2050 roadmap**

Conclusions

- # 9: **Non-technical barriers** slowing the adoption pace persists:
  - TSOs' acceptance and confidence needs funded large scale demonstrations
  - Critical equipment interoperability driven by a few equipment manufacturers on a worldwide market
  - Scarcity of qualified power system engineers and technicians, a general concern for the power industry
  - Financing, which depends on regulatory frameworks and investment incentives in place for transmission systems
  - Administrative procedures, such as multi-authority authorization need harmonization at EU level

Conclusions

- The REALISEGRID roadmap is an **open and living document**
- It is hoped that

  - Manufacturers will position their own views on the proposed technology trajectories
  - TSOs will more and more introduce the pan European vision

  to upgrade it periodically

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