All Island TSO Facilitation of Renewables Studies

Work Package 3: Operational Strategy for 2020

Industry Forum
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Ecofys, Department Power Systems and Markets

Agenda

- Who we are
- Scope of work
- Problem formulation
- Methodology
- Conclusions and today's progress

Who we are (I / II)

Ecofys key data

- **Founded in 1984**
- **Market leader for consultancy and innovation services in the field of renewable energy and energy efficiency**
- **Over 250 professionals**

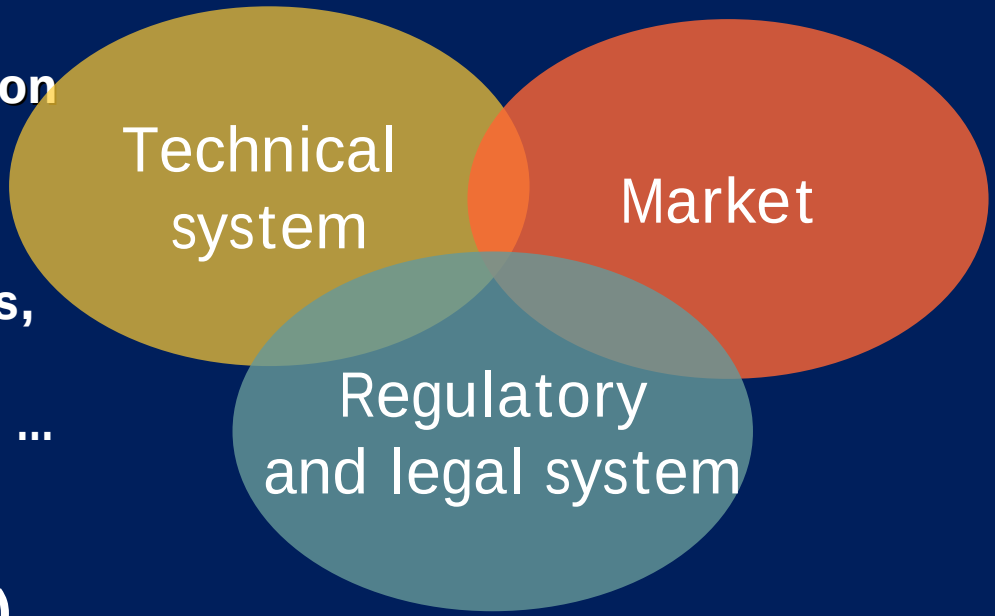
Areas of expertise

- **Energy and climate strategies**
- **Renewable energy and emission management**
- **Energy in the built environment & transport**
- **Product and system innovation**

Who we are (II / II)

Department Power Systems and Markets

- enabling efficient power systems planning and operation



Clients

- grid operators, energy utilities, governments, regulatory authorities, industries, NGOs, ...

Reference projects (selection)

- All Island Grid Study (Ireland): Analysis of Impacts and Benefits (2008) & Update to include Demand Side Management (2009)
- Advanced grid requirements for wind turbines (Germany, 2008/2009)

Scope of work (I / II)

Other consultants

- **Siemens PTI: Work Package 1. Technical Studies**
  - **Task 1.1: Dynamic and Transient Stability**
  - **Task 1.2: Fault Levels**
  - **Task 1.3: Congestion Management**
  - **Task 1.4: Reactive Power and Voltage Control**
  - **Task 1.5: Flexibility Requirements**

- **Ecar: Work Package 2. Frequency Response of the System**

Scope of our work (II / II)

Ecofys

- **Ecofys: Work Package 3. Operational Requirements**
  - **Provide overview of**
    - **Studies undertaken in Work Package 1 & 2**
    - **Technical impacts**
    - **Technical mitigation measures**
  - **Identify "boundaries of stability"**
  - **Develop an "operational strategy for 2020"**

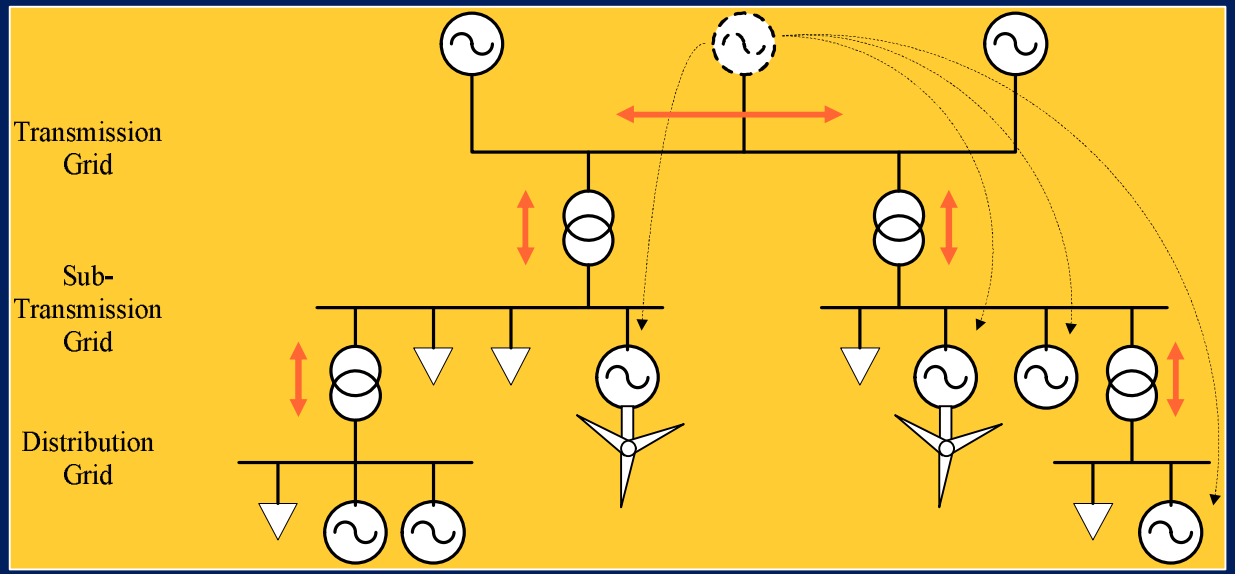
- **Ecofys: Work Package Coordinator**
  - **Smoothen information transfer between Work Packages**
  - **Enable effective quality management**

Problem formulation (I / III)

Driving factors

- **Structural changes...**
- **Operational changes...**
- **Technology changes...**

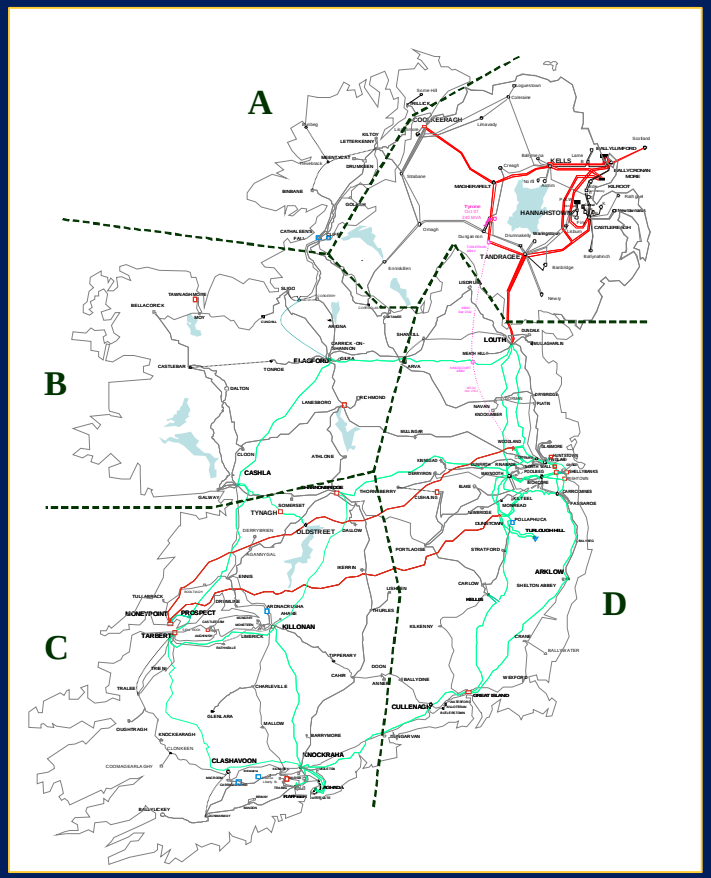
} *... in the All Island Power System*



Problem formulation (II / III)

Expected impacts (1/2)

– – – Scope of studies



Renewable regions All Island Power System

- **Power system planning**
  - **Transmission line upgrades**
  - **Construction of new lines**

- **Power system operation**
  - **Onerous wind patterns that lead to temporary overloading of lines**

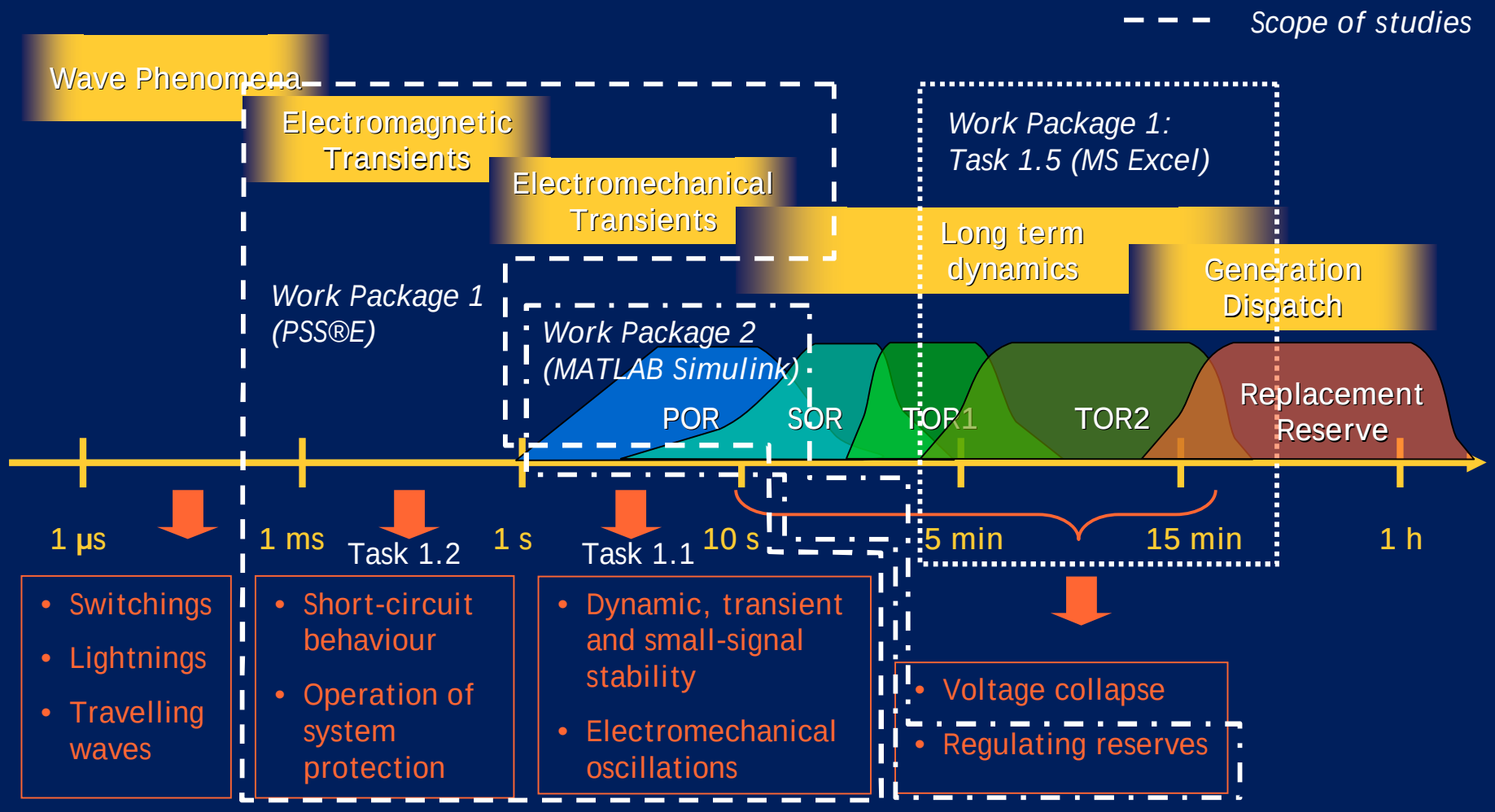
Work Package 1: Task 1.3 (PSS®E & MS Excel)

- **Voltage control**
  - **Reactive power balance**
  - **Maintenance of voltage limits**

Work Package 1: Task 1.4 (PSS®E)

Problem formulation (III/III)

Expected impacts (2/2)

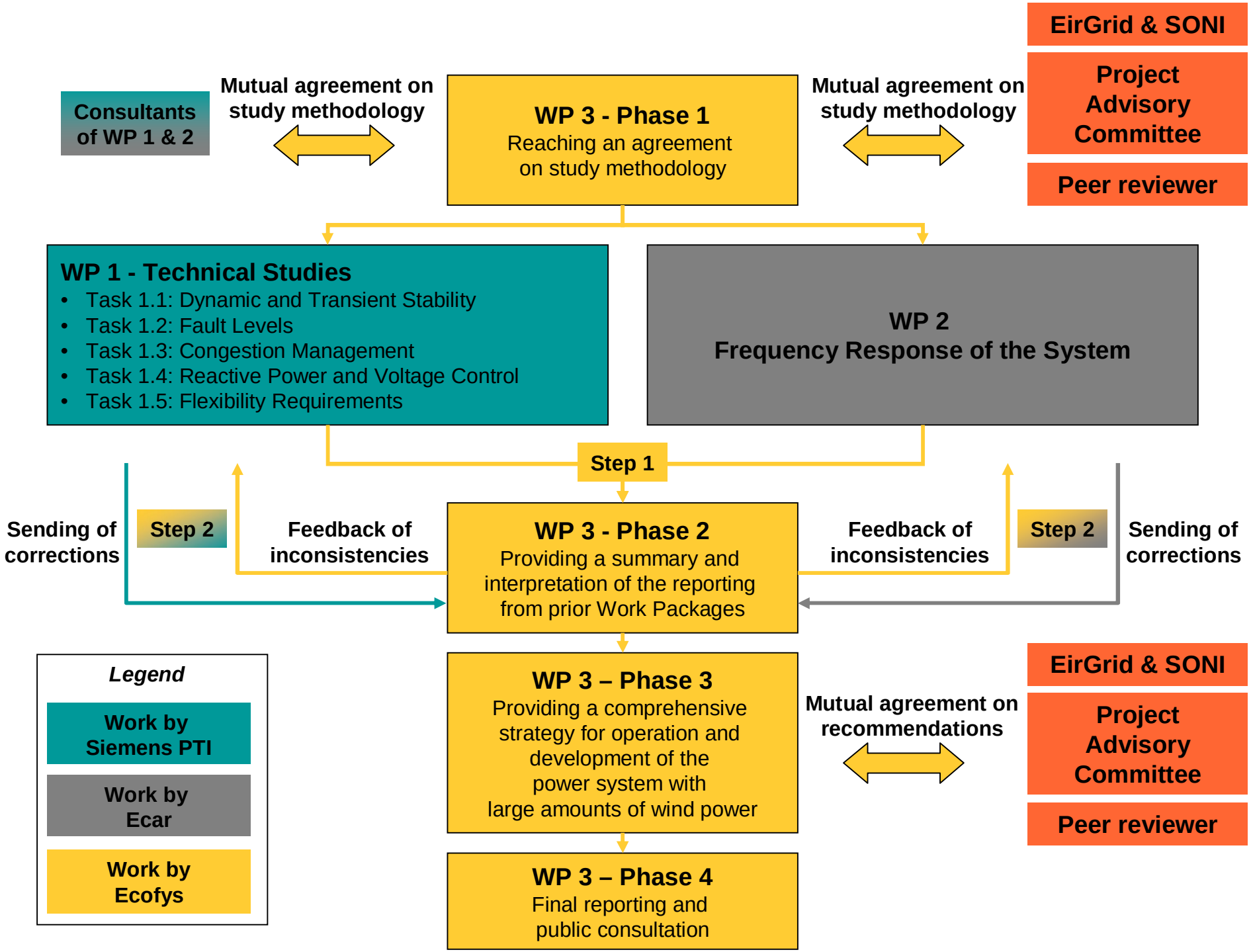


Methodology (I/VII)

Approach

- **Separation of quantitative analyses into two separate Work Packages (WPs) and Tasks**
  - **WP1: Detailed power system modelling in PSS®E**
  - **WP1 (Task 1.5): Statistical analysis with MS Excel**
  - **WP2: Aggregated power system modelling in MATLAB Simulink**
- **Combination of results from quantitative analyses by qualitative assessment in Work Package 3**

ð Process for discussion and review in 4 phases (see next slide)


EirGrid & SONI
Project Advisory Committee
Peer reviewer
Consultants of WP 1 & 2
Mutual agreement on study methodology
WP 3 - Phase 1
Reaching an agreement on study methodology
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WP 1 - Technical Studies
• Task 1.1: Dynamic and Transient Stability
• Task 1.2: Fault Levels
• Task 1.3: Congestion Management
• Task 1.4: Reactive Power and Voltage Control
• Task 1.5: Flexibility Requirements
WP 2
Frequency Response of the System
Step 1
Sending of corrections
Step 2
Feedback of inconsistencies
WP 3 - Phase 2
Providing a summary and interpretation of the reporting from prior Work Packages
Feedback of inconsistencies
Step 2
Sending of corrections
Legend
Work by Siemens PTI
Work by Ecar
Work by Ecofys
WP 3 – Phase 3
Providing a comprehensive strategy for operation and development of the power system with large amounts of wind power
Mutual agreement on recommendations
EirGrid & SONI
Project Advisory Committee
Peer reviewer
WP 3 – Phase 4
Final reporting and public consultation

Methodology (III/VII)

Challenges from separation of Work Packages

- **Work Package (WP) 1 depends on WP2 regarding**
  - **availability of wind power plants after severe frequency disturbances following grid faults**
- **Work Package 2 depends on WP1 regarding**
  - **voltage component for considering location of fault**
- **Work Package 3 depends completely on results from Work Packages 1 & 2**

ð Interdependencies between Work Packages have to be carefully considered and assessed by WP3!

Methodology (IV/VII)

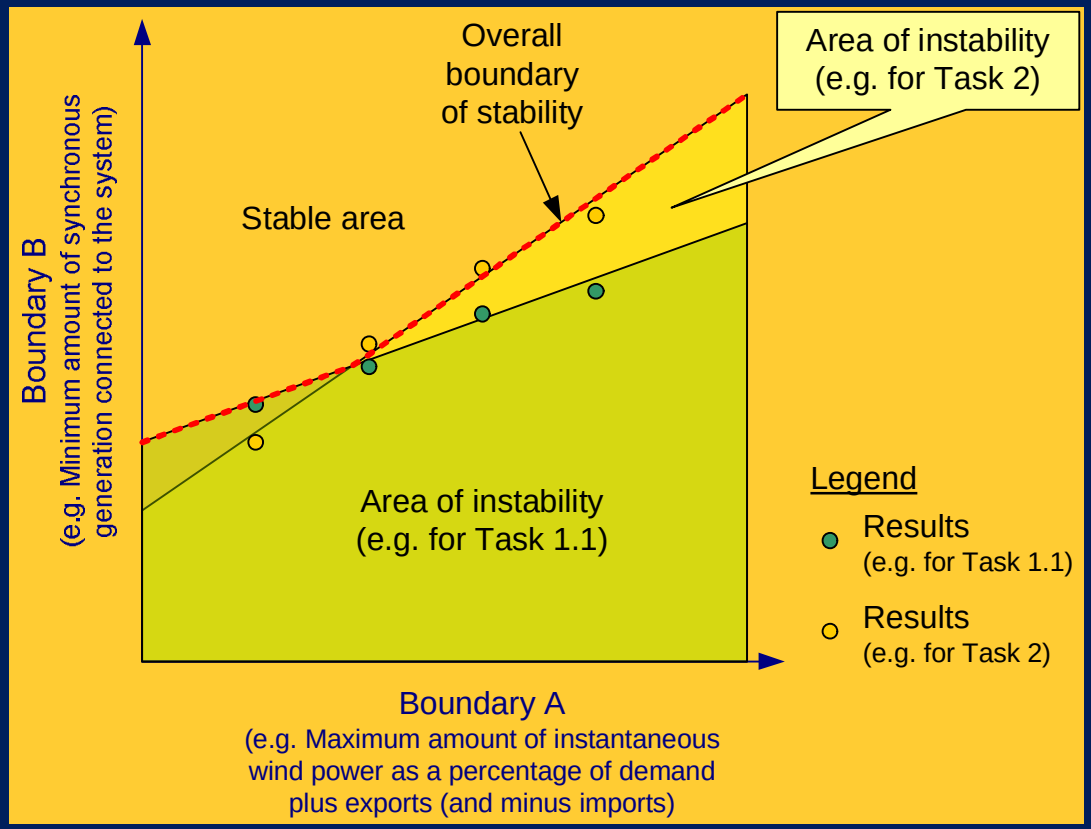
Identification of boundaries of stability (1/2)

Tasks... / ...and Issues / Boundaries of Stability under assessment	1.1 Stability	1.2 Faults and Protection	1.3 Con-gestions	1.4 Reactive Power and Voltage	1.5 System Flexibility	2 System Fre-quency
Minimum amount of synchronous generation connected to the system	X	(X)		(X)		X
Percentage of DFIGS and Fixed speed machines on the system					X	X
Maximum amount of instantaneous wind power as a percentage of demand plus exports (and minus imports)	X	(X)	(X)	(X)	(X)	(X)
Maximum amount of wind power connected to the distribution system	X	(X)		(X)		
Amount of wind power participating in frequency control					(X)	X
System load levels	X		(X)	(X)		

Methodology (V/VII)

Identification of boundaries of stability (2/2)

Illustration of boundaries of stability determined by various issues



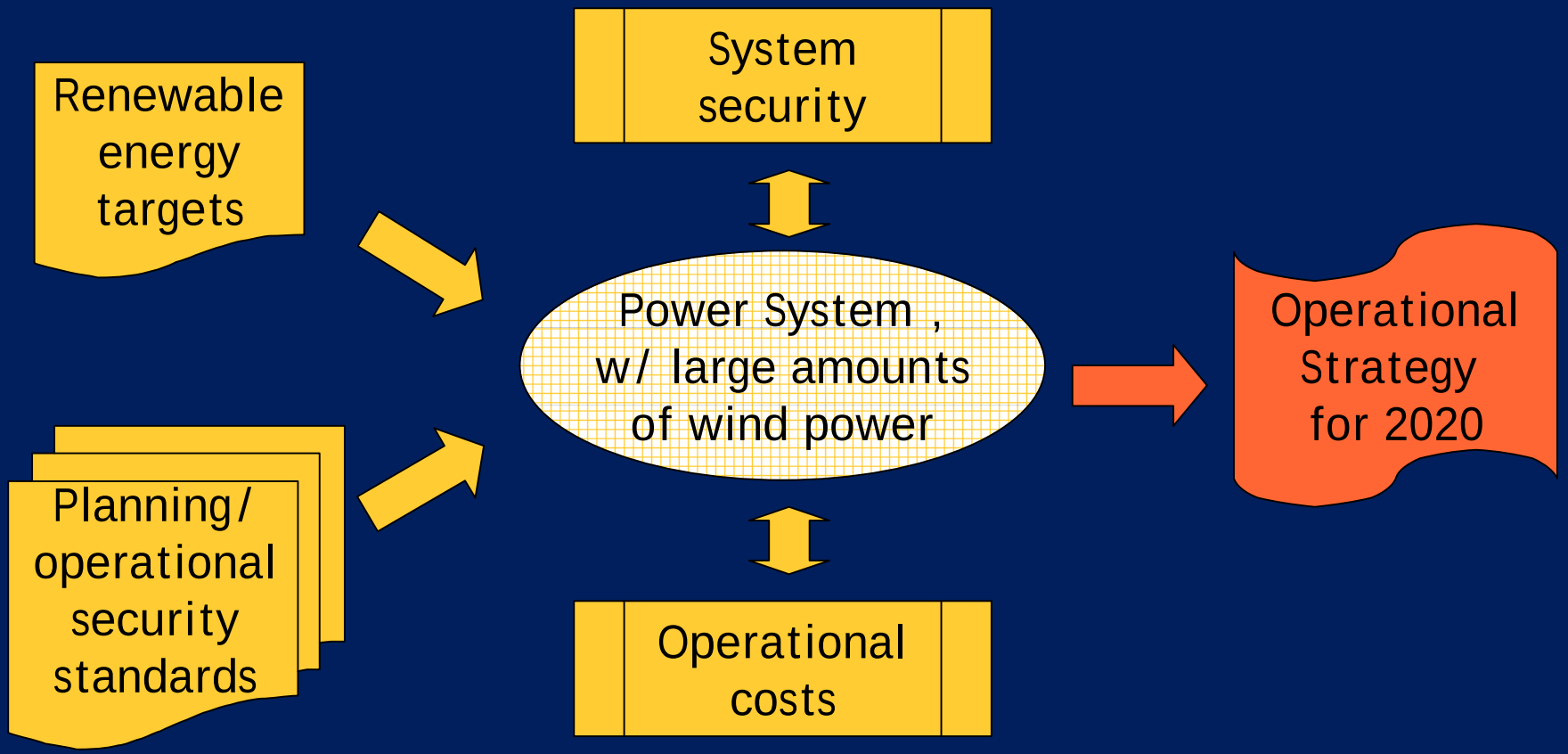
- **Boundaries can be determined by various issues**
- **Power systems are non-linear**

ð **Best possible <u>qualitative</u> assessment**

ð **Conservative approach**

Methodology (VI/VII)

Operational strategy for 2020 (1/2)



Methodology (VII/VII)
Operational strategy for 2020 (2/2)

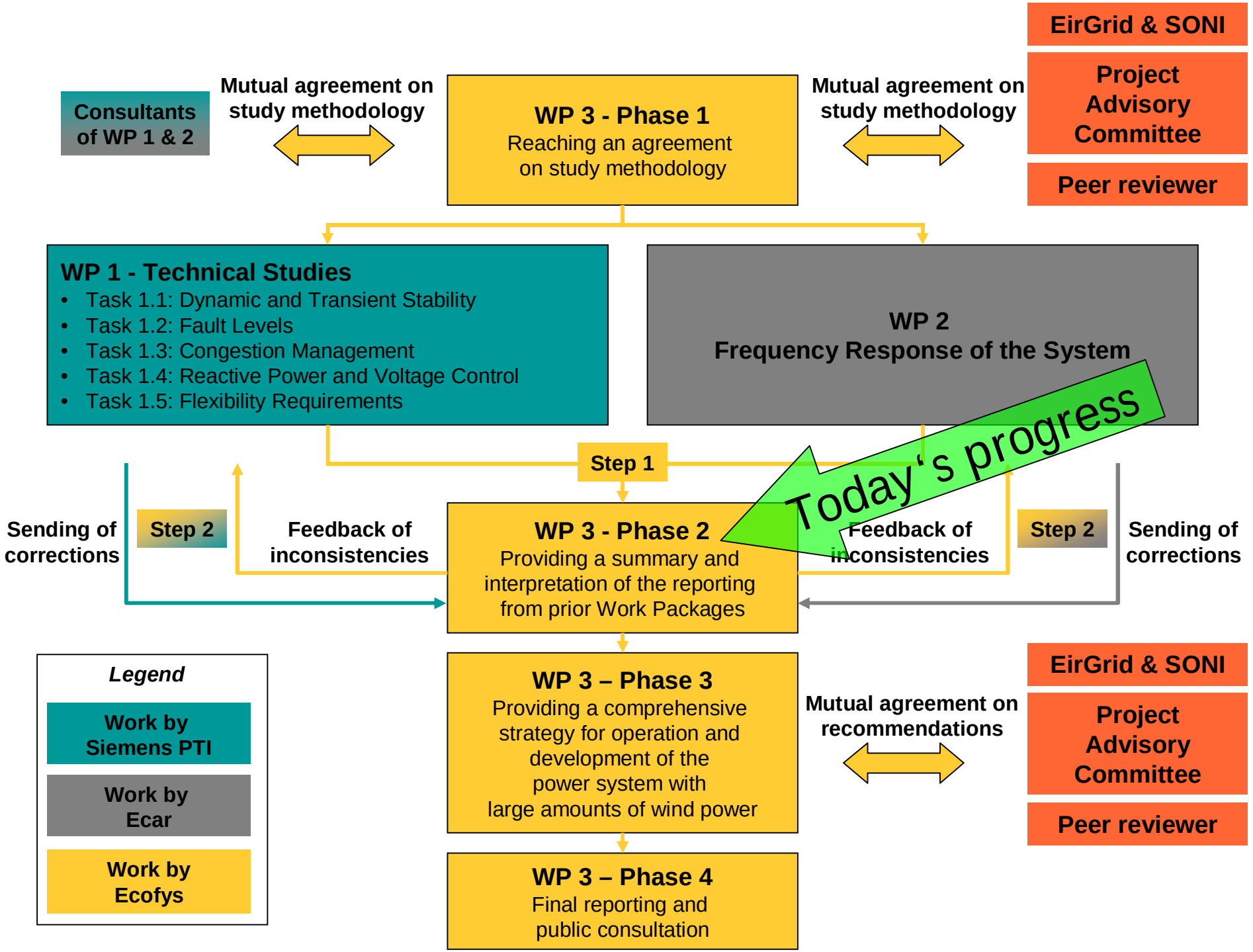
- **Aim: Develop a comprehensive, easily accessible, balanced and robust operational strategy for 2020!**

- **Possible contents**
  - **Boundaries of stability**
  - **Technical mitigation measures**
    - **Generation re-dispatch strategy**
    - **Revised requirements for control of wind farms**
    - **Innovative concepts for power system operation**
  - **Interruptible load (and demand side management)**
  - **Flexibility Requirements / Reserve Targets**
  - **Forecasting and utilisation of forecasts in decision making**

Conclusions and today's progress

- **All Island TSO Facilitation Studies are of *strategic importance* to facilitate renewable energy targets**
- **Boundaries of stability can only be assessed qualitatively**
- **Development of a operational strategy for 2020 will be a complex task, because**
  - **Plenty of complex calculations must be run**
  - **Generalisation of results will probably be difficult**
  - **Interests of many stakeholders have to be considered**

Today, only preliminary results from WP1 & 2 available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Thank you for your attention!

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Backup

Problem formulation

Driving factors (1/2)

Structural changes in the All Island Power System

- **Electric location of generation**
- **Spatial location of generation**

Operational changes in the All Island Power System

- **Reduced commitment and dispatch of conventional power plants**
- **Increased variability of generation**

Problem formulation

Driving factors (2/2)

Technology changes in the All Island Power System

- **Different electrical characteristics of generators**
- **Reduced coupling / Complete decoupling of mechanical and electrical parts**
- **High inertia to energy ratio**
- **Increased complexity of control actions**

Problem formulation

Questions for examination (1/2)

Whether the absorption of very large amounts of renewables, mainly wind power, by the All Island power system …

1. **… reduces the dynamic, transient or small signal stability and, if so, what mitigation measures can be applied by the TSOs?**

2. **… threatens the appropriate operation of the current protection scheme and, if so, whether special technical requirements for (renewable/wind) power plants must be included into the Grid Code or a new protection philosophy must be developed by the TSOs?**

3. **… brings along onerous geographical wind patterns that result in (temporal) overloading of transmission lines and, if so, what new operational and/or planning approaches should be followed by the TSOs?**

Problem formulation

Questions for examination (2/2)

4. … reduces the voltage stability and, if so, whether special technical requirements for (renewable/wind) power plants must be included into the Grid Code or (large-scale) reactive power devices be installed by the TSOs?

5. … results in the need for a revised generation portfolio and, if so, what the requirements for such a portfolio were?

6. … reduces the frequency stability and, if so, which special technical requirements for (renewable/wind) power plants must be included into the Grid Code?

Methodology

Possible mitigation measures (1/3)

- **Tasks 1.1, 1.2, 1.3, 1.4**
  - **Generation re-dispatch (including wind generation)**
  - **Revised requirements for control of wind farms, voltage and frequency**
    - **Reactive power and voltage control regimes**
    - **Enabling of wind farm active current limitation during faults**
  - **(Innovative concepts for power system operation (e.g. online temperature monitoring of overhead lines))**
  - **(Spinning inertia)**

Methodology

Possible mitigation measures (2/3)

- **Task 1.5**
  - **Revised requirements for control of wind farms, voltage and frequency**
    - **Enabling of wind farm frequency control capability**
  - **Flexibility Requirements / Reserve Targets**
  - **(Additional reserve requirements)**
  - **(Interruptible load (and demand side management))**
  - **(Forecasting and utilisation of forecasts in decision making)**
  - **...**

Methodology

Possible mitigation measures (3/3)

- **Task 2**
  - **Generation re-dispatch (including wind generation)**
  - **Revised requirements for control of wind farms, voltage and frequency**
    - **Enabling of wind farm inertia contribution control capability**
    - **Enabling of wind farm frequency control capability**
  - **Additional reserve requirements**
  - **Interruptible load (and demand side management)**
  - **Spinning inertia**

  - **(Flexibility Requirements / Reserve Targets)**
  - **(Forecasting and utilisation of forecasts in decision making)**

Who we are

Reference 1: All Islands Grid Study: Examining extreme penetrations of wind in the Irish power system

- Integration of of 2-8 GW of wind in the 9,5 GW Irish power system
- 2020 Scenario: Technical and economic consequences (dispatch, grid, reliability, market)?
- Ecofys aggregate the findings from previous work streams
- Analysis of cost and benefit implications for various stakeholders
- The results are compiled into a document accessible and applicable for policy makers.
- Further projects in Ireland: Underground cable study, Demand side management

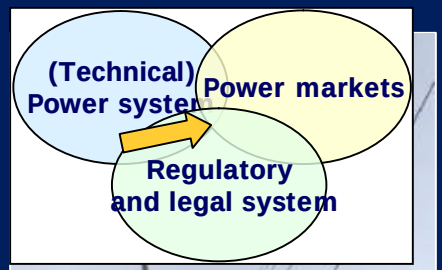
Formed basis for present All Island TSO Facilitation of Renewables Studies

Who we are

Reference 2: Amended Renewable Energy Act

Client: Federal Ministry for the Environment

Scope: Amending the RES-E support scheme (various projects)



Contributions Ecofys :

- **Cost benefit analysis of market based trading concepts for RES-E**
- **Development of a support scheme for virtual power plants**
- **Support scheme to upgrade old wind generators to ensure system security**

Approved by German Cabinet on May 27th, 2009

Who we are

Reference 3: Island Power supply system

Client: Water en Electriciteits-bedrijf Bonaire (WEB)

Scope: Techno-economic feasibility studies for power supply system with high wind contribution

Contribution Ecofys:

- Resource assessments
- Scenario analysis / master plan development
- Power plant configuration (gensets, wind farm)
- Loss of Load Probability Assessment

Financial closure on March 24th, 2009