## InnoEnergy Project Proposal for the topic ``Smart Electric Grid and Storage``

**PROJECT TITLE: Controllable and Intelligent Power Components**

**Topical Area: Smart Grid Power Components**

**Project acronym: CIPOWER**

**Proposal No: 28**

**Project type:** *R&D / pilot / demonstration*

**Project Duration:** 2011 - 2013

**Name of coordinating person: Rajeev Thottappillil ( Project Manager: Hans Edin)**

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### 1. *LIST OF PARTICIPATING INSTITUTIONS:*

| | Participant legal name | CC | Organisation type | Contact person |
|---|---|---|---|---|
| 1 | KTH | Sweden | Academic | Hans Edin |
| 2 | Uppsala University | Sweden | Academic | Magnus Rahm<br>Cecilia Boström |
| 3 | ABB | Sweden | Industry | Mikael Dahlgren |
| 4 | Vattenfall | Sweden | Utility | Christian Cleber |
| 5 | Fortum | Sweden | Utility | Marie Fossum |
| 6 | SvK | Sweden | Utility | Göran Eriksson |
| 7 | Seabased | Sweden | Industry | Erik Lejerskog |
| 8 | Elforsk | Sweden | Research org. | Susanne Olausson |
| 9 | K.U. Leuven | Benelux | Academic | Tom De Rybel |
| 10 | UPC | Iberia | Academic | Daniel Montesions Miracle |
| 11 | UPC - ETSEIB | Iberia | Academic | Juan A. Martinez-Velasco |
| 12 | AGH | Poland | Academic | Zbigniew Hanzelka |
| 13 | Grenoble-INP | Alps Valley | Academic | Francois Weiss |
| 14 | KIT | Germany | Academic | Thomas Leibfried |
| 15 | Tecnalia | Iberia | Industry | Susana Apiñániz |
| 16 | Eandis | Benelux | Utility | Edwin Haesen |
| 17 | VITO | Benelux | Research Org. | Venkemans Guy |
| 18 | IST Lisbon | Iberia | Academic | Maria Teresa Correia de Barros |

## 2. MOTIVATION AND PROJECT OBJECTIVES;

The route towards a more energy sustainable world goes through an improved energy system on all levels from the producers to the consumers. The technological challenges that need to be addressed to realize the strategic energy objectives are faced in the program "controllable and intelligent power components". The objective is to develop innovative power components with advanced control and monitoring that pave the path towards an optimum power transmission and distribution system. This implies that we investigate how to add smartness (intelligence and controllability) and added novel functions to power components used in grid connections. The project is organized in eight work packages (WP):WP0: Management, WP1: power component design, WP2: power component monitoring and diagnostics, WP3: Power asset management, WP4: Components for relaying and protection, WP5: Integration and interaction of power components, WP6: Submergible power components, and WP7: Intelligent communicating power devices.

## 3. MAJOR RESULTS (KPI, INCLUDING THEIR TIMING)

40 students (Masters+PhD) to labour market 2013
7 new products and/or services 2013
7 European patents 2013
1 patents transferred to SME & Ventures 2013
1 start-up 2013
60 scientific publications (20 per year)

In relation to these KPIs we will also coordinate and arrange a joint Master of Science on "Smart Electrical Networks and Systems" (SENSE) and the PhD school on Smart Electric Grid and Storage. The Master and PhD schools are for the whole thematic area 'Smart Electric Grid and Storage.'

## 4. PARALLELS AND DIFFERENCES BETWEEN CCBENELUX "ACTIVE SUB-STATIONS" AND CCSWEDEN "CONTROLLABLE AND INTELLIGENT POWER COMPONENTS"

Controllable power components are an integral part of smart grids at any voltage level. It thus comes as no surprise that there are significant overlaps between both the active sub-station project and the controllable components project.

However, these overlaps are in fact minimal. This is because of the different focus of both projects. The intelligent components project focuses on components for high-voltage transmission and distribution systems. In active sub-stations, the focus is on the interface between the medium-voltage and low-voltage distribution grid. Both systems have very different requirements on these components.

There are, in some cases, techniques that are applicable to all voltage levels. In such cases, both projects can benefit from a mutual collaboration and their different background complement each other in the development of these devices.

To this end, both projects actively tune their work packages to one another to ensure the desired synergy and seek active, mutual participation.

| WORK PACKAGE DESCRIPTION | | WP No | 0 |
|---|---|---|---|
| **Work package Title** | Management of CIPOWER | | |
| **Institution(s):**<br>**Contact person(s):** | ***Lead:*** *CCSweden, Coordinator Rajeev Thottappillil, Project Manager Hans Edin*<br>***Participants:*** *All Project Partners* | | |

**Objectives:**
Organization of the joint key activities within the technical work packages in CIPOWER, i.e.:
Innovation: creating innovative products, processes and services that can be provided to the electric power energy market in order to create a more controllable, effective, flexible, reliable power system through increased intelligence added to the power componets.
Education: to organize a PhD school on "Smart Electric Grid and Storage" (SMEGS, SEGS ?)
to organize a two year MSc education on "Smart Electrical Networks and Systems" (SENSE).
Research and technology: providing new findings that has its ground on scientific basis

**Work plan and distribution of tasks** (including timing of tasks):
The general organization is common to all technical workpackages WP 1 – WP 7.

Task 0.1 Management

The management process is run by the following team
Steering board: A number of experienced people from industry, utility and innovation community will act as a decision and advisory board to support the coordinator(s) and project manager(s).

Coordinator: Rajeev Thottappillil (KTH)
Area of responsibility: Provide overall direction for the project and coordination between various partners and the knowledge triangle

Coordinator deputy: Mikael Dahlgren (ABB)
Area of responsibility: Work with the coordinator as a team. Specifically provide the industry perspective and connection to innovation.

Project manager: Hans Edin (KTH)
Area of responsibility: Manage the day-to-day coordination between the various work packages, and tasks. Call meetings and follow up the progress.

Project manager deputy: Nathaniel Taylor (KTH)
Area of responsibility: Work with project manager as a team. More specific responsibility for education including PhD school.

Work Group Leaders:
WP1: Göran Engdahl, KTH
WP2: Hans Edin, KTH
WP3: Patrik Hilber, KTH
WP4: Hans-Peter Nee, KTH

WP5: Nathaniel Taylor, KTH
WP6: Cecilia Boström, UU
WP7: Marie-Cécile Alvarez-Hérault, INP Grenoble

Responsible for organizing and following up their-own WP's. Take part in WP meetings.

Deliverables: A well-managed CIPOWER

Task 0.2 Innovation process (all partners)
The innovation process starts with an idea and ends with a commerciable product or service.
In reality many innovations are improved products/processes/services from ideas that are not completely new. According to the Oslo-manual *"An 'innovation' is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organization or external relations."*

As a means to provide the first stage in the innovative process, i.e. the idea, we need to create an atmosphere were new ideas for a new or better product, a new or improved process and a new or improved service can be generated.

The idea stage is by nature stochastic, but is enhanced and facilitated by a high amount of knowledge and "know-how" by the people in the work packages. The amount of knowledge is usually large and is not foreseen to be a limiting factor. The first step is therefore an idea inventory step or popularly termed "brainstorming". This project proposal has been preceded by such activities, but this must be performed on a regular basis. In order to promote this we will organize Instead we will organize two "thematic review" days per year where we meet and go through the materials that have been published elsewhere in the world. The outcome of this review process is: 1) an up-to-date summary of other findings and to benchmark them with existing solutions (to do this we need the experts in each organization) and the innovative ideas that are considered in CIPOWER; and 2) identified innovation/research gap and an updated road-map towards (near and far) future.

The technical development of the idea to a product/process/service must be run with the commercialization as a focus. The technical evaluation of the idea as such is made by in two parts: Part 1: analysis, simulations, experiments and 2) prototype building activities. The critical thing is to not get stuck in part 1, which is the home-base for academic research, but to advance to part 2 (prototypes) and then over to stage 3 – commercialization. In order to enhance the entrepreneurship stage the PhD students will be enrolled in a course given by ESADE in Barcelona, see below.

Once per year we will let researchers on innovation investigate our innovation process and come with suggestions to improvements. This will be run together with the CESIS project at KTH.

Deliverables:
7 new products and/or services 2013
7 European patents 2013
1 patents transferred to SME & Ventures 2013
1 start-up 2013

Task 0.3: Link to the PhD school on "Smart Electric Grid and Storage" with focus on innovations and entrepreneurships (All partners).

The PhD school is organized by CCSweden and covers the whole thematic area of 'Smart Electric Grid and Storage'. The general scientific and subject specific education is considered by the schools program for PhD education. However, a larger enrollment of industrial participation is considered, effectively by giving lectures and seminars on preferential subjects and in particular in the SENSE course (see below) that will be the meeting platform between MSc students, PhD students, other CC teachers, industrial people and utilities. In the SENSE course the PhD students will also be giving lectures on their research and on other topics.

The early training in entrepreneurship thinking will be provided by the ESADE business school in Barcelona.

Each PhD project will share a common steering group with people from research, industry and utilities that can assist to route the project and the PhD student in the best way. The steering group will meet twice per year.

PhD students have a mandatory period of six months per year at a partner from a different CC. KIC funding used for part of this activity.

Deliverables: Recruitment of at least 15 PhD each in 2011, 2012, 2013. 5 PhD to labour market 2013

Task 0.4 Links to MSc course on "Smart Electrical Networks and Systems" (All partners)
The university partners within CIPower is also partners in the organization of the MSc school in "Smart Electrical Networks and Systems". As a part of this work we are working hard to achieve funding programs such as Erasmus Mundus Joint Masters, which also offers education on the important matters of smart electrical networks, which is one important part of making the world $CO_2$ neutral.

The novel issues of the Smart Grids are a limited but important and growing part of each course, and it is an aim to communicate the latest findings from the research to the MSc students. The SENSE MSc program is organized the first year in either Stockholm (KTH) or Eindhoven (TU/e). During the second year they go to any of the following universities (but not to the same as the first year) : UPC Barcelona, INP Grenoble, KIT Karlsruhe, TU/e Eindhoven or KTH Stockholm. During the first year they will meet the smart grids issues in a joint course running across all semesters, which ends with a joint summer school where student projects are presented. The main activities of the course is arranged around four thematic weeks or events were teachers and PhDs from other universities, industries and utilities will come and give lectures/seminars. This will give a strong interaction between participants on any level. The first half of their second year is spent in their 'specialization' university and the second half on the MSc thesis.

KIC funding used for connecting Master's thesis project with innovation:

Deliverables: 35 students Masters to labor market 2013 (10 in 2011, 10 in 2012, 15 in 2013)

Task 0.5 Assessment of the economic impact of the projects (All partners)
The impact of the economic value of the projects will be measured over time. We will attempt to track the career and progress of examined students, developed ideas and innovations implemented in industry and among utilities.

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| **Links to KIC InnoEnergy Strategy:**<br><br><u>Exploitation:</u> New products, processes and services provided to make a smart electric grid with storage<br><br><u>Education</u>: Explore House. The dissemination of knowledge is actively perused in this WP. Through open laboratory facilities, KIC partners and students will be allowed to interact with the new developments. |
| **Milestones:**<br><u>M 0.1</u>: Inventory of novel findings in the world and brainstorming around new ideas (Q1 2011, Q1 2012, Q1 2013).<br><u>M0.2:</u> Developed innovation process suitable for controllable and intelligent power components, concerning products, processes and services. (Q4 2011) |
| **Deliverables/Outcome KPI:**<br><u>D 0.1</u> PhD School on "Smart electric grid and storage" linked to Innovation projects<br><u>D 0.2</u> MSc education on "Smart electrical networks and systems" linked to Innovation projects<br><u>D 0.3</u> Managed and developed innovation process |

| WORK PACKAGE DESCRIPTION | | WP No | 1 |
|---|---|---|---|
| **Work package Title** | Power Component Design | | |
| **Institution(s):**<br><br>**Contact person (s)** | <u>Lead:</u> KTH, Göran Engdahl, goran.engdahl@ee.kth.se<br><u>Participants:</u><br>ABB, Mikael Dahlgren, mikael.dahlgren@se.abb.com<br>KTH and ABB, Marley Becera, marley.becerra@se.abb.com<br>KTH, Hans-Peter Nee, hansi@kth.se<br>KTH, Rajeev Thottappillil, rajeev@kth.se<br>UPC-Iberia, Daniel M. Miracle, daniel.montesinos@upc.edu<br>UPC-ETSEIB, Juan A. Martinez-Velasco, martinez@ee.upc.edu<br>AGH-Poland, Zbigniew Hanzelka, hanzel@agh.edu.pl<br>UU, Jan Isberg/Vernon Cooray/Anders Rydberg, name@angstrom.uu.se<br>Seabased, Erik Lejerskog, erik.lejerskog@seabased.com | | |
| **Objectives:**<br><br>A smart grid requires a new kind of power components with extended features regarding controllability, intelligence and functional performance. To design such components the following specific project tasks are set up. Task 1.1 aims at the work out of multi-physical models appropriate for crucial components as transformers, power converter, electromechanical systems, and gas discharges. Task 1.2 deals with the design of the switching devices that are vital regarding their extended features | | | |

in a smart grid. Also the scalability with respect to voltage endurance of switching devices is addressed. In Task 1.3 the electromagnetic compatibility in HVDC and AC substations equipped with controllable and intelligent power components is treated. Design of novel power electronics is worked out in Task 1.4. In Task 1.5 environmentally-friendly solutions for the new/and or upgraded components are addressed. The related power quality issues are addressed in Task 1.6. Finally fast charging of electrical vehicles is treated in Task 1.7.

**Work plan and distribution of tasks** (including timing of tasks):

Task 1.1 Power Component design (KTH - Engdahl, ABB –Bormann, UPC-Iberia –Daniel M. Miracle, UPC-ETSEIB – Juan A. Martinez-Velasco, AGH-Poland-Adam Pilat, UU – Mats Leijon)
Close cooperation with Task 6.1
2011 – 2013 A Low frequency model of transformer coil. Analysis on loadability vs dc magnetization of transformers, Low-freq model of power transformer core. [Seyedali]
2012 One licentiate thesis (half way to PhD) on modelling of power transformers with DC magnetisation that addresses the loadability of transformer core issue
2014 One PhD thesis on modelling of power transformers with DC magnetisation
2011 One PhD will be recruited regarding modeling of power electronic converters
2011 One PhD will be recruited regarding modeling electromechanical systems []

Task 1.2 Switching devices and actuators (KTH, ABB (Marley Becera),UU)
Development of fast high-current commutation devices, hybrid switching devices and arc-quenching technologies
Close cooperation with Task 6.1
2010 One PhD student will be recruited regarding electromagnetic actuators for switching devices.
2011 One PhD student will be recruited regarding fast high current commutation device. [1 prototype and 1 patent]
2011 Pre-study initiated regarding scalability with respect to voltage endurance of switching devices [1 MSc stud]

Task 1.3 Electromagnetic compatibility (KTH,ABB,UPC-Iberia)

Task 1.3 Electromagnetic compatibility (KTH,ABB,UPC-Iberia)

Start Q3 2011. 2011-2013 EMC of multi-pole HVDC stations, ac sub-stations.

Substations (HVDC and AC alike) have harsh electromagnetic environments with time varying sources such as electronic switching, corona, arcing at breakers, unwanted flashovers at insulators, magnetic fields created by stray currents etc. Novel intelligent power components will have to be able to operate under these conditions without degradation in efficiency. In addition, the demand of sophistication has greatly increased. Problems such as sufficient grounding for accumulate charges on component bodies, high-frequency filtering of communication signals, surge protection, reliability of signal content etc., have to be handled.

Task 1.4 Novel power electronics (KTH (Engdahl, Nee), ABB, UU, UPC-Iberia, UPC-ETSEIB)
2011-2013 Device development based on new power electronic technologies such as Silicon Carbide, diamond etc. Advanced control methods and new convertor topologies. Models of power electronics converters.
Close co-operation with task 6.3

Task 1.5 Environmentally- friendly solutions (ABB, UU, KTH)
Start Q4 2011. 2011 –Pre-study will be initiated on ways to reduce, eliminate or significantly reduce SF6, dry-type components that eliminate use of insulating oil, low noise (sound) equipments.

Task 1.6 Achieving power quality (AGH-Poland [Zbigniew Hanzelka], UPC-Iberia, UPC-ETSEIB KTH,ABB)
2011 Pre study to be initiated on the impact of distributed generation on power quality. power converters as active filters or active components, and integrating renewable not only from power injection point of view, but as an active power source that can increase grid power quality.

Task 1.7 Integration of sensors with the power components (UU, KTH, ABB).
Adaptation of wireless sensor for inclusion in the power component design. The sensors are used for monitoring the operation of the components not being tracked and transmitted by wired sensors. The sensors has to be closely integrated and designed for operation in an EM and physically hostile environment

(Due to the reduced budget during 2011, UU will not be working with WP 1 during 2011, 2012 One PhD student will be recruited by UU.)

**Links to KIC InnoEnergy Strategy:**
Exploitation: Links to innovation system

Education: Several of the projects will be run as project groups around PhD students. The general knowledge gained from the projects will be fed back to the MSc course in Smart Grids. Coupling to PhD School in Smart Electric Grid and Storage and Masters program in Smart Grids.

**Milestones:**

M 1.1 (Q4 2011) Model for transformer loadability vs DC magnetisation
M 1.2 (Q4 2012) Protype developed of *Fast medium voltage load current and fault current commutation device*
M 1.3 6 MSc/PhD students to labour market by 2013
M1.4 1 new product /service by 2013
M 1.5 1 European patent by 2013

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| M 1.6 1 licentiate thesis, 1 PhD student<br>M 1.7 10 Scientific publications by 2013 |
| **Deliverables/Outcome KPI:**<br><br>D 1.1 6 MSc/PhD students to labour market by 2013<br>D 1.2 1 new product /service by 2013<br>D 1.3 1 European patent by 2013<br>D 1.4 1 licentiate thesis, 1 PhD student<br>D 1.5 10 Scientific publications by 2013 |

| WORK PACKAGE DESCRIPTION | WP No | 2 |
|---|---|---|
| Work package Title | Power Componet Monitoring and Diagnostics | |
| Institution(s):<br><br>Contact person (s) | **Lead:** **KTH, Hans Edin,** hans.edin@ee.kth.se<br>**Participants:**<br>**ABB,** Robert.Saers@se.abb.com<br>**UPC-Iberia, Daniel M. Miracle,** daniel.montesinos@upc.edu<br>UPC-ETSEIB, Juan A. Martinez-Velasco, martinez@ee.upc.edu<br>**KU Leuven-Benelux, Tom De Rybel,** tom.derybel@esat.kuleuven.be<br>**AGH-Poland, P. Piatek**<br>**KIT-Germany,** Thomas Leibfried, Thomas.Leibfried@kit.edu<br>**Eandis-Benelux,** Edwin.Haesen@eandis.be | |

**Objectives:**

The risk-of-failure of a power component is to a large extent related to local degradation phenomena in the materials of which the component is designed. The objectives with the projects in this work package is to develop methods that can monitor the required signals and then with the existing knowledge of the relation between signal response and material properties define innovative diagnostic methods that can be useful in prognostics of the risk-of-failure and speed of degradation. The route towards the goals goes through a number of projects. Task 2.1 deals with the devices used to sense the required signals and Task 2.2 concerns the complete network of sensing devices and possible wireless communication between sensor and other units. Task 2.3 will develop a framework to handle insulation diagnostics by input stimuli from different natural (or controlled) transients that can be used as input stimuli in an insulation diagnostic framework. The objective of Task 2.4 is to develop methods for diagnostics of winding structures in transformers and generators.

**Work plan and distribution of tasks** (including timing of tasks):

Task 2.1 Smart sensing devices (KTH/ETK, ABB, KU- Leuven, Eandis-Benelux)

2011 Pre-study on non-contact high voltage current and voltage measurement, Energizing sensors and actuators on high electric fields, Optical fiber-based sensors, Microwave antennas and acoustics for transformer diagnostics

2011 Pre-study completed on the fundamental aspects for using microwave antennas for diagnostics of power transformers (KTH, Norgren and Edin). 2 MSc students delivered

Task 2.2 Sensor networks and communications (KTH, UPC-Iberia)

Start Q3 2011. Automation and sensor networking using industrial buses

Task 2.3 Development of novel methods for on-line insulation diagnostics(KTH, ABB, KIT-Germany, Eandis-Benelux, UPC-ETSEIB)

2010 One PhD student will be recruited with the aim to work on developing a method that can utilise natural transients as stimuli for on-line dielectric response.

2012 First prototype system developed for on-line natural transient diagnostics based on a specific

power component.
2012 One Licentiate thesis (Mohammad Ghaffarian Niasar) presented on partial discharge diagnostics on power transformers.
2013 1 Licentiate thesis on method for natural transients
2011-2013 Three MSc students delivered on these topics

Task 2.4 Magnetic apparatus diagnostics (KTH, UPC-Iberia, KIT-Germany, UPC-ETSEIB)
2011 One PhD student finished on Frequency response analysis on transformers

Task 2.5 Real-time state estimation (KTH, ABB, AGH-Poland, Eandis-Benelux)
Real-time state estimation using controlled low-level introduction of disturbance or known existing signals. Robustness and cyber-security of monitoring systems for power networks.

**Links to KIC InnoEnergy Strategy:**

Exploitation: Links to innovation system

Education: Several of the projects will be run as project groups around PhD students. The general knowledge gained from the projects will be fed back to the MSc course in Smart Grids. Coupling to PhD School in Smart Electric Grid and Storage and Masters program in Smart Grids.

**Milestones:**

M2.1 Device for non-contact measurement of voltage and currents on high voltage lines. Prototype (Q4 2012)

M2. 2 Device for power harvesting from electromagnetic fields around lines to power sensors. Prototype Q4 2012)

M2. 3 Develop on-line system for detecting response to components to transients and relating it to certain deterioration mechanisms of components. Method provided (=instrumentation + model), Q3 2012.

M2.4 Model suitable for FRA analysis on power transformers (Q3 2011)

M2.5 A developed strategy for how and when to perform controlled disturbances for state estimation. (Q3 2013)

M 2.6 6 MSc/PhD students to labor market by 2013
M2.7 1 new product /service by 2013
M 2.8 1 European patent by 2013
M 2.9 1 licentiate thesis, 1 PhD student
M 2.10 10 Scientific publications by 2013

**Deliverables/Outcome KPI:**

D 2.1 6 MSc/PhD students to labor market by 2013
D 2.2 1 new product and 1 service by 2013
D 2.3 1 European patent by 2013
D 2.4 1 licentiate thesis, 1 PhD student
D 2.5 10 Scientific publications by 2013

| WORK PACKAGE DESCRIPTION | WP No | 3 |
|---|---|---|
| **Work package Title** | Power Asset Management | |
| **Institution(s):**<br><br>**Contact person (s)** | KTH, Patrik Hilber, patrik.hilber@ee.kth.se<br>ABB, Robert Saers<br>Fortum<br>Vattenfall<br>SvK<br>Eandis-Benelux<br>UU, Marcus Lindahl<br>Seabased | |

**Objectives:**
Power asset management is about utilizing existing resources as good as possible. With the development of more smart devices for diagnostics and local grid smartness it becomes important to identify where to deploy/invest and where to not. This involves the use and development of methods for risk and reliability optimization, identification of critical components, lifetime estimates, and dynamic rating. This should be combined with economical methods and information to ensure that the methods work towards an optimal utilization with respect to all involved partakers.

It is important to note that this work package to a major extent will deliver methods, knowledge, education and a relatively high possibility of startups. The potential for patents is mainly restricted to the topic of dynamic rating.

**Work plan and distribution of tasks** (including timing of tasks):

<u>Task 3.1 Dynamic rating of components (ABB, KTH, Eandis-Benelux)</u>
Robert Saers, Patrik Hilber, Fredrik Carlsson,

Dynamic rating of components can help us utilize the power system more efficiently. The main questions address the overloading capability of components in different magnitudes of time in relation to how much the lifetime/reliability is reduced. In addition it is interesting to use results from diagnostics to reduce loading capabilities in order to keep a safe margin against outages caused by degraded components, while not necessitate an immediate replacement of the component. The topic builds on the following competence areas; sensors, diagnostics and life time modeling.

3.1.1 Economic value of dynamic rating of components (Patrik Hilber)
3.1.2 Short-term overloading capacity of components vs lifetime (Robert Sears)
3.1.3 Lifetime modeling and management of transformers, ongoing (Johanna Rosenlind)

2011 Method developed for establishing the potential benefits of dynamic rating.

2011 Licentiate thesis defense on lifetime modeling and management of transformers
2014 PhD thesis on lifetime modeling and management of transformers

Task 3.2 Reliability/Cost estimation  (KTH, ABB, SvK, Vattenfall, Fortum, UU, Seabased)
Patrik Hilber, Mikael Dahlgren, Georgios Demetriades, Tommie Lindquist, Fredrik Carlsson, Olle Hansson, Marcus Lindahl
Close cooperation with Task 6.2.

To find the right level of risk and reliability to the right cost is as important as it is difficult. One of the major problems is to identify expected probabilities and risks. The introduction of Smartgrids constitutes both a challenge and an opportunity. The challenge is to make the power system "smart" in the right way, only implementing these solutions where beneficial and aiming for simple constructions elsewhere. The opportunity is to be able to deliver better system performance at relatively low cost. Not only does this raise questions of optimization, but also questions related to strategy and business model development. A central question is how to strategically merge new utility systems with "aging" assets, from a technological, but also from an economic and strategic point of view. Procedures and business models will have to adequately cope with the new blend of technologies – indicating new modes of cooperation between stakeholders, and rearrangements of existing value chains.

3.2.1 Right level of risk and external disturbance (Patrik Hilber, Daniel Månsson)

3.2.2 Short-term asset management – Business models & strategy (Marcus Lindahl)

3.2.3 Long-term asset management– Business models & strategy (Marcus Lindahl)

2010/2011 PhD Student recruitment

2011 Method developed for evaluation of external disturbances with unknown probabilities against traditional asset management strategies

2011 Method development for evaluating Business models & strategy including constraints of new technologies and new value chains in utility sector

2013 Licentiate thesis on power asset management optimization

2013 Licentiate thesis on Business models & strategy - Technological, economic and strategic constraints for asset management with new & old technologies

(2015 PhD Thesis Business models & strategy - Technological, economic and strategic constraints for asset management with new & old technologies

Task 3.3 Distributed Generation and storage investment (KTH, ABB, SvK, Vattenfall, Fortum,UU)

Patrik Hilber, Reza Muhammad, Fredrik Carlsson, Olle Hansson

With the introduction of more distributed generation and temporary storage a number of questions arise. For example:
Where to allocate these units for best benefit/lowest cost?
How much does the network need to be reinforced?
How will the reliability importance of components in the network be altered?
How to perform investments in an optimal way?

One thing is clear; with large investments in these units the power system will change. Components that before were critical should stand back for investments in local energy sources.

3.3.1 Life-cycle cost analysis of storage and distributed generation
3.3.2 Risk and reliability optimization with storage and distributed generation

2010/2011 PhD Student recruitment Life-cycle cost analysis of storage and distributed generation
2010/2011 PhD Student recruitment Risk and reliability optimization with storage and distributed generation

2012 Licentiate thesis defense Life-cycle cost analysis of storage and distributed generation
2013 Licentiate thesis defense Risk and reliability optimization with storage and distributed generation

2012 One PhD student will be recruited by UU.

Task 3.4 Reliability and maintenance in windpower farms (KTH, ABB, Vattenfall, Fortum):

**Links to KIC InnoEnergy Strategy:**

Exploitation: Links to innovation system

Education:
Reliability Evaluation of Electrical Power Systems - Course
The students learn to use reliability analysis as a tool for decision support during design, operation and maintenance of electric power systems. The application studies are focused on real world electrical distribution systems.

**Milestones:**

M3.1 Method to determine economic value of dynamic rating of key components in the grid (Q4 2012)
M3.2 Method to determine overload cycle of components without affecting lifetimes (Q4 2012)
M3.3 Method to determine economic value of on-line diagnostic capability for components (Q4 2012)
M 3.4First patent application in dynamic rating, 2012
M 3.5 Workshop on power asset management, 2012
M 3.6 Startup of consultancy company based on developed methods, 2014

**Deliverables/Outcome KPI:**

D 3.1 6 MSc/PhD students to labour market by 2013
D 3.2 1 new product /service by 2013
D 3.3 1 European patent by 2013
D 3.4 1 licentiate thesis, 1 PhD student
D 3.5 10 Scientific publications by 2013

| WORK PACKAGE DESCRIPTION | WP No | 4 |
|---|---|---|

| | |
|---|---|
| **Work package Title** | Components for relaying and protection |
| **Institution(s):**<br><br>**Contact person (s)** | Lead: KTH, Hans-Peter Nee, hansi@kth.se<br>Particpants:<br>ABB, Jianping Wang, , @se.abb.com<br>ABB, Lars.Liljestrand@se.abb.com<br>AGH-Poland, Krzysztof Kołek<br>UPC-Iberia, Daniel M. Miracle<br>Tecnalia-Iberia, Susana Apiñániz, apinaniz@robotiker.es<br>UPC-ETSEIB, Juan A. Martinez-Velasco, martinez@ee.upc.edu<br>SvK, Stefan Arnborg<br>Vattenfall, |

**Objectives:**

Achieve high level of robustness and security of power grid by developing and deploying novel relaying and protection technologies.

**Work plan and distribution of tasks** (including timing of tasks):

Task 4.1 Extremely fast fault detection (ABB, KTH, UPC-ETSEIB))

Algorithms for fault prediction and identification
Short circuit detection and protection using power electronic converters
Real-time frequency estimation of distorted grid

Task 4.2 Reconfigurable high-speed hardware controllers for energy conversion and monitoring (AGH-Poland, KTH, ABB)

Task 4.3 Surge and current limitation (KTH, SvK, Vattenfall, ABB, UPC-ETSEIB))

Distributed generation creates new problems and EMC challenges for the future producers-consumers. Surge protection, overvoltage and current limitation have to be adopted to protect connected intelligent power components, limit spread of disturbances and for safety reasons. The complexity of the evolving grid requires robustness through protection technologies to ensure operative efficiency. In addition, the possible effect of geomagnetically induced currents and Intentional electromagnetic interference will increase with more sensitive and sophisticated control systems. Protection against these can however not be limited to traditional EMC solutions alone.

**Links to KIC InnoEnergy Strategy:**

Exploitation: Links to innovation system

| |
|---|
| Education: Several of the projects will be run as project groups around PhD students. The general knowledge gained from the projects will be fed back to the MSc course in Smart Grids. Coupling to PhD School in Smart Electric Grid and Storage and Masters program in Smart Grids. |
| **Milestones:**<br><br>M 4.1 Fast fault current detector on sub-millisecond scale. Prototype (Q42013) |
| **Deliverables/Outcome KPI:**<br><br>D 4.1 4 MSc/PhD students to labour market by 2013<br>D 4.2 1 new product /service by 2013<br>D 4.3 1 European patent by 2013<br>D 4.4 1 licentiate thesis, 1 PhD student<br>D 4.5 5 Scientific publications by 2013 |

| WORK PACKAGE DESCRIPTION | WP No | 5 |
|---|---|---|
| Work package Title | Integration and interaction of power components | |
| Institution(s):<br><br>Contact person (s) | Lead: KTH, Nathaniel Taylor<br>Particpants:<br>ABB, Lars.Liljestrand@se.abb.com<br>KTH, Lennart Söder, lennart.soder@ee.kth.se<br>KTH, Nathaniel Taylor, nathaniel.taylor@ee.kth.se<br>Tecnalia-Iberia, Susana Apiñániz, apinaniz@robotiker.es<br>UPC-Iberia, Juan A. Martinez-Velasco, martinez@ee.upc.edu | |

**Objectives:**

**Dynamic and transient behavior of individual power components under various operating conditions has impact on other power components in the grid. Objective is to understand and model this interaction and thereby minimize unfavourable mutual impact.**

**Work plan and distribution of tasks** (including timing of tasks):

Task 5.1 Minimizing impact of transient events (ABB, KTH, Tecnalia-Iberia, UPC-Iberia)
Start Q1 2012.
The topics in this task is to deal with fast short-circuit handling and controlled power switching to minimize transients.
The purposes are:
1. utilizing the models developed in WP1 and the algorithms in WP4 to verify:
• system benefits
• reduced stress on the system components
2. to give input on system requirements to the other WP:s
The work will consist of computer system simulations.
1. The system simulations in this case is defined as the interaction of two or more components in limited parts of a larger system.
2. The simulations will be based on detailed models of the components.
Examples of activities are sub work packages :
5.1.1 Fast short-circuit handling
Reduced stress and limited damages on system components and minimizing the duration of voltage dips in the system utilizing switch models from WP1.2 and algorithms for fast fault detection from WP4.1
5.1.2 Controlled power switching to minimize transients
Ex. Synchronized energizing of transformers utilizing models from WP1.1 & WP1.2 for minimizing system voltage disturbances and reduced stress on the transformers.

Task 5.2 Adaptive self-healing solutions (ABB, KTH, Tecnalia-Iberia)
Start Q1 2012
Task 5.3 System impact assessment due to dynamic loading (ABB, KTH, Tecnalia-Iberia, UPC-ETSEIB))
Start Q1 2012

| |
|---|
| **Links to KIC InnoEnergy Strategy:**<br><br><u>Exploitation:</u> Links to innovation system<br><br><u>Education:</u> Several of the projects will be run as project groups around PhD students. The general knowledge gained from the projects will be fed back to the MSc course in Smart Grids. Coupling to PhD School in Smart Electric Grid and Storage and Masters program in Smart Grids. |
| **Milestones:**<br><br><u>M 5.1</u> Simulation model for analysis of impact of transients (Q4 2013) |
| **Deliverables/Outcome KPI:**<br><br><u>D 5.1</u> 4 MSc/PhD students to labour market by 2013<br><u>D 5.2</u> 1 new product /service by 2013<br><u>D 5.3</u> 1 European patent by 2013<br><u>D 5.4</u> 1 licentiate thesis, 1 PhD student<br><u>D 5.5</u> 5 Scientific publications by 2013 |

| WORK PACKAGE DESCRIPTION | WP No | 6 |
|---|---|---|

| | |
|---|---|
| **Work package Title** | **Submerged Controllable Power Devices** |
| **Institution(s):**<br><br>**Contact person (s)** | Lead: Cecilia Boström, cebo@angstrom.uu.se<br><br>Participants:<br><br>Seabased, Erik Lejerskog<br>Fortum – Thomas Wall<br>Vattenfall – Silva<br>ABB – Birger Drugge<br>KTH-Thottappillil<br>UU, Magnus Rahm, magnus.rahm@angstrom.uu.se, Anders Alhén anders.alhen@angstrom.uu.se |

**Objectives:**
**Marine substations give the possibility to have power components in electrical systems submerged. This could be beneficial where there are limitations for onshore installations and is an alternative to platforms for offshore installations. Marine substations are today suggested and used for wave power farms and marine power farms. The components used in the marine substation should be able to withstand harsh marine environment, to be ecologically friendly, to be highly controllable, and should have low maintenance requirements.**

**Objectives:**
**Marine substations give the possibility to have power components in electrical systems submerged. This could be beneficial where there are limitations for onshore installations and is an alternative to platforms for offshore installations. Marine substations are today suggested and used for wave power farms and marine power farms. The components used in the marine substation should be able to withstand harsh marine environment, to be ecologically friendly, to be highly controllable, and should have low maintenance requirements.**

Work plan and distribution of tasks (including timing of tasks):

Task 6.1 AC/DC/AC IV magnetic controller (UU, KTH, Seabased, ABB, Fortum)
Close cooperation with Tasks 1.1, 1.2.
At several places in the grid there are requirements for regulation of voltage and active/reactive effect. Voltage regulation could be made by using tapchangers. Depending on application and regulation requirements, different solutions could be suitable.
To have the possibility to control reactive/active power in the grid increases the power quality and flexibility of the grid. The control can be performed by installing intelligent reactors and capacitors and

also by using an AC/DC/AC-conversion system between the generating units and grid.
The study includes simulations and full scale test in marine substation where the operation performance and reliability of the components are evaluated.
For many renewable energy systems control of the power is required between the generator and grid-connection point to optimize the power production. This could be done by controlling the DC-bus voltage in different ways.

6.1.1 Hybrid systems tapchangers (UU + Seabased)
2011 Simulations and laboratory test of different tapchangers. Evaluation of possible problems at different load conditions.
2011-2012 Test of developed tapchanger systems in grid connected marine sub-station.
2011 One PhD will be recruited regarding the tapchanger system.

6.1.2 Submerged intelligent reactors and capacitors (UU + KTH + ABB)
2012 Simulations of grid quality and flexibility improvements by using intelligent reactors and capacitors installed at sites where it would be suitable to use marine substations.
2012-2013 Test of components, where the performance of the main task is evaluated by testing the components submerged at desirable sites.
2012 One PhD will be recruited regarding the simulations and test of the system.

6.1.3 Direct IGBT control systems (UU + Seabased)
2011-2013 Test of different grid-connected IGBT inverters in marine substations for wave power. Evaluating performance and reliability of the control system and inverter, the ability to control reactive/active power, different cooling possibilities for the components.
2011 One PhD will be recruited to further develop IGBT control system for grid connected inverters.

6.1.4 LVDC bus control (UU)
2011-2013 test of different LVDC-bus controls in a marine substation for wave power and current power and find the optimum control for the different power plants.
2011 One PhD will be recruited to study different systems.

6.1.5 Novel rectifiers (UU + Seabased)
2012-2013 test and evaluation of novel rectifiers in a marine substation for wave power and in a system for marine power.
2012 One PhD will be recruited to test and analyze different rectifier bridges.

<u>Task 6.2 Maintenance/reliability studies /marine environment (UU + Seabased + ABB +Vattenfall + Fortum). Close cooperation with Task 3.2.</u>
Three main areas to study when using marine substations are the maintenance requirements, the reliability and environmental impact of a submerged system. Since this is a novel system these areas must be evaluated to determine its pros and cons compared to other solutions and these areas plays a significant role in the future developments of the system. The most efficient way to investigate the areas is to do experiments under real conditions. It is also important to have good knowledge of the components and to perform accurate risk assessments of the systems. The marine substations installed by UU and Seabased will be used in the study which will be carried out during the entire period (2011-2013).

6.2.1 Overloadability
6.2.2 Maintainability
6.2.3 Reliability

2012 One PhD will be recruited to study the areas.

Task 6.3 Low maintenance AC/ DC control (UU +KTH)
Close cooperation with Task 1.4.

6.3.1 Diamond electronics (UU)
The emerging technology of new wide-bandgap materials such as silicon Carbide Gallium Nitride and Diamond are expected to yield a whole class of new power semiconductors with low losses, low cooling and low maintenance requirements; in particular this is true for the most extreme material in the class, i.e. diamond. Therefore it is important to study how to utilize the emerging technology of diamond diodes and FETs to reduce the total losses and improve reliability in the electric system involving oceanic electric generators, transmission systems and connection to the grid. The task involves detailed device simulations of diamond devices implemented in converter systems as well as the testing of demonstrator devices in marine substations installed by UU and Seabased.

2012 One PhD will be recruited to simulate and test the diamond devices in marine substations.

6.3.2 Low complexity electromagnetic power devices (UU+KTH)
2012 One PhD will be recruited on the area

Task 6.4 Submerged energy storage [UU]
Electric power production utilized from renewable energy sources will have a varying power production and can in some cases require energy storage. The fluctuation in power production can both have an impact on the efficiency of the electrical conversion system and on the grid quality. Therefore, it is important to study to witch extent these fluctuations can be/needs to be reduced to ensure a good power quality that both meets the grid demands and make the electrical system more efficient. An energy storage system can also be installed to compensate for rapid power changes in loads.
The purpose is to investigate two different submerged energy storage systems. One consisting of a novel flywheel and the other consisting of batteries. The proposed flywheel has its novelty based on the two set of windings, electrically separated from each other, which divides the system in two voltage/power levels. That allows the flywheel to handle input and output power completely independently.

2012 One PhD will be recruited to analyze and test different energy storage devices in marine substation applications.

6.4.1 Flywheel storage
2012 Simulations of a flywheel in a wave power plant and in a marine current plant. The purpose of the simulations amongst others is to decide how the flywheel should be rated in relation to the power fluctuations, and where in the system the flywheel should be placed.
2013 Construct a flywheel system for submerged operation.
2013 Test the submerged flywheel system.

6.4.2 Battery storage

Task 6.5 Submerged communication (UU, Anders Alhén)

6.5.1 Internal submerged system
Submerged communication has similarities and differences compared to communication above sea level. The enclosure of the switchgear is most likely to be of material that is electrically and magnetically shielded. This could be beneficial for communication inside each switchgear but act as a barrier for communication between units in the submerged system. Another obstacle for communication between units is the water itself. If metal (a cable) is used as the communication medium corrosion is a big problem. If fiber optics is used reliable contacting might be a problem. If water is used as the communication medium the bandwidth and range might be a limiting factor. Communication on the electric distribution cable is possible but failure modes must be taken in to consideration if this medium is used.
6.5.2 Noise immunity
6.5.3 Wireless underwater VLF communication of sensordata

2011 One PhD will be recruited to study submerged communication systems.

**Milestones:**

M 6.1 Tapchanger systems in grid connected marine sub-station, 2012.

M 6.2 Prototype submerged flywheel storage system

**Deliverables/Outcome KPI:**

D 6.1 6 MSc and PhD students to labour market by 2013
D 6.2 1 new product /service by 2013
D 6.3 7-8 European patent by 2013
D 6.4 4 licentiate thesis, 1 PhD student by 2013
D 6.5 10 Scientific publications by 2013

| WORK PACKAGE DESCRIPTION | WP No | 7 |
|---|---|---|
| **Work package Title** | Intelligent communicating power devices | |
| **Institution(s):**<br><br>**Contact person (s)** | Lead: Grenoble InP- Alps Valley,<br>Marie-Cécile Alvarez-Hérault/Raphael Caire, alvarez@g2elab.grenoble-inp.fr<br>raphael.caire@g2elab.grenoble-inp.fr<br>Schneider Electric ?- Alps Valley<br>Participants:<br>UPC-ETSEIB, Juan A. Martinez-Velasco, martinez@ee.upc.edu<br>UPC, Daniel Montesinos i Miracle,daniel.montesinos@upc.edu<br><br>KTH, Karl Henrik Johansson | |

**Objectives:**
Smart Grids requires advanced intelligent components able to transmit valuable data for the optimal operation of the electrical system. Those components, which can process locally the data from in-field sensors, have to communicate with centralized or dispersed intelligence (or control center). Indeed, it could enable the enhancement (best use) of the assets and the advanced distribution automation (ADA) functions such as voltage profile management, power losses minimization and self healing. These novel operation functions, in real time, can be also improved while using a well fitted architecture and the optimal location of such devices.

**Work plan and distribution of tasks** (including timing of tasks):

Task 7.1 Development of intelligent and communicating Fault Passage Indicators (KTH, INP-G UPC-ETSEIB))
Fault Passage Indicators have to evolve towards more intelligent and communicating indicators. Current fault indicators only give the information of the presence of a fault and give, more often, a local information. But the increase of distributed generation and the development of ICTs lead to improve them. It will contribute to the creation of advanced network functionalities (self healing, power flow optimization and so on).

Task 7.2 Medium performance Communicating decentralized protection (KTH, INP-G)
New communicating decentralized protections have to be developed to create self-healing areas able to secure each other. These automatic devices need to be adapted to bidirectional power flows induced by the presence of distributed generation. It will increase the reliability of the network, improving the stability of distributed generators that may be responsible of ancillary services to the grid.

Task 7.3 High performance Communicating decentralized protection (KTH, INP-G)
New communicating decentralized protections can be easily embedded into the grid and provide a very efficient protection scheme. Indeed, thanks to standards such as IEC 61850 and goose communication with latency as low as 2 to 5 ms in addition with advanced algorithms to cope with distribution network particularity, local area of Meshed (new architectures) Smartgrids can be protected. These new

protection schemes may largely improve the reliability of distribution networks in presence of Distributed Energy Resources.

Task 7.4 Planning of Smart Grids architectures
In order to implement ADA functions within a smarter network, intelligent power devices have to be optimally located within the network. Reliability and efficiency of these devices can be improved while coordinating them in a system point of view. The development of planning algorithms for the best use of ADA functions will decide both the number of protections and their location it the network taking into account the difference of shelf life (communicating protections, lines, transformers…).
The

**Links to KIC InnoEnergy Strategy:**
Exploitation: Links to innovation system

Education: Several of the projects will be run as project groups around PhD students. The general knowledge gained from the projects will be fed back to the MSc course in Smart Grids. The general knowledge gained from the projects will be fed back to the MSc course in Smart Grids. Coupling to PhD School in Smart Electric Grid and Storage and Masters program in Smart Grids.

**Milestones:**

M 7.1 *Planning algorithm for smart grid architecture, 2012*

**Deliverables/Outcome KPI:**

D 7.1 6 MSc and PhD students to labour market by 2013
D 7.2 1 new product /service by 2013
D 7.3 1 European patent by 2013
D 7.4 1 licentiate thesis, 1 PhD student
D 7.5 10 Scientific publications by 2013

## 4. WORKPACKAGE ORGANISATION

Figure Workpackage interdepencies:

| | WP0 | WP1 | WP2 | WP3 | WP4 | WP5 | WP6 | WP7 | |
|---|---|---|---|---|---|---|---|---|---|
| WP0 | x | x | X | x | x | x | x | x | |
| WP1 | x | x | 2.1,2.2 1.1,1.7 | 3.1, 1.7 | 4.1, 1.4, 4.3, 1.2 | 5.1, 1.1, 1.2, 1.4 | 6.1, 1.1, 1.2, 6.3, 1.4 | 1.7 | |
| WP2 | x | 2.1,2.2 1.1,1.7 | X | 3.1, 2.3 | | | | 2.2 | |
| WP3 | x | 3.1, 1.7 | 3.1, 2.3 | x | | | 6.2, 3.2 | | |
| WP4 | x | 4.1, 1.4, 4.3, 1.2 | | | x | 5.1, 4.1 | | | |
| WP5 | x | 5.1, 1.1, 1.2, 1.4 | | | 5.1, 4.1 | x | | | |
| WP6 | x | 6.1, 1.1, 1.2, 6.3, 1.4 | | 3.2, 6.2 | | | x | | |
| WP7 | x | 1.7 | 2.2 | | | | | x | |

**SCHEDULE**

Note! Almost all activities involoves a PhD student and therefore all PhD projects started in 2010 and afterwards will run during the whole period.

| | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task/Milestones** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** |
| T1.1 Power Component design | | | | | | | | | | | | |
| M 1.1 Model | | | | x | | | | | | | | |
| Task 1.2 Switching devices and actuators | | | | | | | | | | | | |
| M 1.2 Protype | | | | | | | | x | | | | |
| Task 1.3 Electromagnetic compatibility | | | | | | | | | | | | |
| Task 1.4 Novel power electronics | | | | | | | | | | | | |
| Task 1.5 Environmentally-friendly solutions | | | | | | | | | | | | |
| Task 1.6 Achieving | | | | | | | | | | | | |

| | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task/Milestones** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** |
| power quality | | | | | | | | | | | | |
| Task 1.7 Integration of sensors with power components | | | | | | | | | | | | |
| Task 2.1 Smart sensing devices | | | | | | | | | | | | |
| M2.1 . Prototype | | | | | | | | x | | | | |
| Task 2.2 Sensor networks and communications | | | | | | | | | | | | |
| M2. 2 Prototype | | | | | | | | x | | | | |
| Task 2.3 Development of novel methods for on-line insulation diagnostics | | | | | | | | | | | | |
| M2. 3 Method provided (=instrumentation + model) | | | | | | | x | | | | | |
| Task 2.4 Magnetic apparatus diagnostics | | | | | | | | | | | | |
| M2.4 Model FRA anal. | | | x | | | | | | | | | |
| Task 2.5 Real-time state estimation | | | | | | | | | | | | |
| M2.5Proposed strategy | | | | | | | | | | | x | |
| Task 3.1 Dynamic rating of components | | | | | | | | | | | | |
| M3.1 Method Dyn. rating | | | | | | | | x | | | | |
| Task 3.2 Reliability/Cost estimation | | | | | | | | | | | | |
| M3.2 Method ext. disturbances | | | | | | | | x | | | | |
| Task 3.3 Distributed Generation and storage investment | | | | | | | | | | | | |
| M3.3 Method LCC storage and distr. gen | | | | | | | | x | | | | |
| Task 4.1 Extremely fast fault detection | | | | | | | | | | | | |
| M4.1 Protype | | | | | | | | | | | | x |
| Task 4.2 Reconfigurable high-speed hardware controllers for energy conversion and monitoring | | | | | | | | | | | | |
| Task 4.3 Surge and | | | | | | | | | | | | |

| | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task/Milestones** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** |
| current limitation (KTH, SvK, Vattenfall, ABB, UPC-ETSEIB)) | | | | | | | | | | | | |
| Task 5.1 Minimizing impact of transient events | | | | | | | | | | | | |
| M 5.1 Model | | | | | | | | | | | | x |
| Task 5.2 Adaptive self-healing solutions | | | | | | | | | | | | |
| Task 5.3 System impact assessment due to dynamic loading | | | | | | | | | | | | |
| Task 6.1 AC/DC/AC IV magnetic controller | | | | | | | | | | | | |
| M 6all Simulations and protypes, of some number | | | | | | x | x | x | x | x | x | x |
| Task 6.2 Maintenance/reliability studies /marine environment | | | | | | | | | | | | |
| Task 6.3 Low maintenance AC/ DC control | | | | | | | | | | | | |
| Task 6.4 Submerged energy storage | | | | | | | | | | | | |
| Task 6.5 Submerged communication | | | | | | | | | | | | |
| M 6.1 tapchanger systems in grid connected marine sub-station, 2012. | | | | | | | | X | | | | |
| M 6.2 Prototype submerged flywheel strorage system | | | | | | | | | X | | | |
| Task 7.1 Development of intelligent and communicating Fault Passage Indicators | | | | | | | | | | | | |
| M 7.1 *Planning algorithm for smart grid architecture, 2012* | | | | | | | | X | | | | |
| | | | | | | | | | | | | |
| Task 7.2 Medium performance Communicating decentralized protection | | | | | | | | | | | | |
| Task 7.3 High performance | | | | | | | | | | | | |

| | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task/Milestones** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** |
| Communicating decentralized protection | | | | | | | | | | | | |
| Task 7.4 Planning of Smart Grids architectures | | | | | | | | | | | | |

## 5. *BUDGET BREAKDOWN*

(Note: Firm figures for in kind contribution is not available from all partners. When it is absent, it is estimated by the following rough method. Participation in each task is valued as 25 k€ in kind contribution (25% time) of one person for non-academic partners and 25 k€ in kind of one person (25 %) plus one PhD student (70 k€) in kind for academic partners. Equipment use is valued as 10-20% of personnel+PhD costs)

| Institution | Own funding [k€] ("in kind contribution") | | | | | Requested KIC funding [k€] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Type** | **2011** | **2012** | **2013** | **Total own** | **2011** | **2012** | **2013** | **Total KIC** |
| *ABB (CC Sweden)* | *ABB: Personnel* | 200,00 | 200,00 | 200,00 | 600,00 | | | | |
| | ABB: Equipment | 40,00 | 40,00 | 40,00 | 120,00 | | | | |
| | KTH/ABB: PhD New | 50,00 | 65,00 | 125,00 | 240,00 | | | | |
| | KTH/ABB: ongoing PhD | 74,00 | 60,00 | | 134,00 | | | | |
| **ABB Total** | | **364,00** | **365,00** | **365,00** | **1094,00** | **25,70** | **121,67** | **121,67** | **208,20** |
| KTH (CC Sweden) | KTH: Personnel | 600,00 | 600,00 | 600,00 | 1800,00 | | | | |
| | KTH:Equipment | 240,00 | 240,00 | 240,00 | 720,00 | | | | |
| | KTH: PhD | 1680,00 | 1680,00 | 1680,00 | 5040,00 | | | | |
| | KTH: Project coordination | 40,00 | 40,00 | 40,00 | 120,00 | | | | |
| **KTH Total** | | **2560,00** | **2560,00** | **2560,00** | **7680,00** | **287,50** | **853,33** | **853,33** | **1728,00** |
| Vattenfall (CC Sweden) | Vattenfall:Personnel | 125,00 | 125,00 | 125,00 | 375,00 | | | | |
| | Vattenfall:Equipment | | | | | | | | |
| **Vattenfall Total** | | **125,00** | **125,00** | **125,00** | **375,00** | **8,80** | **41,67** | **41,67** | **71,30** |
| UU (CC Sweden) | UU:Personnel | 102,00 | 300,00 | 300,00 | 702,00 | | | | |
| | UU:Equipment | 38,00 | 112,50 | 112,50 | 263,00 | | | | |
| | UU: PhD | 229,50 | 675,00 | 675,00 | 1579,50 | | | | |
| **UU Total** | | **369,50** | **1087,50** | **1087,50** | **2544,50** | **100,00** | **362,50** | **362,50** | **848,25** |
| Fortum (CC Sweden) | Fortum:Personnel | 100,00 | 100,00 | 100,00 | 300,00 | | | | |

| Institution | Own funding [k€] ("in kind contribution") | | | | | Requested KIC funding [k€] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Type | 2011 | 2012 | 2013 | Total own | 2011 | 2012 | 2013 | Total KIC |
| | Fortum:Equipment | | | | | | | | |
| **Fortum Total** | | **100,00** | **100,00** | **100,00** | **300,00** | **7,00** | **33,33** | **33,33** | **58,50** |
| SvK (CC Sweden) | SvK: Personnel | 75,00 | 75,00 | 75,00 | 225,00 | | | | |
| | SvK: Equipment | | | | | | | | |
| **SvK Total** | | **75,00** | **75,00** | **75,00** | **225,00** | **5,30** | **25,00** | **25,00** | **43,88** |
| *Elforsk (CC Sweden)* | Elforsk: Personnel | 25,00 | 25,00 | 25,00 | 75,00 | | | | |
| ***Elforsk Total*** | | **25,00** | **25,00** | **25,00** | **75,00** | **1,80** | **8,33** | **8,33** | **14,63** |
| *Seabased (CC Sweden)* | Seabased: Personnel | 100,00 | 100,00 | 100,00 | 300,00 | | | | |
| ***Seabased Total*** | | **100,00** | **100,00** | **100,00** | **300,00** | **7,00** | **33,33** | **33,33** | **58,50** |
| AGH (CC Poland+) | AGH:Personnel | 100,00 | 100,00 | 100,00 | 300,00 | | | | |
| | AGH:Equipment | 50,00 | 50,00 | 50,00 | 150,00 | | | | |
| | AGH: PhD | 280,00 | 280,00 | 280,00 | 840,00 | | | | |
| **AGH Total** | | **430,00** | **430,00** | **430,00** | **1290,00** | **30,30** | **143,33** | **143,33** | **251,55** |
| UPC (CC Iberia) | UPC:Personnel | 150,00 | 150,00 | 150,00 | 450,00 | | | | |
| | UPC:Equipment | 100,00 | 100,00 | 100,00 | 300,00 | | | | |
| | UPC: PhD | 420,00 | 420,00 | 420,00 | 1260,00 | | | | |
| **UPC Total** | | **670,00** | **670,00** | **670,00** | **2010** | **47,30** | **223,33** | **223,33** | **391,95** |
| Grenoble INP (CC Alps Valley) | Grenoble INP: Personnel | 100,00 | 100,00 | 100,00 | 300,00 | | | | |
| | Grenoble INP: Equipment | 100,00 | 100,00 | 100,00 | 300,00 | | | | |
| | Grenoble INP: PhD | 350,00 | 350,00 | 350,00 | 1050,00 | | | | |
| **Grenoble INP Total** | | **550,00** | **550,00** | **550,00** | **1650,00** | **38,80** | **183,33** | **183,33** | **321,75** |

| Institution | Own funding [k€] ("in kind contribution") | | | | | Requested KIC funding [k€] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Type** | **2011** | **2012** | **2013** | **Total own** | **2011** | **2012** | **2013** | **Total KIC** |
| KU-Leuven (CC Benelux) | KU-Leuven: Personnel | 25,00 | 25,00 | 25,00 | 75,00 | | | | |
| | KU-Leuven: Equipment | | | | | | | | |
| | KU-Leuven: PhD | 85,00 | 85,00 | 85,00 | 255,00 | | | | |
| **KU-Leuven** | | **110,00** | **110,00** | **110,00** | **330,00** | **7,80** | **36,67** | **36,67** | **64,36** |
| KIT (CC Germany) | KIT: Personnel | 50,00 | 50,00 | 50,00 | 150,00 | | | | |
| | KIT:Equipment | | | | | | | | |
| | KIT: PhD | 140,00 | 140,00 | 140,00 | 420,00 | | | | |
| **KIT Total** | | **190,00** | **190,00** | **190,00** | **570,00** | **13,40** | **63,33** | **63,33** | **111,15** |
| Tecnalia (CC Iberia) | Tecnalia: Personnel | 50,00 | 50,00 | 50,00 | 150,00 | | | | |
| | Tecnalia: Equipment | | | | | | | | |
| **Tecnalia Total** | | **50,00** | **50,00** | **50,00** | **150,00** | **3,50** | **16,67** | **16,67** | **29,25** |
| VITO (CC Benelux) | VITO: Personnel | 25,00 | 25,00 | 25,00 | 75,00 | | | | |
| **VITO Total** | | **25,00** | **25,00** | **25,00** | **75,00** | **1,80** | **8,33** | **8,33** | **14,63** |
| Eandis (CC Benelux) | Eandis: Personnel | 100,00 | 100,00 | 100,00 | 300,00 | | | | |
| **Eandis Total** | | **100,00** | **100,00** | **100,00** | **300,00** | **7,00** | **33,33** | **33,33** | **58,50** |
| IST, Technical University of Lisbon (CC Iberia) | IST: Personnel<br>PhD student: | 50<br>50,00 | 50<br>50,00 | 50<br>50,00 | 150,00<br>150 | | | | |
| **IST Total** | | **100,00** | **100,00** | **100,00** | **300,00** | **7,00** | **33,33** | **33,33** | **58,50** |
| **Total** | | **6067,00** | **6662,50** | **6662,50** | **20117,00** | **600,00** | **2220,83** | **2220,83** | **5067,41** |

| KIC Funding [k€] | 2011 | 2012 | 2013 | | | Total |
|---|---|---|---|---|---|---|
| CC Alps Valleys | 38,80 | 183,33 | 183,33 | | | 405,47 |
| CC Benelux | 16,60 | 78,33 | 78,33 | | | 173,27 |
| CC Germany | 13,40 | 63,33 | 63,33 | | | 140,07 |
| CC Iberia | 57,80 | 273,33 | 273,33 | | | 604,46 |
| CC Poland+ | 30,30 | 143,33 | 143,33 | | | 316,97 |
| CC Sweden | 443,10 | 1479,17 | 1479,17 | | | 3427,18 |
| Total | 600,00 | 2220,83 | 2220,83 | | | 5067,41 |

The KIC funding will be spent on the following items:

- Project management and running of work packages (Task 0.1)
- Joint projects between different CC's
- Lifting of innovations from the projects (Task 0.2)
- Research mobility from CC's within the PhD program connected to the projects (Task 0.3)
- Master's project work across CC:s (Task 0.4)
- Yearly thematic project symposium across all CC's (for dissemination of own and others results and generation of new ideas)

## 6. *OTHER SOURCES OF CO-FUNDING ENVISAGED*

FROM SWEDISH NATIONAL FUNDING AGENCIES TO MATCH KIC FUNDING.