Programme Area: Smart Systems and Heat

Project: Data Management and System Architecture

Title: SSH International ICT Initiatives Report, Review of UK/EU ICT Directives

Abstract:

The envisaged ETI Smart Systems and Heat system will depend on Information and Communications Technology (ICT) for its efficient design, operation and management. The ICT system will need to provide functionality right along the energy delivery chain: from supply to the end consumer. It will also need to support commercial activities such as billing, and to support academic analysis and review of the system during trials and proving. The purpose of Work Area 3 (WA3) is to specify a data architecture that fulfils the information and service requirements of the smart energy system (including data security and privacy). The principal objective achieved within the reports is the identification from other relevant projects of architectural techniques that can be applied to the SSH data architecture design and to identify and assess UK and EU directives, protocols, and legislative initiatives that may impact upon delivery of the SSH Programme.

Context:

This project specified the data system functionality and architecture that would fulfil the information and service requirements of a smart energy system. This included data security and privacy aspects. Hitachi Europe and energy & sustainability consultants DNV Kema worked independently on two £100,000 contracts to identify any data system constraints that need to be incorporated into smart energy systems. The projects were launched in February 2013. The envisaged ETI Smart Systems and Heat system will depend on Information and Communications Technology (ICT) for its efficient design, operation and management. The ICT system will need to provide functionality right along the energy delivery chain: from supply to the end consumer. It will also need to support commercial activities such as billing, and to support academic analysis and review of the system during trials and proving.

ETI Smart Systems and Heat Programme

Data Management and Overall System Architecture WA3 WP1 (Technology Landscape and Outline Functional Specification)

D.H3.1
(Report on International Initiatives)

V1.0

Date: 11th February 2013

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Confidentiality Statement

Executive Summary

Expert analysis of initiatives from around the world informs the SSH ICT architecture

This document forms deliverable D.H3.1 of the Smart Systems and Heat Programme (SSHP) Work Area 3 (WA3) Work Package 1 (WP1) project undertaken by Hitachi Europe Ltd and its subcontractors on behalf of the ETI. This deliverable provides an expert review of selected projects. Together these contain a number of technical aspects that provide valuable insights to inform the design of the ICT architecture for the SSHP pilot. The principal objective achieved within this deliverable is the identification from other relevant projects of architectural techniques that can be applied to the SSH data architecture design. In addition this report provides a useful literature survey of the relevant state-of-the-art that will form a reference for future WA3 WP1 deliverables.

Our experts have identified a number of global initiatives that have relevance to a high performance SSH ICT architecture

A formal analysis methodology based on defined Research Questions is used as the basis of analysis. This methodology permits the analysis of initiatives against defined quality aspects and is based on software engineering best practice. Each initiative is analysed to determine how the designers sought to achieve a specified quality aspect (such as performance or reliability) using known design techniques.

From an initial extensive list of initiatives the following are identified as directly relevant to the SSHP:

- HiPerDNO
- OpenNode
- NIST IR 7628 Smart Grid Cyber Security
- Prototype Island Smart Grid
- Autonomous Decentralised Transport Operation Control System
- Traffic Management System for Kyushu Shinkansen train
- Danish Cell Controller Pilot Project
- M/490 Smart Grid Information Security working group
- EU-Commission Smart Grid Task Force (SGTF)

Together, the design aspects and tactics employed in these initiatives provide a basis for the design of the data management architecture for the SSHP.

The conclusions of this work include the selection of a number of design aspects for an ICT architecture

The analysis of a number of projects from around the world informs the design choices relevant to the SSH ICT architecture. HiPerDNO, OpenNode and the Danish Cell Controller project provide interesting approaches to designing a high performance computing and communications architecture in support of smart distribution networks. Work from NIST and the EU provides guidance on security aspects whilst Hitachi's own experience with management and control systems for bullet trains and mass transit systems gives insight into the design of large scale, high availability transactional processing systems, especially when controlling critical infrastructure. Finally, the integrated island smart grid and low carbon electricity system deployed by Hitachi in Hawaii provides immediately relevant data on the performance and applicability of several aspects of an ICT architecture in support of a consumer-focused system quite similar to SSH.

1 Introduction

1.1 Context

The key objective of Work Area 3 (WA3) is to design a scalable, flexible, reliable and secure ICT system, providing all the data management functionality in support of the ETI's envisaged SSH system. Within WA3, Work Package 1 will enable the ETI to more clearly define the content and outputs for the following two Work Packages. To successfully complete Work Package 1, two strands of activity have been created:

1) The first strand of activity covers an international review of initiatives and projects (hereafter collectively referred to as projects) undertaken in the ICT / Systems Architecture arena, an overview of UK/EU directives, protocols and legislative initiatives that may have an impact on the delivery of Smart Systems, and an outline of the ICT technology roadmap including likely developments out to 2050.

2) The second strand of activity develops an ICT system outline performance specification. It describes performance criteria and indicates flows of information with reference to key stakeholders. The focus is on the needs of both the UK SSHP and the demonstration phase (Phase 2). This strand also develops a ROM budget and timeframe estimates for Phase 2; including billing and system control requirements.

The scope of this deliverable is the analysis of the technology aspects of the first strand of activity.

1.2 Objectives of This Deliverable

1.2.1 Principal Objective

The principal objective of D.H3.1 is to determine the appropriate ICT architecture for the UK SSHP. This is achieved by first creating an extensive list of ICT projects that, in the judgement of the subject matter experts on the WA3 WP1 team, are most relevant to the architecture of a UK SSH implementation. These projects are then analysed to deduce relevant insights. The methodology is described in greater detail in Chapter 3.

1.2.2 Other Objectives

D.H3.1 has a number of other objectives including:

1) A listing of all the relevant projects found together with a summary of the aims and objectives of each and their timeframes and geographical area.

2) For each project, the identification of any common features or overlaps of these projects with the SSH programme and those elements that should be considered in the timeframe of the overall SSH programme.

3) For each project, a summary of the key elements and the scope of the project; the energy system it relates to (heat networks, EV charging, etc.); the key features of the ICT architecture; the scale; cost if available and the companies involved.

2 Methodology

2.1 Introduction

Basic techniques employed in this deliverable are a literature survey and expert interviews. To apply these techniques systematically, Research Questions (RQs) were defined. Literature was surveyed and analysed to find answers to RQs one by one, and interviews were conducted to confirm the findings.

The task was executed through the following analytical stages:

1) Define the set of questions to which answers are sought. This is formalised using the RQs described in greater detail in the following section.

2) Identify the information sources through expert referrals, literature search and Internet search.

3) Identify the exhaustive list of candidate projects for further analysis.

4) Filter the exhaustive list using criteria derived from the research questions to produce a final candidate list capable of analysis within the resource budget.

5) Analyse each project in the final candidate list by applying the analysis methodology described below and produce an analysis report.

6) Conduct an expert review with the CTs to validate the results.

Although only step 6 above includes a formal validation step by the CTs in practice regular workshops ensure that the CTs provide guidance and comment throughout the process.

2.2 Research Questions

The RQs formalise the research objectives of the task and were designed in conjunction with the CTs. Four major RQs were set:

RQ1-1: What aspects of an ICT system are determined by its architecture?

RQ1-2: How are those aspects achieved by the projects studied?

RQ1-3: Which of those projects can inform the design of the UK SSHP architecture?

RQ1-4: What are the pros and cons when applying learning from those projects to the UK SSHP?

The first RQ defines the framework for analysis of the projects. *Aspects* in this RQ mean attributes of an ICT system that are determined fundamentally by its architecture. The second RQ concerns the analysis of the project in terms of the aspects identified in the first RQ.

There are two classes of aspects: design aspect and quality aspect. Design aspects flow from decisions taken by designers of the system under analysis. Quality aspects are properties of the system that result from design decisions. Within the field of ICT research there are various well-known *tactics* that can be employed during system design, as design aspects, with the specific objective of achieving a specified quality aspect. For example, *security* is a quality aspect and "*separate entities*" is a tactic for security [1]. One design aspect that can be employed to support the desired tactic is the use of private networks, although this is only one of the technological options to separate a number of entities.

The use of design aspects, tactics and quality aspects as an analysis framework supports a systematic analysis method that is applied to each of the selected projects.

The application of this framework means that RQ1-1 and RQ1-2 are further broken down as follows:

RQ1-1

a) RQ1-1-1: What quality aspects of an ICT system are determined by its architecture?
b) RQ1-1-2: What tactics and design aspects are used to support each quality aspect?

RQ1-2

c) RQ1-2-1: Within each project what tactics are implemented and in support of what quality aspects?
d) RQ1-2-2: Within each project what design aspects are used to implement the identified tactics?

The survey scope of RQ1-2 covers:
(i) Projects within the SSH field; and
(ii) Projects in other fields where Hitachi has experience.

We include (ii), because we expect to find advanced technologies that are applicable to the SSH system and which may not have been applied previously.

RQ1-3 and RQ1-4 address relevance and applicability to the SSHP respectively.

3 Architecture Aspects

3.1 Quality Aspects

Within the literature there can be found a considerable number of quality aspects applicable to ICT architectures (Table 3.1.1). The table also shows aspects obtained from CTs and other experts to complement literature. Using expert judgement those aspects that were considered to be irrelevant and/or low priority were excluded. Excluded aspects and the reasons for their exclusion are given in Table 3.1.2.

Table 3.1.1 - Quality Aspects from Literature

Literature	Quality Aspects
Clements (2012) [2]	availability, interoperability, modifiability, performance, security, testability, usability
ISO/IEC 25010 (2011) [3]	functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, portability
NIST (2012) [4]	options, interoperability, maintainability, upgradeability, innovation, scalability, legacy, security, flexibility, governance, affordability
From Discussion with CTs and experts (complementing literature)	real-time response, fail-safe, resiliency, standardised interoperability, coverage rate of threats, confidentiality, integrity of data, privacy protection, component availability from multi-vendors

Table 3.1.2 - Excluded Aspects

Omitted aspects	Reason
Usability	As can be seen in the well-known architecture MVC (Model, View, and Control), this aspect focuses strictly on user interface issues. Although the user interface is understood as a key part of the ICT system, and plays an important role in customer acceptance, the majority of the design aspect would come after service definition, which is beyond the scope of this work package.
Functional suitability	ISO/IEC 20510 covers all quality issues other than architectural aspects. Functional suitability here means the degree of functional fit against requirements. This is a functional design issue and not an architectural aspect.
Governance	Governance here means setting consistent design policies. We consider that our findings on other quality issues will help set design policies. Governance should be driven from the results of this work. Hence, we don't treat this as an independent aspect. For instance, governance is important in security. In this context, governance may need further discussion but is outside of the scope of this work package.

Table 3.1.3 shows the quality aspects that are considered to be within the scope of RQ1-1-1. Some of the aspects considered in this analysis have a broader meaning and include similar aspects as shown in the table.

1) **Performance -** This is a key challenge for the SSH system, especially in the variety of performance requirements. For instance, the performance requirements for business transactions, customer interaction and real-time system control differ significantly. SSH, however, constitutes critical infrastructure and so one of the most important performance requirements relates to the response of the control system. Hence we define *Performance* as pertaining to "*the software system's ability to meet timing requirements*" according to Clements (2012) [2].

2) **Reliability -** Reliability is the proportion of time that the system is able to operate within normal parameters (availability) and its ability to maintain normal operation when subjected to negative internal and external factors including failure (resilience). This is essential for critical infrastructure.

3) **Interoperability -** This is also an indispensable aspect for the UK SSH system. The SSH system is composed from a number of subsystems that are likely to be the responsibility of a number of independent entities some of which may compete to provide different components of the system. Standardisation is important, but standards alone are insufficient [2] and appropriate software architectural mechanisms are required.

4) **Cyber Security -** In the ICT context this aspect means cyber security and privacy including grid resilience, privacy protection, and trusted transaction in order to securely support data and business respectively.

5) **Adaptability -** This covers a number of aspects as listed in Table 3.1.3. The SSH system must be able to evolve from the current system into a future system over several decades, incorporating new technologies and regional differences. This ability we collectively call adaptability in this deliverable.

6) **Affordability -** We define affordability here as an aspect to "*enable multivendor procurement*" according to NIST (2012) [4]. One of the objectives of the SSHP is an affordable smart energy system. The architecture must enable multi-vendor procurement so as to secure the most economical solution through harnessing the power of competition. This is also related to the interoperability aspect.

Table 3.1.3 - Quality Aspects

Quality Aspect	Including
Performance	performance efficiency, real-time response
Reliability	availability, resiliency
Interoperability	standardized interoperability, compatibility
Cyber Security	coverage of threats, grid resilience against cyber attack, privacy protection, trusted transaction including confidentiality and integrity of both data and transaction
Adaptability	modifiability, scalability, maintainability, testability, variability, portability, options, upgradeability, innovation, legacy, flexibility
Affordability	component availability from multiple vendors, standard compatibility, simplicity of mechanism

3.2 Tactics and Design Aspects

Each of the quality aspects described above has well-known associated tactics and design aspects. There are a large number of tactics, and associated design aspects, and the purpose of this section of the report is to focus on one - cyber security - in order to illustrate the methodology. For a full description of the range of tactics and design aspects the reader is referred to the literature sources provided. Actual tactics and design aspects found in the projects considered within the task are presented in Section 5.

Table 3.2.1 shows a number of tactics appropriate to the cyber security aspect [1]. Each tactic can be associated with selected design aspects as its implementation. "*Detect Intrusion*" tactics, for example, are a detection mechanism for recognising intruders' discriminative behavioural patterns, or signatures. This is implemented using a logging function and a comparing function with data storage containing known signatures. The logical architecture that contains these elements is a design aspect as are the chosen elements. An example is shown in Figure 3.2.1. This architecture prevails in cyber security related tactics with variations of sensing methods, used log data, signature patterns and comparison algorithms.

As demonstrated in the above example, there can be an enormous number of design aspects. In this task, ICT engineers and researchers with expert knowledge analysed international projects and discerned design aspects for all the quality aspects defined in the previous section. Practical systems employ combinations of known design aspects.

Table 3.2.1 - Tactics for Cyber Security

Quality aspect	Tactics category	Tactic
Cyber Security	Detect Attacks	Detect Intrusion, Detect Service Denial, Verify Message Integrity, Detect Message Delay
	Resist Attacks	Identify Actors, Authenticate Actors, Authorize Actors, Limit Access, Limit Exposure, Encrypt Data, Separate Entities, Change Default Settings
	React to Attacks	Revoke Access, Lock Computer, Inform Actors
	Recover from Attacks	Maintain Audit Trail, Restore

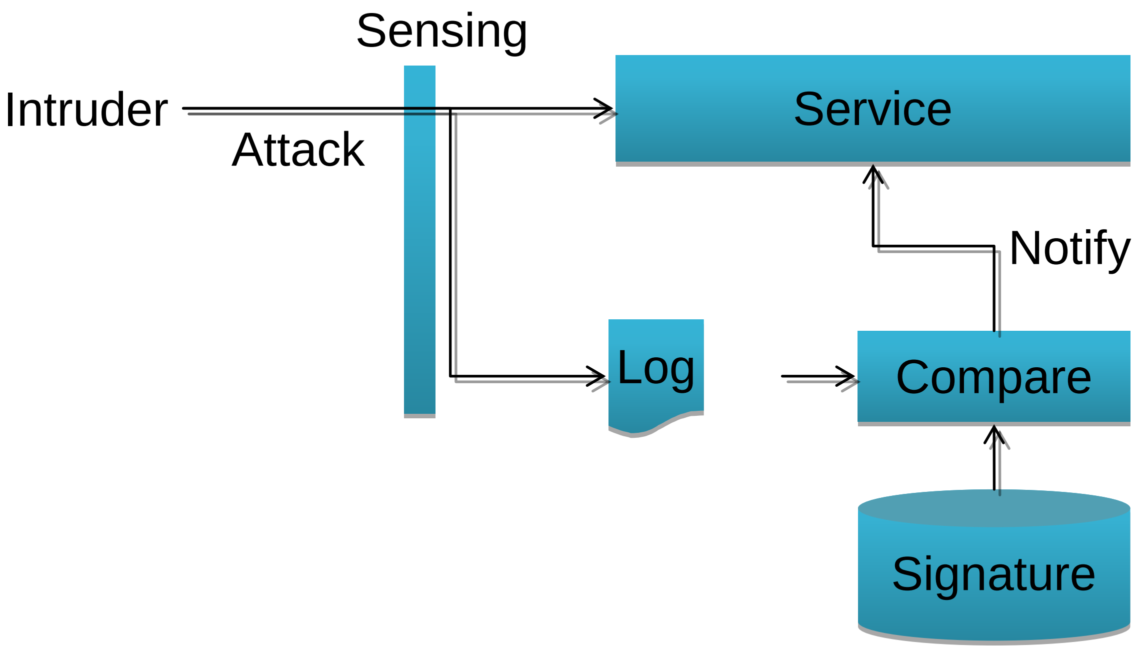

Figure 3.2.1 - Signature Comparison Architecture.

4 Project Extensive List

4.1 Selection Policy

The policy for selection of projects is based on the following criteria.

1) At least one of the three following should be satisfied:
   a) With reference to the Smart Grids Architecture Model (SGAM) [5]; elements including the distribution network, distribution energy resources, and customer premises are with the scope of the project ICT system.
   b) Advanced heat (space and water) technologies having ICT systems applicable to the SSH system should be covered.

c) Projects in other fields should be considered, if they have an ICT system aspect applicable to the SSH system.

2) Each project in the extensive list should include at least one of the six quality aspects described previously. All six quality aspects should be covered by the projects in the entire extensive list.

3) It must be possible for the WA3 team to access project information.

4.2 Information Source

Two kinds of information source are used. The first source is referrals from the experts within the project partners: Hitachi, gemalto, University of Oxford and Brunel University. The second source is publically accessible information through well-known bodies such as standardisation bodies. The complete list of information sources is:

1) Projects in which Hitachi, gemalto and/or the CTs are participants.

2) Projects undertaken by the following organisations:
   a) CEN (Comité Européen de Normalisation) / CENELEC (Comité Européen de Normalisation Electrotechnique) / ETSI (European Telecommunications Standards Institute)
   b) ISO (International Organisation for Standardisation) / IEC (International Electrotechnical Commission)
   c) ITU (International Telecommunication Union)
   d) NIST (National Institute of Standards and Technology)

3) Comprehensive list contained within International Smart City 2012 [7]

Items 2 and 3 correspond to public information research. Item 3 is a Japanese publication by a major Japanese private research company and has an exhaustive list of 400 international smart city projects.

4.3 The Extensive List

The extensive list considered 32 separate projects and initiatives from around the world and from a variety of sources. The previously described criteria were used to produce this list. Please see Appendix A for the extensive list.

5 SSHP Applicability

5.1 Selection Policy

This section addresses RQ1-3. To answer this RQ, a set of projects with an ICT architecture design applicable to the UK SSHP were extracted. The selection policy for the extraction was set as follows:

1) All six quality aspects should be covered by the short list.

2) Each project is assessed using expert opinion to determine its relevance to SSH.

The short list contains the following: four are energy infrastructure related projects; three are cyber security and privacy related and two are high reliability, real-time control infrastructure projects. A detailed evaluation of each project is contained in Appendix B but there follows a brief summary of each project.

5.2 Projects and UK applicability

5.2.1 High Performance Distributed Network Operation (HiPerDNO)

This project covers the capability improvement of distribution networks that would be essential for the introduction of, for example, an SSH system even at an early stage of deployment. This idea could also be incrementally applied as the SSH expands.

One of the architectural innovations within the HiPerDNO project is adding High Performance Computing (HPC) to a Distribution Management System (DMS). Another innovation is the use of an information bridging module with a standard API. The module provides a scalable and robust middleware capability. The modules are deployed in the intermediate nodes within the distribution network, at a location close to consumers, for the purpose of gathering data and conflating the raw data to produce aggregated data-streams. The final data stream is provided to the DMS. This is achieved by hierarchically aligned modules within the distribution networks.

Through collaborative working between the hierarchically aligned modules, and a messaging layer of the distribution network that is integrated to the HPC platform, the DMS can undertake state estimation using conflated data from the distribution network.

Table 5.2.1.1 - Positive Points in HiPerDNO Design

*: Remarks show elements of the corresponding architecture.

Quality aspect	Positive Points in Design	Remarks
Performance	Data transfer between the Parallel Processing system (HPCE) and the highly fault-tolerant file system (HPCDS) is fast due to physical co-location.	HPC performance
	Fast data aggregation can be achieved as data conflation is executed by multiple distributed modules in intermediate nodes, in parallel.	Information bridge module performance
	A scheduler in the HPCE allocates computational resources to prioritised tasks.	HPC configuration
	High performance is achieved through parallel processing.	HPC performance
Adaptability	New technologies for the HPCE and the HPCDS can be incorporated independently from the business logic in the DMS.	HPC configuration
	The DMS can be upgraded independently of the HPCE and the HPCDS.	HPC configuration

	As each module is defined to require narrowly specified skills, the efficiency of development and maintenance is high.	DMS and HPC alignment
	Hierarchical aggregation model enables incremental settlement of data aggregation system.	Information bridge module alignment
	The HPCE system can be upgraded when required with minimum impact on application and overall layout; extra nodes can be added, components of higher performance can replace existing ones or be added.	HPC configuration
Cyber Security	Irregular access to the HPCDS can be easily prohibited as the interface of the HPCDS is limited.	HPC configuration
	Use of public libraries increases transparency.	DMS and HPC configuration
Interoperability	A range of DMSs are employed by DNOs, and the client-server model minimises the modifications required by different DMSs to access the HPC mechanisms.	DMS and HPC configuration
	Use of open standards for APIs facilitates price erosion of the modules in intermediate nodes through competition.	Information bridge module configuration
Affordability	Hierarchical aggregation model enables incremental settlement of data aggregation system.	Information bridge module alignment
	High reliability asset management enables state based maintenance (replacement of aging asset), and it costs less than scheduled maintenance.	HPC performance
	Use of public libraries makes the maintenance cost lower due to rich peripheral tools (i.e. debugging tools).	HPC configuration
	It is possible to produce the HPCE system or enhance performance with less expensive commodity computational resources.	HPC configuration
	Use of open standards for APIs facilitates price erosion of the modules in intermediate nodes through competition.	Information bridge module configuration
Reliability	Data aggregation is robust as data in distribution network is aggregated hierarchically	Information bridge module configuration

	Integration of messaging layer of distributed network and the DMS with the HPC platform enables high reliability asset management so as to minimize customer interruptions.	Total system configuration
	In the case of a cluster malfunction, the HPCE system does not stop.	HPC configuration

Table 5.2.1.2 - Negative Points in the HiPerDNO Design

No.	Negative Points in Design
1	High initial investment. Economical evaluation is required. Initial investment (i.e. initial cost, physical space for equipment, administration load and hardware maintenance) needs to be compared with the long term cost saving (i.e. system performance enhancement, switching from periodical maintenance to condition based maintenance and operational cost decrease through visualization of the total system status, etc.).

5.2.2 OpenNode

This project is for a practical solution to establish a multi-standard interface access model that would be applicable to the SSH system as it is expected to have a similar degree of complexity in terms of multi-standard support.

The OpenNode project focuses on inner parts of the distribution grid, namely the smart Secondary Substation Nodes (SSN) as a substantial component to monitor and control the distribution grid status. The communication architecture was also defined including the evaluation and selection of standards. The CIM data model will also be used for the communication between the middleware system and the control centre. This ICT system has the following characteristics:

1) Overall there are three layers: applications in the control centre, middleware and SSN functionality.
2) Middleware is rich in terms of functionality. An important role is the protocol conversion between the control centre and SSN.
3) SSNs are based on an open standard.
4) Distributed controls are implemented with distribution substations as control nodes.

Table 5.2.2.1 - Positive Points in the OpenNode Design

*: Remarks relate to the four points above.

Quality aspect	Positive Points in Design	Remarks*
Interoperability	Communication amongst SSN products produced by different suppliers.	3)

Adaptability	Communication with the IT-system is independent from any proprietary specification.	3)
	The development can be done separately for each layer; the Control Centre, Middleware and SSN layers.	1), 2)
	CIM allows incremental deployment of the SSN. For instance, first deployment is small, and incremental deployment follows.	2), 3)
	By monitoring the status of the distribution grid with the information from the SSN, it is possible to control the system in order to maintain optimal operation.	4)
Affordability	Because of the independent layered structure, the development can be focused on a single layer such as the Control Centre, Middleware, and SSN layers. This structure reduces the time and cost for the development.	1),3)
	Simplification in SM (Smart Meter) specification (because the connection between the SM and SSN depends only on the standards applicable to the SSN).	3)
	Using open standards for the SSN and Middleware allows competition among vendors to lower the cost.	3)

Table 5.2.2.2 - Negative Points in the OpenNode Design

No.	Negative Points in Design
1	The performance degradation due to additional middleware would be an issue in some cases. If such issues are expected to be a problem, the system design phase should include pre-assessment to prevent them.

5.2.3 NIST IR 7628 Smart Grid Cyber Security

NIST IR 7628 are the Guidelines for Smart Grid Cyber security, prepared by the Cyber Security Working Group (CSWG) of the Smart Grid Interoperability Panel (SGIP) and set the trend for all further work in the area in other regions of the world and especially the European Union. This project focuses on Security.

A Smart Grid's logical security architecture is constantly in flux because threats and technology evolve. The following are key concepts and assumptions that were the foundation for the logical security architecture. The following cyber security design aspects are the key strategy for SSH protection against Cyber Security threats.

1) Defence-in-depth strategy to mitigate the risk of one component of the defence being compromised or circumvented.
2) Power system resiliency to events potentially leading to outages
3) Multi-level Security (confidentiality, integrity and availability) specified based upon the expected adverse effect of a security breach upon organizational operations, organizational assets or individuals.

Table 5.2.3.1 - Positive points in the NIST IR 7628 Design.

*: Remarks relate to the three points above.

Quality aspect	Positive Points in Design	Remarks*
Cyber Security	Confidentiality: Preserving authorised restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information. A loss of confidentiality is the unauthorised disclosure of information.	1), 3)
	Integrity: Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity. A loss of integrity is the unauthorised modification or destruction of information.	1), 3)
	Availability: Ensuring timely and reliable access to and use of information. A loss of availability is the disruption of access to or use of information or an information system	1), 2), 3)

Table 5.2.3.2 - Negative Points in the NIST IR 7628 Desing

No.	Negative Points in Design
1	Strengthening security can often mean a reduction in performance and increase in cost.

5.2.4 A Prototype for Island-type Smart Grid

This project is for electric power grid control technology and business model demonstration under the scenario of a massive penetration of renewable energy. The configuration of the ICT system in this project is applicable to the SSHP in terms of a multi-business configuration with a high level of cyber security and privacy protection.

The system architecture is hierarchical control architecture and consists of Energy Management system (EMS), Electric Vehicle Energy Control Centre (EVECC), Advance Distribution Management system (ADMS that includes DLC functions in this project), μDMS, Home Area Network control gateway (HAN control gateway or the HAN controller embedded in a SmartMeter) and SmartPCS for PV.

The summary of the ICT architecture is following.

1) The hierarchical control architecture enables multi-layer energy management capability for better use of RE and mitigation of RE-related electric power quality issues.

2) By enabling multi-business entity collaborative work, the EV charging schedule can be matched to RE generation prediction to maximize usage of RE energy.

3) By using autonomous control and latest field area network technology (M2M), short turn around can be achieved.

4) By using ICT PF which has Information Message Bus for enterprise network and control and an Information Bus for the field device control network, the complexity of the application dependent communication interface can be hidden. Also the cyber security counter measures embedded into the ICT PF make for easier governance control for the cyber security of the application.

5) The affordability of the system is determined by an economic evaluation to confirm the sustainability of the business model. The evaluation is based on a system cost-benefit analysis considering all the stakeholders including local government, the utility company, consumers, etc.

6) The loads chosen for DLC are selected subject to the constraint that there should be no perceived impact by the consumer on their quality of life.

Table 5.2.4.1 - Positive points in A Prototype for Island-type Smart Grid Design

*: Remarks relate to the four points above.

Quality aspect	Positive Points in Design	Remarks
Performance	One day ahead EV charging load control schedule making for maximizing RE usage by mitigating excess energy of Wind Power Generator during night	1) ,2), 6)
	Short turn around control for mitigation of frequency issue by ADMS including DLC	3), 6)
	Short turn around control for LV voltage level control by μDMS along with SmartPCS	3)
	Short turn around control for LV load level control by μDMS along with HAN control gateway	3), 6)
Adaptability	Application dependent interface is hidden behind ICT PF to enable multi-business entity communication and data sharing	4)
Cyber Security	The system is based on NERC CIP V5	4)
Interoperability	Interoperability is kept by ICT PF.	4)
Affordability	Hierarchical architecture enables incremental settlement of ADMS, μDMS, Home Network control gateway.	1), 2), 3), 6)
	It is possible to use less expensive commodity computational resources for the system.	1), 2), 3)
	An economic evaluation ensures the sustainability of the business model.	5)
Reliability	The architecture of hierarchal configuration and autonomous local control provides redundant means to provide energy control service functions even under the communication network failure.	1), 3)

Table 5.2.4.2 - Negative Points in A Prototype for Island-type Smart Grid Design

No.	Negative Point in Design
1	If the precondition of the system such as a high level of penetration of RE and EV is not the issue for the application, only a limited portion of the system such as ICT PF is applicable.

5.2.5 ATOS (Autonomous decentralised Transport Operation control System)

This architecture is based on the Autonomous decentralized transport operation control system (ATOS) and is applicable to the SSH system, where online-maintenance and incremental system wide expansion is necessary; facilities are frequently updated while other facilities not impacted by the update are used for continual service. For instance, in the case of the SSH system composed of multiple local smart systems with incremental expansion, the impact of system-wide maintenance can be minimized to only the local smart system.

The objective of this architecture is to improve the flexibility of inserting or modifying new subsystem(s). The abstract architecture has the following characteristics:

1) A subsystem (representing a station in this case) is a data-driven mechanism,

2) There is a data field, through which a subsystem communicates to another

3) Transmitted data are tagged in order for a subsystem to identify whether or not it needs it.

Table 5.2.5.1 - Positive Point in the ATOS Design

*: Remarks relate to the three points above.

Quality aspect	Positive Point in Design	Remarks*
Adaptability	Cost and work load necessary to change services and infrastructure are small.	1)
Reliability	In case of failure in a subsystem its effect propagates little to other subsystems.	2), 3)
	Replacement does not require system suspension, which leads to a smaller duration of outage of the subsystem. It consequently improves availability.	2), 3)
	The architecture of autonomous decentralized system provides redundant means to prevent system wide failure even under the center ICT system failure. This feature is essential if the SSHP is designed to be "the critical national infrastructure".	2), 3)

Table 5.2.5.2 - Negative Point in the ATOS Design

No.	Negative Point in Design
1	The architecture originally comes from the well-known pipe-and-filter architecture, which is said to be inherently unsuitable for an interactive system for the reason of the difficulty in inserting a new subsystem.

5.2.6 Traffic management system for Kyushu Shinkansen (Bullet Train)

This project is applicable since the SSH will consist of multiple components and needs high resiliency and reliability for its service. It will also have elements of critical infrastructure as does this system. Within the system, components with different levels of availability co-exist, distinct functionalities exchange data with each other, and rules governing external communications are varied. This project provides a solution to inclusively manage those differences by developing a common interface, allowing the external gateway, and other elements, to achieve their required service level. The objectives of this project are; a) to connect two different bullet train operation systems together, and b) to adopt a highly reliable and fault tolerant model.

There are three design aspects found within this project; Replication based voting with abstract interface layer, Taylor interface and isolated functions.

The implementation of three design aspects is characterised by the following configurations:

1) Quadruple loosely-coupled system (the replication based voting),
2) Software synchronisation system at the operating system level which relieves constraints on hardware such as CPUs (the replication based voting),
3) A voter set consists of two voters to detect voter error (the replication based voting),
4) Fault-tolerant network (the replication based voting),
5) The external gateway designed with high adaptability (the Taylor interface), and
6) The logical isolation of functions depending on levels of reliability (the isolated functions).

Table 5.2.6.1 - Positive Points in the Traffic management system for Bullet Train Design

*: Remarks relate to the six points above.

Quality aspect	Positive Points in Design	Remarks*
Reliability (Availability)	High availabilityby fault tolerant system..	1), 3), 4)
	The architecture of fault tolerant system and interlocking control provides high resiliency and reliability for the service. This feature is essential if the SSHP is designed to be "the critical national infrastructure".	1),2), 3), 4), 6)
Interoperability	It is relatively easy to add a new function which is required to communicate externally. The new function is able to inherit part	2), 4), 5)

Adaptability	of the current communication channel.	
	High adaptability to a change in market-available hardware, e.g. CPU.	2)
	It is highly adaptable in the case of necessary modifications on communications with external entities while there are multiple internal functions communicating externally.	2), 4), 5)

Table 5.2.6.2 - Negative Points in the Traffic management system for Bullet Train Design

No.	Negative Points in Design
1	Adverse impact on development time due to the abstract layer.
2	Possibly adverse impact on Performance.
3	Adverse impact on development time due to the abstraction layer when the number of internal functions communicating externally is small.
4	More constraints to exchanging data amongst subsystems.

5.2.7 Danish Cell-controller Pilot Project (CCPP)

The power systems of Denmark are characterised by a high penetration of distributed generation (DG) comprised of small to medium scale combined heat and power plants (CHP) and wind turbines (WTs).

Coordinated smart control of existing distributed assets such as wind turbines, co-generation facilities and managed loads can support transmission operations during an emergency condition, while also enabling enhanced market-based control over these assets during routine operations. The aim of the Cell Project is to develop the controllers and the data-acquisition, command, and communication infrastructure necessary to realise such wide-area control of a distribution grid. Similar requirements apply to SSH and therefore this project is beneficial and applicable to the SSH system.

The abstract architecture has multiple Virtual Power Plants (VPPs) to form a single large VPP. Using distributed agent technology and a high speed fibre network, the SCADA system comprises a layered control hierarchy, and it enables construction of VPPs. Since agents are embedded between VPPs in the SCADA system, those multiple VPPs form a single large VPP. The agents between VPPs are in charge of balancing of the power and providing a stable energy supply.

Table 5.2.7.1 - Positive Points in the CCPP Design

Quality aspect	Positive Points in Design	Remarks*
Interoperability	Optimal distribution of surplus energy.	
	Providing ancillary services at selected locations within the distribution system.	
Adaptability	Contributing to rapid recovery from transmission system emergency.	

	Reducing impact on consumers in transmission system emergency.

No relevant negative points were found in the CCPP Design.

5.2.8 M/490 Smart Grid Information Security working group

M/490 produced by the Smart Grid Task Force (SGTF) of the European Commission Energy Directorate General (DG ENER) aims at encompassing all smart grid domains beyond smart metering, with special attention on enabling bi-directional energy flows and managing decentralized energy resources such as localized solar or wind energy generation and storage facilities including electric vehicle batteries.

The Reference Architecture used by M/490 is the layered conceptual model based on domains and zones. This information security architecture is intended to be used in smart grid systems and has clear applicability to SSH.

Table 5.2.8.1 - Positive Points in M/490 Design

Quality aspect	Positive Points in Design	Remarks*
Cyber Security	Identifies sets of available security requirements for all smart grid actors, product and systems.	
	Provides a methodology to identify the requirements applicable to an organization or system, in the context of a specific use case.	
	In 2013/2014, the approach will be further adapted to several EU countries regulations, including UK, and assessed on several use cases including demand-response management and Distributed Energy Resources management.	
	Some good insight to perform Risk Assessment in a smart grid context is also provided. The approach is not tied to any specific formal methodology of Risk Assessment so it can perfectly fit in the UK environment.	

Table 5.2.8.2 - Negative Points in M/490 Design

No.	Negative Points in Design
1	Specific security requirements standards for some smart grid domains are still lacking, so the requirements at this stage remain largely based on NIST 7628 and ISO 27000 series.
2	Efforts to consider applicability of further standards such as IEC 62351, parts of IEC 62443, ISO 15408 and ISO 19790 are planned for 2013 - 2014.

5.2.9 EU-Commission Smart Grid Task Force (SGTF)

The EU-Commission SGTF under DG ENER has instructed in early 2012 further work on Smart Grid additional to the standardization mandate M/490. Amongst a High Level Steering Committee four Experts Groups (EGs) were formed. Gemalto contributes resources to the ESMIG representation in EG2 and EG3.The aim of EGs is to work out jointly agreed, regulatory recommendations and to identify projects with which an economical, efficient and fair realization of Smart Grids can be ensured. A Data Privacy Impact Assessment Framework for Smart Grids and a set of “Best Available techniques” (i.e. countermeasures) to address the smart grids cyber security threats are currently being finalised.

The abstract architecture has the conceptual Reference Architecture developed under M/490 as a model. This information security processes and tools developed within this project are intended to be used in smart grid systems and have clear applicability to SSH.

Table 5.2.9.1 - Positive Points in the SGTF Design

Quality aspect	Positive Points in Design	Remarks*
Cyber Security	There exist a number of important benefits when performing a DPIA. The following benefits are identified when using this DPIA: Preventing costly adjustments in processes or system redesign by mitigating privacy and data protection risks Prevention of discontinuation of a project by early understanding of the major risks. Reducing the impact of law enforcement and oversight involvement Improving the quality of personal data (minimisation, accuracy) Improving service and operation processes Improving decision-making regarding data protection Raising privacy awareness within the organisation Improving the feasibility of a project Strengthening confidence of customers, employees or citizens in the way which personal data are processed and privacy is respected Improving communication about privacy and the protection of personal data. The DPIA process can be used by involved smart grid stakeholders to demonstrate to customers and regulators that due diligence has been made toward protecting personal data.	

Table 5.2.9.2 - Negative Points in SGTF

No.	Negative Points in Design
1	Performing a DPIA involves significant cost and workload for an organization, with a strict process to follow and documentation to produce.

5.3 UK SSHP relevant ICT architecture

The architectures important and relevant to the UK SSH were extracted by collecting and summarising the design aspects from the projects listed in the tables above, which correspond to one or more of six quality aspects as previously determined.

For example, a design aspect of adaptability is extracted from five different projects mentioned above; the importance of "using a layered structure for simplification to system-upgrading and continuous system operation" is determined. The following identifies where learning from each project can be used to address each quality aspect (please refer to Appendix B for the detail of each individual Design aspect).

1) **Performance:** use of parallel processing and a layered structure information gathering method.
   Projects highlighted: HiperDNO, A Prototype for Island-type Smart Grid,
2) **Reliability:** use of autonomous operation method, equipment redundancy and layered structure.
   Projects highlighted: HiperDNO, A Prototype for Island-type Smart Grid, A Traffic Management System for Mass transit (ATOS), A Traffic Management System for Bullet Train
3) **Cyber security:** use of appropriate assessment methods, layered structure and abstraction.
   Projects highlighted: NIST Smart Grid Cyber Security, A Prototype for Island-type Smart Grid, M/490 Smart Grid Information Security working group, EU-Commission Smart Grid Task Force (SGTF)
4) **Adaptability:** use of layered structure and autonomous operation for simplification of system upgrades and system continuous operation.
   Projects highlighted: HiperDNO, OpenNode, A Prototype for Island-type Smart Grid, A Traffic Management System for Mass transit (ATOS), A Traffic Management System for Bullet Train, Danish Cell-controller Pilit Project (CCPP)
5) **Affordability:** use of the appropriate structure to minimize the impact of integration and maintenance processes; and use standard communication methods to widen equipment choice to reduce cost.
   Projects highlighted: HiperDNO, OpenNode, A Prototype for Island-type Smart Grid
6) **Interoperability:** use of common and standardised communication methods, including an appropriate Common Information Model for creating the information management node or platform architecture, to lower the number of proprietary communication interfaces.
   Projects highlighted: HiperDNO, OpenNode, A Prototype for Island-type Smart Grid, Danish Cell Pilot Project (CCPP)

6 Conclusions

6.1 Summary of Key Findings

The principal objective of D.H3.1 is to collect the appropriate ICT architecture knowledge for the UK SSHP. For this objective, the methodology for the analysis of projects is based on RQs and selection policies as defined earlier in this document. The summary of the outcome from the research is presented in Table 6.1.1 together with the names of the projects and the knowledge applicable to the SSH programme.

Table 6.1.1 - Extracted design aspects from each project

No.	Name	Applicable design aspect
1	HiPerDNO	In this project, a high performance DMS was developed. The DMS can estimate the distribution network state in near-to-real-time using data collected from distribution networks. The data are from many and varied devices, the scope and scale of which are expected to increase in the future. This capability improvement is achieved by two major features: adding High Performance Computing to DMS; and data collection node technology enabled by a scalable and robust middleware embedded in the node. Because of the similar computational requirement and data acquisition topology, the technologies are essential for the introduction of an SSH system even in the early stage of the deployment.
2	OpenNode	In this project, the existing distribution substations are transformed into intelligent Secondary Substation Nodes (SSN). Monitoring of the status of, and control of, a distribution network is undertaken from the DNO's management system via the SSNs. The objective is the design and development of an Open Common Reference Architecture, and so this interoperable model is applicable to the SSH system in order to establish a multi-standard interface access model.
3	NIST Smart Grid Cyber Security	This initiative presents an analytical framework for developing effective cyber security strategies for smart grids that have similar complexity to the SSHP in terms of designing for Confidentiality, Integrity and Availability.
4	A Prototype for Island-type Smart Grid	In this project, the electric power grid control technology and business model is demonstrated. The hierarchal configuration and autonomous local control by the ICT system is distinctive and applicable to SSH. Also, the multi-business entity connection with a high level of cyber security, privacy protection, and the policy of DLC target selection based on the idea of minimising the impact on the consumer's quality of life, is beneficial in the implementation

		of the SSH system. From a business model perspective, the system economic evaluation framework - based on a system cost-benefit analysis - is applicable.
5	A Traffic Management System for Mass Transit (ATOS)	In this project, by adopting an autonomous decentralized system, the train company can maintain each subsystem without affecting others, and moreover, there is no impact on other subsystems even if a subsystem fails. This architecture with those characteristics is highly valuable in the development of the SSHP, which may consist of multiple subsystems.
6	A Traffic Management System for Bullet Train	This project shows a highly reliable fault tolerant system, which is a critical issue in the deployment of the SSH system. Also the system has functionality which is easily adaptable and interoperable to connect with multiple different kinds of operating systems. The SSH system is considered to consist of a variety of operating systems and so this project is a good guide to the SSH system.
7	Danish Cell-controller Pilot Project (CCPP)	This project shows how to logically connect distributed power plants as one entity in the distribution network and also shows how to realise the autonomous operation of local distribution networks as a microgrid under the failure of the transmission network. The communication infrastructure of this project realises wide-area control of a distribution grid, which is required for the deployment of the SSH system.
8	M/490 Smart Grid Information Security working group	This initiative shows some good insights to perform Risk Assessment in a smart grid context. The approach is not tied to any specific proprietary methodology for Risk Assessment. So it can fit well with SSHP.
9	EU-Commission Smart Grid Task Force (SGTF)	This initiative shows guidelines for performing a Data Protection Impact Assessment (DPIA) to Smart Grid and Smart Metering systems. The DPIA is applicable to design privacy protection in the SSHP context for the personal information of the consumer.

From this table it is evident that a number of design aspects addressing the six identified quality aspects have been found. The design aspects of each project give useful knowledge and insights to inform the design of the SSHP ICT architecture.

6.2 Cross-reference with Acceptance Criteria

The following table provides a cross-reference between the contents of this report and the acceptance criteria as specified in the contract between Hitachi Europe Limited and the ETI [25].

Table 6.2.1 – Cross-reference between acceptance criteria and report content

No.	Acceptance Criteria	Correspondence
1	(Description of Deliverable) A report summarising International initiatives being undertaken in the ICT/systems architecture arena.	Requirements 1) to 3) in "Selection Policy" of Section 4.1 specifically include "the ICT/systems architecture arena". As a result, all projects in the extensive list are undertaken within that arena.
2	(Description of Deliverable) Indicates their (projects') applicability and relevance to a UK smart systems and heat programme.	This is included within the descriptions in Section 6.2 and the applicability is further described in Sections 6.2 and 7.1.
3	(Description of Deliverable) Lists the initiatives by category (e.g. region, supplier, R&D programme)	The list in Appendix A is categorized by smart grid domain, technical domain, and quality aspect, and also the location of each project is specified.
4	(Description of Deliverable) Maps them (projects) onto the smart systems and heat energy value chain (e.g. generator/producer, transmission, distribution, end use),	The category element within the table in Appendix A refers to the smart grid domain, which has three types: distribution, DER and consumer premises. With this category, each initiative is mapped into one or more.
5	Categorises them(projects) against relevance to the Programme (Description of Deliverable)	The category element within the table in Appendix A includes a flag "Ac" (Accepted to Short List, and Initiative (or project) Number) and quality aspect field. Within this field, relevancy to the Programme is categorized.
6	Provides a listing of the initiatives being undertaken with a summary of the aims	The aims are explained in Section 6.2 and also described in Appendix B.
7	Provides objectives of each along with their timeframes	The objectives are explained in Section 6.2 and described in Appendix B, and the timeframes are also included in Appendix B.
8	Provides geographical area	The geographical area is stated in Appendix B. Table: "Initiative(or project) Basic Information", Field: "Nation delivered"
9	Identifies any common features or overlaps of these initiatives with the Programme and those elements that should be considered in the timeframe of the overall Programme;	Timeframe aspects are covered in Appendix B. Table: "UK SSH Applicability", Field: "Possible application" There is some common features, such as using off the shelf product and using standardisation. However, the projects selected have essentially different ICT archtectures.
10	Includes a summary of the	The key elements are described in Appendix B, and the summary is within the main body.

	key elements	Table: “Initiative(or project) Basic Information”, Field: “What the system intends to achieve” Item: “2) ICT system overview”
11	Includes the scope of the initiative	The scope is described in Appendix B, and the summary is in the main body. Table: “Initiative(or project) Basic Information”, Field: “Scope “
12	Includes the energy system it relates to (heat networks, EV charging or etc)	The related energy system is stated in Appendix B. Table: “UK SSH Applicability”, Field: “Possible application”
13	Includes the key features of the ICT architecture	The key features are described in Appendix B, and the summary is in the main body. Table: “Initiative(or project) Basic Information”, Field: “What the system intends to achieve” Item: “2) ICT system overview”
14	Includes the scale	The scale information is stated in Appendix B and in the main body. Table: “Initiative(or project) Basic Information”, Field: “Scale”
15	Includes cost if available	The cost is stated in Appendix B only if available. Table: “Initiative(or project) Basic Information”, Field: ve(or project) Basic I
16	Includes the companies involved	The companies involved are stated in Appendix B and in the main body. Table “Initiative(or project) Basic Information”, Field “Organization”

6.3 Suggestions for Next Steps

6.3.1 Knowledge sharing in this programme

Due to the limited project period, this deliverable does not present an exhaustive survey. WA3 work packages that follow may find valuable architectures from other or new projects. If WA3 has common templates to share knowledge among consortiums, it would enable efficiency of the whole work in this area. We believe that our architecture survey framework and survey sheet are useful to accumulate and share architectural knowledge in WA3.

6.3.2 The SSH system architecture

This deliverable presents several architecture patterns for the defined quality aspects. Though each pattern has its own characteristics, a pattern found here, generally speaking, represents its own approach to decomposition of an ICT system. Security centric architecture, for example, requires the decomposition of a system according to the asset importance. Strictly confidential data must be separated from other data and should be protected by an elaborate security scheme such as defence-in-depth strategy found in the project we studied. On the other hand, the performance requirement may demand the confidential data should be stored with some other data to guarantee quick data merging. Or, adaptability may, for example, require data separation so that a change of regulation should cause only a simple exchange of corresponding components. In this way quality aspects, or criteria of decomposition, sometimes collapse and bring design discrepancies.

The SSH system, however, should achieve all quality requirements. That is the challenge for WA3 and the challenge for the architect of the SSH system. Architecture is essentially the definition of how a system should be decomposed and how the components should be integrated. In this deliverable, we decomposed an ICT system into six quality aspects. Hence, the fundamental research question that WA3 WP2 and later should answer is “What architecture can satisfy all quality aspects required by the SSH system?”

One of the challenges facing UK power networks is dealing with power instability in the distribution network caused by the increase of RE and increase of variation and number of demand devices in the future [24]. Thus, in future work, we will focus on control of power and devices in distribution networks as challenges in SSHP.

Glossary

Terms	Definition
ACP	Autonomous Control Processor
ADMS	Advanced Distribution Management System
ADS	Autonomous Decentralized System
ATOS	Autonomous decentralized Transport Operation control System
CIM	Common Information Model
CIS	Customer Information System
CTC	Centralised Traffic Control
DA	Distribution Automation
DCS	Distributed Control System
DG	Distributed Generation
DLC+VIT4IP	Distribution Line Carrier: Verification, Integration and Test of PLC Technologies and IP Communication for Utilities
DMS	Distribution Management System
DRMS	Demand Response Management System
DSE	Distributed State Estimation
DSR	Demand side response.
EMS	Energy Management System, Environmental Management System
ESP	Encapsulated Security Payload
EV	Electric Vehicle
EVECC	Electric Vehicle Energy Control Centre
GIS	Geographic Information System
HAN	Home Area Network
HiPerDNO	High performance Computing Platform for Smart Distribution Network Operation
HPC	High Performance Computing
HPCDS	HPC Data System
HPCE	High Performance Computing Engine)
HV	High Voltage
ICT	Information and Communication Technology
IED	Intelligent Electronic Device

ISO	Independent System Operator
LMS	Load Management Systems
LV	Low Voltage
MDMS	Meter Data Management System
MV	Middle Voltage
NEDO	New Energy and Industrial Technology Development Organization
NIST	National Institute of Standards and Technology
PEV	Plug-in Electric Vehicle
PV	Photovoltaic
RTO	Regional Transmission Operator
SCADA	Supervisory Control And Data Acquisition
SSH	Smart System and Heat
SSN	Secondary Substation Nodes

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Appendix A: Project Extensive List

Table A.1 - Abbreviation for Table A.2.

Cat: Category of Information sources		
	1	Expert referrals
	2	Standard Organization Documents
	3	Nikkei survey publication
Ac: Accepted to Short List, and Initiative (or project) Number		
	✓	Check if the initiative (or project) is selected as a part of the short list.
	Number	Number in the short list
SD: Smart Grid Domain		
	D	Distribution
	DER	Distributed Energy Resource
	CP	Consumer Premises
TD: Technical Domain		
	SG	Smart Grid
	HT	Heat
	M	Miscellaneous

QA: Quality Aspect		
	Pf	Performance
	Re	Reliability
	In	Interoperability
	Se	Cyber Security
	Ad	Adaptability
	Af	Affordability

Table A.2 - Initiative (or project) Extensive List

No.	Ac	Cat	Title										
		Source											
		Descriptions											
		SD			TD			QA					
		D	DER	CP	SG	HT	M	Pf	Re	In	Se	Ad	Af
1	✓	1	High Performance Distributed Network Operation (HiPerDNO)										
	1	http://www.hiperdno.eu/											
		Spain, Slovenia, and the UK. The aim of the HiPerDNO project is to answer the following questions: How will our electricity distribution networks cope with a low-carbon future? How can the transition be made? The objective of the project is to develop a new generation of distribution											

		network management systems.											
		✓		✓	✓			✓	✓	✓	✓	✓	✓
2	✓ 2	1	OpenNode										
		http://www.opennode.eu/											
		Spain The OpenNode project will especially focus on the inner parts of the distribution grid, namely the smart Secondary Substation Nodes (SSN) as a substantial component to monitor and control the distribution grid status. It establishes an architecture of Middleware and SSN on the same CIM. The tests were executed on two SSN (Siemens and Nucleo) fast prototype implementations.											
		✓			✓					✓		✓	✓
3		1	EcoGrid EU										
		http://www.eu-ecogrid.net/ http://www.eu-ecogrid.net/images/Documents/120322EcoGridEU_Newsletter_nr.%201_February%2029_2012.pdf http://www.eu-ecogrid.net/images/Documents/120322EcoGridEU%20Detroit2011.pdf http://www.eu-ecogrid.net/images/Documents/121206ecogrid%20eu_standard-presentation_december2012_b.pdf http://www.eu-ecogrid.net/images/Documents/121218ecogrid%20eu%20-%20guide%20to%20the%20large-scale%20project_dec_update.pdf											
		Denmark The objective of EcoGrid EU is to develop a prototype of a European Smart Grid market platform. The demonstration will take place on the Danish island Bornholm where 2.000 households by means of more flexible consumption will show how Europe can manage over 50 % wind power and other fluctuating and less predictable renewable energy sources. The aim of EcoGrid EU is to demonstrate a market concept that is designed to incorporate small-scale distributed energy resources as well as flexible demand into the existing power system markets, balancing tools and operation procedures. The concept will remove the barriers that have been complicating introduction of DERs into the present market structure, e.g. barriers related to size, online monitoring as well as a significant administrative burden including bidding on the markets, complying with schedules and financial obligations. Likewise, the market tool will provide a transparent and simple mechanism as well as sufficient incentives for encouraging the participation of small end consumers. Reason to be omitted from short list: From the view point of ICT architecture, this project mainly focuses on the demonstration of a real-time power system market that is transmission leve, thus the scope of the ICT architecture of this project differs from the envisaged direction of SSH.											

		✓	✓	✓	✓			✓		✓		✓	✓
4		1	DLC+VIT4Ipa										
		http://www.dlc-vit4ip.org/wb/ http://www.dlc-vit4ip.org/wb/media/Downloads/D1.2%20system%20architecture%20design.pdf http://www.dlc-vit4ip.org/wb/pages/home/project-overview/dlc-infrastructure.php											
		(EU) The focus of DLC+4IP (Distribution Line Carrier: Verification, Integration and Test of PLC Technologies and IP Communication for Utilities) project is Power-Line Communication, which on distribution networks is often called Distribution Line Carrier. Power-line communications have a large potential to enable new and intelligent applications to and from the last branch of the distribution grid, including monitoring and control of energy consumption. DLC+VIT4IP will develop, verify and test a high - speed narrow - band powerline communications infrastructure using the Internet Protocol (IP) which is capable of supporting existing and extended new and multiple communication applications. Reason to be omitted from short list: The good quality of communication is needed to implement reliable SSHP, but it is not integral to the ROM (Rough Order of Magnitude) estimate and the Phase 2 trial.											
		✓		✓		✓		✓		✓		✓	
5	✓ 7	1	Danish Cell-controller Pilot Project (CCPP)										
		http://energinet.dk/EN/FORSKNING/Energinet-dks-forskning-og-udvikling/Celleprojektet-intelligent-mobilisering-af-distribueret-elproduktion/Sider/Celleprojektet-fremtidens-intelligente-elsystem.aspx											
		Denmark The power systems of Denmark are characterised by a high penetration of distributed generation (DG) comprised of small to medium scale combined heat and power plants (CHP) and wind turbines (WTs). The aim of the Cell Project is to develop the controllers and the data-acquisition, command, and communication infrastructure necessary to realise such wide-area control of a distribution grid.											
		✓	✓		✓	✓			✓	✓		✓	
6		2	4th Generation District Heating Technologies and Systems										
		http://www.4dh.dk/											
		This project covers low temperature and small scale DH system. Because the systems are the first of this kind in terms of small size but good efficiency, it is expected that the recovery of the initial investment will take a relatively short time compare with large scale DH. So, 4th generation DH has the potential to replace the conventional style of individual heating. Reason to be omitted from short list: From an ICT architecture point of view, the system can be seen as an aggregated electrical power load or middle size of prosumer and as such it requires no special											

		information architecture.											
		✓	✓	✓		✓		✓	✓			✓	✓
7	✓	1	A Prototype for Island-type Smart Grid										
	4	1) Hitachi internal source 2) The overall project introduction http://www.ct-si.org/events/APCE2011/sld/pdf/85.pdf <Japanese> http://www.hitachihyoron.com/2012/03/pdf/03_topics01.pdf 3) The Use Case is registered in EPRI Use Case Repository. http://www.smartgrid.epri.com/Repository/Repository.aspx (can be searched by chedww.smartgrid.epri.com4) Cyber Security specification the system based on. http://www.nerc.com/filez/standards/Project_2008-06_Cyber_Security_Version_5_CIP_Standards_.html											
		USA Official project name is /stand “U.S. Island Grid Project” funded by NEDO (New Energy and Industrial Technology Development Organization). This project is for the electric power grid control technology and business model demonstration under massive penetration of renewable energy. The information architecture support for countermeasure to the issue caused by variable renewable energy is unique and registered in EPRI Smart Grid repository. Also the ICT system has the capability for information sharing among the multi business entities with hi level of Cyber Security and privacy protection along with latest USA standard of NERC CIP v5.											
		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
8	✓	1	A Traffic Management System for Mass Transit										
	5	http://dbnst.nii.ac.jp/pro/detail/534											
		Japan Traffic-management network connects plural subsystems each of which represents a station. Due to maintenance, subsystems are added, modified, and deleted. These ICT functionalities are realised by autonomous.											
		-	-	-			✓		✓			✓	
9	✓	1	A Traffic Management System for Bullet Train										
	6	http://www.hitachihyoron.com/2012/06/pdf/06a08.pdf											
		Japan Bullet-train operation system. PRC (Programmed Route Control) on a highly reliable IT platform with cutting-edge design of architecture. The bullet train operation interoperates with other operator.											
		-	-	-			✓		✓	✓		✓	
10	✓	2	Guidelines for Smart Grid Cyber Security										
	3	http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol1.pdf											
		NIST IR 7628 is the Guidelines for Smart Grid Cyber Security, prepared by the Cyber											

		Security Working Group (CSWG) of the Smart Grid Interoperability Panel (SGIP), set the trend for all further work in the area in other regions of the world and especially the European Union.											
		✓	✓	✓	✓						✓		
11	✓ 8	2	M/490 Smart Grid Information Security working group										
		ftp://ftp.cen.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/Security.pdf											
		M/490 produced by the Smart Grid Task Force (SGTF) of the European Commission Energy Directorate General (DG ENER) aims at encompassing all smart grid domains beyond smart metering, with special attention on enabling bi-directional energy flows and managing decentralized energy resources such as localized solar or wind energy generation and storage facilities including electric vehicle batteries.											
		✓	✓	✓	✓						✓		
12	✓ 9	1	EU-Commission Smart Grid Task Force (SGTF)										
		gemalto internal source											
		The EU-Commission SGTF under DG ENER has instructed in early 2012 further work on Smart Grid additionally to the standardization mandate M/490. Amongst a High Level Steering Committee four Experts Groups (EGs) were formed. The aim of EGs is to work out jointly agreed, regulatory recommendations and to identify projects with which an economical, efficient and fair realization of Smart Grids can be ensured. A Data Privacy Impact Assessment Framework for Smart Grids and a set of “Best Available techniques” (i.e. countermeasures) to address the smart grids cyber security threats are currently been finalizing.											
				✓	✓						✓		
13		3	Smart Grid R&D Stockholm Royal Seaport										
		http://www.fortum.com/en/pages/default.aspx http://www.energimyndigheten.se/Global/Forskning/Kraft/NDS%20f%C3%B6rstudie%20ENG%20final%20_public.pdf											
		Sweden This project was a pre-study which consists of six work packages (WPs) covering from business model design to demonstration of prosumers’ components control. Among the WPs, WP 5 (SRS Information Management System) exclusively related to the ICT system. A solution overview of the WP which depicts functions, structure of actors and communication network structure was reported in the final report. The first installation of the secondary substattion equippment and residential buildings (apartments) would be finished in 2013. Reason to be omitted from short list: Because of the time line of the project, the disclosed information is high level system concept. So, it is difficult to see the linkage between architecture and quality aspects. Thus, it is difficult to determine the implications for the ICT architecture.											
		✓	✓	✓	✓	✓	✓		✓	✓			✓
14		2	DH : Water source (River) Heat Pump System										

		Tokyo Toshi Service Home Page http://www.tts-kk.co.jp/tts-kk/service/dhc/index.html Kan-ed corporation http://www.kan-ed.co.jp/db/db_06.pdf											
		Japan The Heat source of this DH is the water (River Water). The energy reduction for heat source is 6% - 13% (15% Kan-ed case) compare to previous air source system. Reason to be omitted from short list: From an ICT architecture point of view, the system can be seen as an electrical power load and as such it requires no special information architecture.											
		✓				✓	✓					✓	
15		2	DH : Water source (sewerage water treatment plant) Heat Pump System										
		TOKYO SEWERAGE ENERGY CoRPORATION http://tse-kk.co.jp/plantguide/kouraku01.shtml											
		Japan The Heat source of this DH is the water (sewarge water) . The energy reduction for heat source is around 38% compare to individual heating/cooling system. Reason to be omitted from short list: From an ICT architecture point of view, the system can be seen as an electrical power load and as such it requires no special information architecture.											
		✓				✓	✓					✓	
16		2	DH : Water source (sea water) Heat Pump System										
		SHIKOKU ELECTRIC POWER CO., INC. http://www.yonden.co.jp/corporate/csr/report/pdf/csr_report2012_03.pdf http://enec-n.energia.co.jp/enec_data/chikunetsu/heatpump/hp73/hp73-01.pdf											
		Japan The Heat source of this DH is the water (Sea Water) . The energy reduction for heat source is around 20% compare to previous air source system. Reason to be omitted from short list: From an ICT architecture point of view, the system can be seen as an electrical power load and as such it requires no special information architecture.											
		✓				✓	✓	✓					
17		2	DH : ground source Heat Pump System										

		TOBU ENERGY MANAGEMENT CO.,LTD. http://www.tobu-em.co.jp/dhc.html											
		Japan The Heat source of this DH is the ground heat. The energy reduction for heat source is around 43% compare to previous air source system. Reason to be omitted from short list: From an ICT architecture point of view, the system can be seen as an electrical power load and as such it requires no special information architecture.											
		✓				✓	✓	✓					✓
18		2	AIM: A novel architecture for modelling, virtualising and managing theenergy consumption of household appliances										
		http://cordis.europa.eu/fetch?CALLER=PROJ_ICT&ACTION=D&DOC=1&CAT=PROJ&QUERY=013c9f6bda86:a9bc:23f73ed0&RCN=86728											
		Germany, Greece, Netherlands, Switzerland and Italy The main objective of the project is to foster a harmonised technology for managing in real time the energy consumption of appliances at home, interworking this information to communication devices over the home network and virtualising it with the final aim of making it available to users through home communication networks in the form of standalone or network operator services. Reason to be omitted from short list: From an ICT architecture point of view, the system is applied only within home and so can be seen as a consumer side intelligent agent in the SSH network. Because its scope is mainly in-home application and interconnection between in-home and outside SSH looks very simple,											
				✓			✓			✓			✓
19		2	DEHEMS: Digital environment home energy management system										
		http://cordis.europa.eu/projects/rcn/87608_en.html											
		UK, Bulgaria, and Romania DEHEMS will extend the current state of the art in intelligent meters, moving beyond energy "input" models that monitor the levels of energy being used to an "energy performance model" that also looks at the way in which the energy is used. It will bring together sensor data in areas such as household heat loss and appliance performance as well as energy usage monitoring to give real time information on emissions and the energy performance of appliances and services. It will enable changes to be made to those appliances/services remotely from the mobile phone or PC and provide specific energy efficiency recommendations, for the household. The impact will be to personalize action on climate change, and so help enable new policies such as Personal Carbon Allowances as well as supporting the move towards increased localized generation and distribution of energy. Reason to be omitted from short list:											

		From an ICT architecture point of view, the system is applied only within home includes intelligent meter and so can be seen as a consumer side intelligent agent in the SSH network. Because its scope is mainly in-home application and interconnection between in-home and outside SSH looks very simple,											
			✓	✓		✓	✓						✓
20		2	E-STARS: Efficient smart systems with enhanced energy storage										
		http://cordis.europa.eu/projects/rcn/86717_en.html											
		France, Netherland, Ireland, Italia, and Germany E-STARS project aims at developing enhanced sensing and communication capability on an autonomous smart micro system powered by a new 3D high capacity integrated micro battery. According to the experts, the market of wireless smart sensors should generate revenues more than 5 billion euro in 2011 (source: http://www.rfidjournal.com). Faced with such future strong technical and economical impact, it is of strategic importance to maintain the Europe's leadership in these domains. Considered as an RandD topic of high relevance in such domain (EpoSS Strategic Research Agenda), the energy-management, scavenging and storing techniques aspects will be particularly investigated by the E-STARS project. Reason to be omitted from short list: From an ICT architecture point of view, the project provides a battery-based energy storage in the SSH network and forcuses on investing new deposition processes for micro battery, and, as such, it presents no special information on the ICT architecture relevant to the SSH programme.											
			✓		✓				✓				✓
21		2	EBADGE: Development of Novel ICT tools for integrated Balancing Market Enabling Aggregated Demand Response and Distributed Generation Capacity										
		http://cordis.europa.eu/projects/rcn/105542_en.html											
		Slovenia, Austria, SUOMI/Finland, Italia, and Germany The 3rd Energy Package clearly boosts the development of an Integrated European balancing mechanism. In this context, ACER has in 2011 started the development of the Framework Guidelines on Electricity Balancing. It is expected from the ACER statements that Demand Response will play significant role in the future integrated balancing market allowing Virtual Power Plants, comprising Demand Response and Distributed Generation resources to compete on equal ground. Reason to be omitted from short list: From an ICT architecture point of view, the project describes Demand Ressponse which is already within the scope of the anticipated architecture. Also this project is still ongoing and will end in 2015, and thus, the result is not yet achieved.											
		✓					✓		✓				
22		1, 2	SMARTHOUSE/SMARTGRID: Smart houses interacting with smart grids to achieve next-generation energy efficiency and sustainability										

		http://cordis.europa.eu/projects/rcn/87374_en.html											
		Germany, Greece, and Netherlands Current smart house/energy technologies treat home and working environments as effectively consisting of isolated and passive individual units. This severely limits achieved energy efficiency, as it ignores the potential delivered by homes, offices, and commercial buildings seen as intelligent networked collaborations. Thus, the SmartHouse/SmartGrid project introduces a holistic concept for smart houses situated and intelligently managed within their broader environment. It develops intelligent networked ICT technology for collaborative technical-commercial aggregations of Smart Houses able to communicate, interact and negotiate with both customers and energy devices in the local energy grid so as to achieve maximum overall energy efficiency as a whole. Reason to be omitted from short list: From an ICT architecture point of view, the project uses available open industry standards in both the ICT and energy sectors and employs communication and computing capabilities that are already in widespread use in mainstream home and working environments. In other words, this project does not assume any new feature in those fields.											
				✓	✓		✓			✓			✓
23		2	INERTIA: Integrating Active, Flexible and Responsive Tertiary Prosumers into a Smart Distribution Grid										
		http://cordis.europa.eu/projects/rcn/105543_en.html											
		Greece, Netherland, Slovakia, Sweeden, Italia, and Spain INERTIA will introduce the Internet of Things/Services principles to the Distribution Grid Control and DSM Operations. It will provide an overlay network for coordination and active grid control, running on top of the existing grid and consisting of distributed and autonomous intelligent Commercial Prosumer Hubs. This way, it will address the present "structural inertia" of DG by introducing more active elements combined with the necessary control and distributed coordination mechanisms. Semantically enhanced DER (generation and consumption) will be the main constituents of the INERTIA active DG framework. DER will constitute active and flexible components carrying contextual knowledge of their local environment. DER will form dynamic clusters comprising self-organized networks of active nodes that will efficiently distribute and balance global and local intelligence. The DER self-organized overlay network will allow for seamless management and control of the active grid and the optimal exploration of single and aggregated prosumer capacity (generation and consumption) to participate in energy balancing and other DG related services. Reason to be omitted from short list: This project is just started in Oct. 2012 and is in progress untill Sep. 2015. The information may be a good reference, but nothing is prooved yet. Regarding DER from an ICT architecture point of view, the project describes DER which is already within the scope of the anticipated architecture.											
		✓			✓					✓			

24		2	INTEGRIS: INTelligent Electrical Grid Sensor communications										
		http://cordis.europa.eu/projects/rcn/93726_en.html											
		Spain, Finland, France, Switzerland, and Italia INTEGRIS project proposes the development of a novel and flexible ICT infrastructure based on a hybrid Power Line Communication-wireless integrated communications system able to completely and efficiently fulfill the communications requirements foreseen for the Smart Electricity Networks of the future. This includes encompassing applications such as monitoring, operation, customer integration, demand side management, voltage control, quality of service control, control of Distributed Energy Resources and asset management and can enable a variety of improved power system operations, some of which are to be implemented in field trials that must proof the validity of the developed ICT infrastructure. Reason to be omitted from short list: From an ICT architecture point of view, the project describes the detail of communication technology, and therefore it does not have much impact on the whole outline architecture of the SSH. (It may be important in consideration of the detail of the UK SSH.)											
			✓		✓			✓		✓			
25		2	SMARTC2NET: Smart Control of Energy Distribution Grids over Heterogeneous Communication Networks										
		http://cordis.europa.eu/fetch?CALLER=PROJ_ICT&ACTION=D&DOC=11&CAT=PROJ&QUERY=013ca2d414c6:0a96:21e244a8&RCN=106172											
		Austria, Germany, Denmark, Portugal, Italia, and Netherland Stability and cost-efficient operation of Power distribution grids are the main targets of novel information-rich demand, voltage, and generation control, while at the same time aiming to reduce costs for the grid infrastructure. However, adding intelligence to the power grid requires communication and computation infrastructure, with consequent requirements for additional investments. To be cost efficient, it is therefore essential to enable intelligent power grid operation leveraging existing communication infrastructures. The SmartC2Net results will clearly show that intelligent distribution grid operation can be realized in a robust manner over existing communication infrastructures even despite the presence of accidental faults and malicious attacks. Reason to be omitted from short list: From an ICT architecture point of view, the case describes the detail of communication infrastructure technology, and trys to proove that middleware functions create awareness of the communication network properties and their impact on information quality. However, this project is now in the execution precess starting from Dec. 2012 and so need years to hear the results from them.											
		✓	✓		✓				✓		✓	✓	✓
26		2	W2E: WEB to Energy										

		http://cordis.europa.eu/projects/rcn/93736_en.html											
		Germany, Poland, Austria, Netherland, and Switzerland The project WEB to Energy (W2E) aims to develop this open, universally accessible and standardized ICT communication infrastructure. The key idea is the consistent, homogeneous and uniform application of globally accepted IEC standards. W2E thus provides a seamless approach to standardisation from the process level, through the ICT infrastructure up to the control centre level. Reason to be omitted from short list: From an ICT architecture point of view, the case describes the standardization of communication technology, and so it does not have much impact on the whole outline architecture of the SSH. Moreover, this project has just finished at the end of 2012 and so requires more time for them to publish the result of the project. (It may be important in consideration of the UK SSH in detail.)											
							✓		✓			✓	
27		1	Customer-Led Network Revolution										
		http://www.networkrevolution.co.uk/											
		UK Over a three-year period, Northern Powergrid and its partners will be trialling smart grid solutions on the distribution network within the electricity grid as well as creating smart-enabled homes to give customers more flexibility over the way they use and generate electricity. The results will help the industry make sure the electricity networks can handle the mass introduction of solar PV panels, electric cars and other low-carbon technologies. Reason to be omitted from short list: From an ICT architecture point of view, this project provides the concepts of customer involvement into the electricity grid, but show little detailed technical information, especially in ICT architecture.											
				✓		✓	✓					✓	✓
28		1	A coordination action on ICT vulnerabilities of power systems and the relevant defence methodologies										
		<ICT in FP7: Objectives and Overview> http://cordis.europa.eu/fp7/ict/ Project search by key word can be done by the URL following. http://cordis.europa.eu/fp7/ict/projects/home_en.html											
		France FP7: The specific programme on 'Cooperation' supports all types of research activities carried out by different research bodies in trans-national cooperation and aims to gain or consolidate leadership in key scientific and technology areas.											

		Reason to be omitted from short list: From ICT architecture point of view, this case describes some conceptual ICT information, but nothing specific on its architecture relevant to the smart system and heat programme was found in the reference listed above even though some have technically useful information but less important to the SSH..											
							✓					✓	
29		1	SmartGrids ERA-Net										
		http://www.eranet-smartgrids.eu/ <Objective> http://www.eranet-smartgrids.eu/?q=node/5 <Report> http://www.eranet-smartgrids.eu/files/Deliverable4.2.1_final.pdf											
		The objective of the ERA-NET is to ensure essential, coordinated research is conducted in preparation for the large-scale integration of the SmartGrids architecture. It is a pragmatic outcome of the strategy developed by the SmartGrids European Technology Platform (ETP). The ERA-NET will align national and regional research programmes in order to produce the necessary findings to accelerate the ETP's implementation plan, which will eventually include demonstration and deployment projects. The SmartGrids ERA-Net aims at developing transnational research activities to speed up the development of a Smart European Electrical Infrastructure. The latter is regarded as a necessity for a successful realisation of the European Action Plan "Energy Policy for Europe". Reason to be omitted from short list: This is very useful to learn the institutional and legal structure of each country described in this project. But, from an ICT architecture point of view, the report describes the existing national structures, for example laws and rules, and activities of each country and no detailed information of ICT architecture is found in it.											
30		1	WATTALYST										
		http://cordis.europa.eu/projects/rcn/100984_en.html http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=12385382											
		TBD Objective: Demand Response [DR] programs along with the emergence of technology to support DR are known to offer a high potential for energy consumption reduction. Research related to demand response and demand side management has addressed a suite of issues including differential pricing, incentive schemes, consumption profiling, and eco-feedback. Understanding these factors (such as weather, local events, consumer context,) that influence the demand side and appropriately integrated in the DR programs is crucial to the success of DR. WATTALYST (WATT anALYSis Technologies) will address this need by establishing correlations between electricity consumption (monitored on a fine-grained basis) and the factors that influence demand side participation. The insights gained will be											

		presented to DR designers using a visual analytics framework that can help the designers, and possibly also policy makers, to design and implement effective DR solutions and configure related parameters when it comes to energy/DR information communication (visualization) and consumer incentives, including pricing models. Reason to be omitted from short list: From an ICT architecture point of view, this ongoing project describes some insights on Demand Response programs but although useful information may be going to be published when the project ends in 2014,but not much information about ICT architecture is mentioned in it.											
				✓			✓			✓		✓	✓
31		1	Advanced Dynamic Energy Pricing and Tariffs (ADEPT)										
		http://ukerc.rl.ac.uk/cgi-bin/ercri5.pl?GChoose=gpersum&GrantPerson=1590&GRN=EP/I000194/1%20&QString=SearchTerm=Darby											
		UK A crucial research question that must be answered in the near term is "How complicated can, or should, a dynamic electricity tariff be?", such that it is accepted by the public and offers clear enhancements and incentives for reduction in energy demand? The 'can' and 'should' reflect the fact that any ubiquitous technical system is (primarily) designed and implemented by experts, but has to be accepted and operated by non-experts. ADEPT looks at how the information potentially available from smart meters may be exploited to the advantage of both the distribution network operator and the customer. Reason to be omitted from short list: From an ICT architecture point of view, the project does not describe any ICT architecture elements that are beneficial to the ICT architecture on the SSH. This is still in progress, and the technical information of the ICT architecture may be available once it is done.											
		✓		✓			✓						✓
32		1	Intelligent Agents for Home Energy Management										
		http://www.homeenergyagents.info/index.php											
		UK This project seeks to apply novel artificial intelligence approaches to develop intelligent agents that will enable domestic consumers to visualise, understand and manage their energy use. It is a three year EPSRC project (EP/I000143/1), which started in October 2010, within the 'Transforming Energy Demand through Digital Innovation' call. Reason to be omitted from short list: From an ICT architecture point of view, the characteristics of energy use, human factors, etc. are mentioned in this project, but any technological aspects, such as ICT architectures are not described in the reference, and since it is ongoing project, any key findings are not published yet,..											

				✓			✓						✓

Appendix B: Project Survey Sheets

B.1 I0: Explanation of the Project Survey Sheet

A survey on a project consists of several tables which forms a structure. A project may inspire architectures. An architecture may contribute to multiple quality aspects. Taking this structure into account the project survey sheets are organised as follows.

A project survey starts with a **Basic Information** table followed by **Findings** tables and **UK SSH applicability** tables. The study on one of the architectures consists of possibly multiple **Findings** tables and a **UK SSH applicability** table. Each **Findings** table corresponds to a distinct quality aspect.

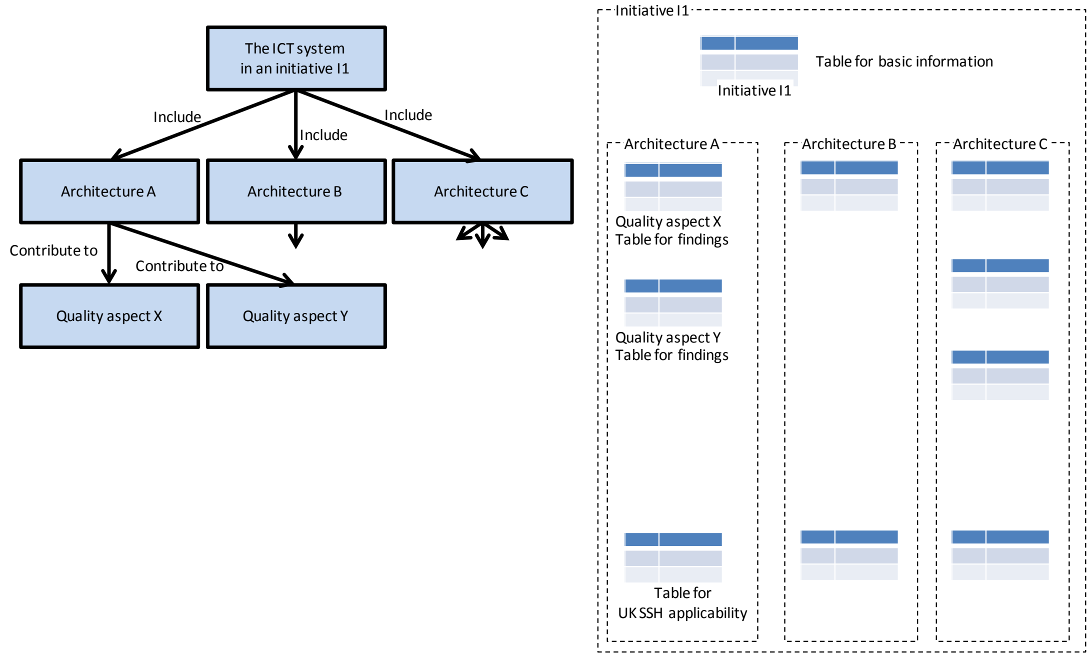

Figure B.1.1 - Structure of Survey Tables for a project.

Table B.1.1 - Project Survey Sheet for Basic Information

Project Basic Information			
Reviewer	Names of reviewers who conducted the survey.	Date	Updated day
ID	ETI-SSHP-WA3-WP1-H-*n*: *n* is unique serial number within the work package.	Revision	Revision Number
Initiative(or project) name (or system name)	Project title grasping its project.		
Application domain	Smart grid: power dedicated project. Smart city: multi domain project. Other projects are presented by its domain, e.g. transportation.		
Organisation (developed or operated by)	Major business and academic entities that practically conducted the project of interest. E.g. companies, universities.		

Nation delivered	Name of nations or geographical information if available and explicit. This must not be precise and exhaustive.
Delivered or trial	Trial for prototyping and delivery for commercial.
Delivered or trial year	Major landmark year of the project for helping readers to grasp the era.
Reference	Pointers to web pages, documents, and academic papers.
What the system intends to achieve	Brief introduction of the domain or service which the system of interest supports. Typically the answer consists of two viewpoints: **1) Project overview** - Background, aims, objectives and characteristics of the project, especially useful information for understanding reasoning of architecture adapted. Aims are something the project hope or hoped to achieve by doing something. And objectives are something that the project tries or tried hard to achieve - Timeframes of the project. When it started and when it finished or will finish. **2) ICT system overview** - ICT system configuration to clarify the key features of the ICT architecture. This typically refers to the figure. - Key elements should be clarified referring the figure.
Scope	Scope of the project should be clarified.
Typical use case	Narrative description of ICT system especially with respect to functionality. Typical scenes are described.
Scale	- Project budget (if possible) - A parameter which appeals the scale of the ICT architecture depending on the project. For example, size of components, target data amount, etc.
Cost (if available)	If information of the budget or cost is found, we refer the information just for reference. This is expected to be supplemental information for readers, instead of fact description.

Table B.1.2 - Project Survey Sheet for Findings

Findings	
Quality aspect	Quality aspect(s) that the derived architecture is effective to. The set of possible QAs are predefined in the main body: adaptability, affordability, availability, interoperability, performance, and security.
Featured system architecture	This describes exploited abstract architecture. While the answer is narrative, this typically refers to a block diagram.
Design aspect	This is the very essence of the architecture described by short sentences.
Pros	Technical merits expected to have from the architecture.
Cons	Technical demerits expected to have from the architecture.

Table B.1.3 - Project Survey Sheet for UK SSH Applicability

UK SSH Applicability	
UK SSH applicability	Yes / No / Uncertain from broader point of view, including technical and political aspects.
Possible application	Taking the SSH definition and pros/cons of the architecture into account possible applications to SSH are described. Overlaps between the project and SSH system considering timeframe of overall SSH program should be emphasized especially SSH energy systems which features of the project

	relates to. This is just supplemental information for readers understanding. Formal studies of SSH applicability should be discussed in Task 4.

B.2 I1: High performance Computing Platform for Smart Distribution Network Operation: HiPerDNO

B.2.1 Project Basic Information

Table B.2.1.1 - Project Survey Sheet for Basic Information: HiPerDNO

Project Basic Information			
Reviewer	Atsushi Kubota	Date	24/01/2013
ID	ETI-SSHP-WA3-WP1-H-1	Revision	1.9
Initiative(or project) me (or system name)	High performance Computing Technologies for Smart Distribution Network Operation : HiPerDNO		
Application domain	Smart grid		
Organisation (developed or operated by)	Brunel University (UK), University of Oxford (UK), Electricite De France S.A (France), Fraunhofer IWES (Germany), GTD (Spain), IBM (Israel), Indra (Spain), Korona (Slovenia), UK Power Networks (UK), Union Fenosa (Spain), and Elektro Gorenjska (Slovenia)		
Nation delivered	Spain, Slovenia, and the UK.		
Delivered or trial	Off-line field trials in Spain, Slovenia, and the UK.		
Delivered or trial year	Off-line field trials in 2013		
Reference	Main reference: - http://www.hiperdno.eu/ [10] Additional reference: - "A hardware and software computational platform for the HiPerDNO project" [8] - "Recent developments towards novel high performance computing and communications solutions for smart distribution network operation" [9] - "High Performance Computing Platform for Advanced Distributed Network Operations" [11]		
What the system intends to achieve	**1) Project overview** - In UK, millions of homes and businesses with smart meters, increasing use of distributed generation and electrification of transportation and heating is envisioned as a low-carbon future. - How will our electricity distribution networks cope with such low-carbon future? How can the transition be made? The aim of the HiPerDNO project is to make answer for the questions. The objective of the project is to develop a new generation of distribution network management systems. - The timeframe of the project is from Feb. 2010 to Mar. 2013. **2) ICT system overview** - One of the architectural innovations by HiPerDNO project is adding High Performance Computing (HPC) level under operational level which Distribution Management System (DMS) usually has for its service. (Right part of Figure B.2.1.1) - In the HPC level, two major components are deployed with Communications platform. One of them is a parallel processing system (HPCE) (Figure B.2.1.2) and the other one is a highly fault-tolerant file system (HPCDS). They are designed to run on commodity hardware. - Also, another architectural innovation in Distribution Network by HiPerDNO is common information bridging module. The module provides		

	scalable and robust capability by the middleware in it. The module are deployed in intermediate node in Distribution network along with the distribution lines and at the location close to consumers for the purpose for gathering data and conflating the raw data to produce aggregated data-streams. The final data stream is to DMS. This is achieved by hierarchically aligned modules in distribution networks (Left part of Figure B.2.1.1)
Scope	- Distribution management system - High speed communication system in distribution network,
Typical use case	- One of the challenges to control future distribution networks is to estimate the network state in near-to-real-time. The following is a use case to cope with this issue. - 1) The DMS (Distribution Management System) sends DSE (Distributed State Estimation) requirement to HPCE (High Performance Computing Engine). - 2) DSE task has the highest priority hence the HPCE scheduler provides the required resources, if necessary by stopping lower priority tasks and requiring them. - 3) Based on the DSE requirement, HPCE requests input data from the HPCDS (HPC Data System), executes DSE, and store result into HPCDS. - 4) The HPC Engine notifies the DMS on completion of the - DSE. - 5) The DMS retrieves the computation results from the HPCDS. - 6) The DMS presents the results to the operator, either on manual or automatic request. - 7) The HPC Engine scheduler restarts the tasks interrupted earlier and/or starts new tasks in the queue according to their priorities.
Scale	- Information about budget of the project is not available - Node of distribution network (typical large one) : 80,000 Nodes Receiving data by HPC platform : 4TB per day for 4Million customers
Cost (if available)	Not available

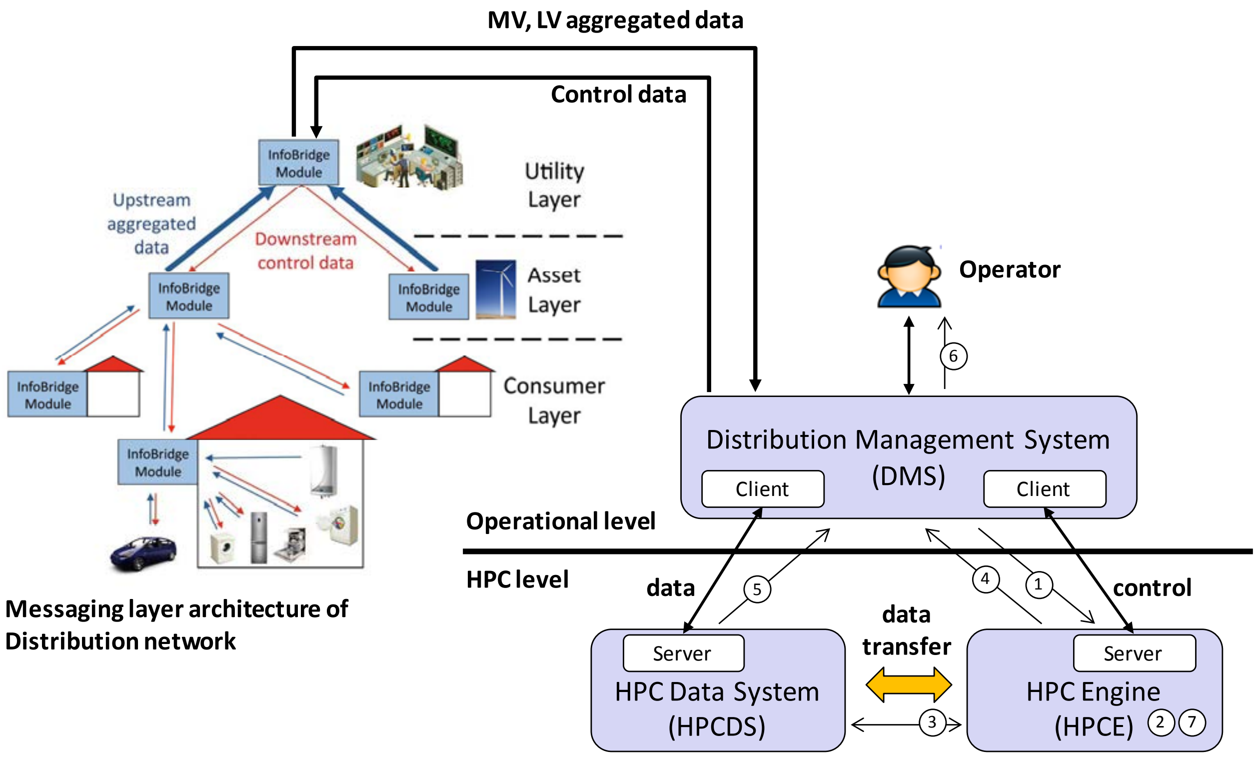

Figure B.2.1.1- System Overview (numbers in circles over arrows corresponds to use case numbers in Table B.2.1.1) [8], [9]

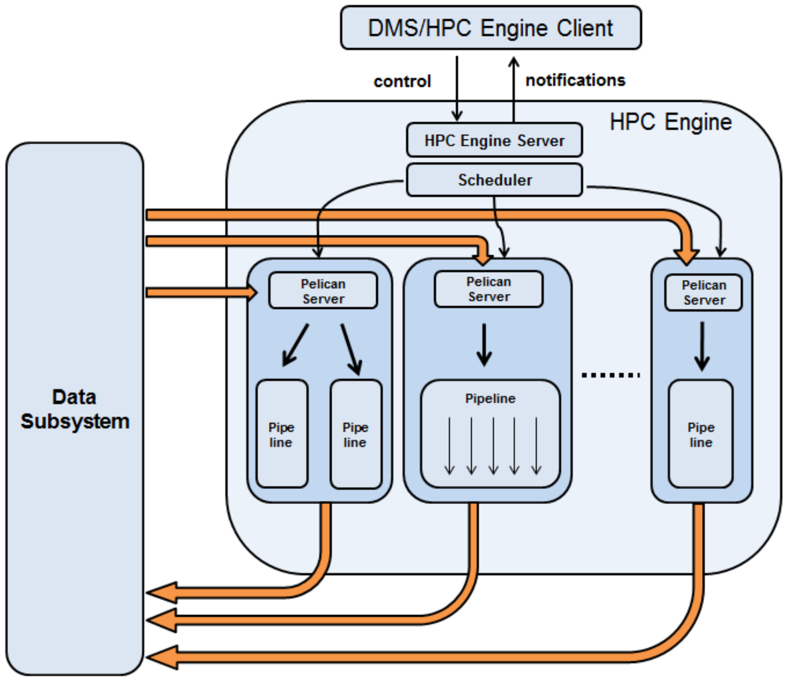

Figure B.2.1.2 - System overview of the HPC Engine [8]

B.2.2 Findings

Table B.2.2.1 - Project Survey Sheet for Findings: HiPerDNO

Findings	
Quality aspect	Performance (Pf), Reliability (Re), Interoperability (In), Security (Se). Adaptability (Ad), and Affordability (Af)
Featured system architecture	1) Separation of functions: function modules for the Distribution Status Estimation (DSE) are implemented by divided module into DMSPCEHPCDS. (a) HPCE and HPCDS would be in close physical co-location because of wide communication bandwidth requirement. (b) Data can only be stored and/or accessed on the Data System; computation control and monitoring can only connect from the DMS to the HPC Engine. Neither can data be accessed nor computations carried out except through the DMS. 2) Client-Server Model: The DMS clients would require either data or computation from appropriate servers residing within the HPCDS and HPCE. The DMS clients would require either data or computation from appropriate servers residing within the HPCDS and HPCE. 3) The HPCE is built using Pelican framework which is a software library for parallel data processing architecture with loosely coupled federation of commodity clusters (Figure B.2.1.2). (a) The HPCE scheduler assigns tasks to each clusters of Pelican (b) In each cluster of Pelican, data streams are processed in parallel to archive high performance concurrent computing. (c) In the case of a cluster shut off, the scheduler would redistribute the load to the others to archive high resiliency. (d) Clusters are made of commodity computational resources to archive cost saving. 4) Clipping data conflation functionality in modules in intermediate nodes and place them hierarchically in distribution networks. The networks enable hierarchical conflation of MV/LV distribution network data (from smart meters et. al.). 5) Middleware is common in the modules in intermediate nodes in the distributed networks whereas input and output of data stream differ corresponding to connected devices to the modules. In the module, two major functions, conflation functionality, are implemented for outbound communication. They are connected through API to the middleware.
Design aspect	(Pf) Physical distance of communication : close (Pf) Degree of concurrency : parallel (Ad, Re, Se) Criterion of modularization: Business logic, Computation and Storage

	(In) Component commonality : Use of commodity (In) API commonality : Use of standard common information model (Af) Modular interoperability : High
Pros	- Data transfer between the HPCE and the HPCDS could be fast as close physical co-location.,(Pf),1)-a) - Fast data aggregation could be achieved as data conflation is executed by multiple distributed modules in intermediate nodes in parallel.,(Pf),4) - A scheduler in the HPCE allocates computational resources to prioritized tasks.,(Pf),3),4)-a) - High performance is achieved by parallel processing.,(Pf),3),4)-b) - New technologies for the HPCE and the HPCDS could be incorporated independently from the business logic in the DMS.,(Ad),1)-b) - The DMS also could be upgraded independently on the HPCE and the HPCDS.,(Ad),1)-b) - As each module is defined to require narrowly specified skills, the efficiency of development / maintenance is high.,(Ad),2) - Hierarchical aggregation model enables incremental settlement of data aggregation system.,(Ad),4) - The HPCE system could be upgraded when required with minimum impact on application and overall layout; extra nodes could be added, components of higher performance could be replaced existing ones or be added.,(Ad),3),4)-d) - Irregular access to the HPCDS can be easily prohibited as the interface of the HPCDS is limited.,(Se),2) - Use of public libraries increases transparency.,(Se),3,4)-a) - A range of DMSs are employed by DNOs, and the client-server model minimises the modifications required by different DMSs to access the HPC mechanisms.,(In),2) - Use of open standards for API facilitates price of the modules in intermediate nodes erosion through competition because any company can produce it.,(In),5) - Hierarchical aggregation model enables incremental settlement of data aggregation system.,(Af),4) - High reliability asset management enables state based maintenance (replacement of aging asset), and it costs less than scheduled maintenance.,(Af),3) - Use of public libraries makes the maintenance cost lower due to rich peripheral tools (i.e. debugging tools).,(Af),3),4)-a) - It is possible to produce the HPCE system or enhance performance with less expensive commodity computational resources.,(Af),3),4)-d) - Use of open standards for API facilitates price of the modules in intermediate nodes erosion through competition because any company can produce it.,(Af),4) - Data aggregation is robust as data in distribution network is aggregated hierarchically,(Re),4)-a) - Integration of messaging layer of distributed network and the DMS with the HPC platform enables high reliability asset management so as to minimize Customer Interruptions and Customer Minutes Lost.,(Re),3)-a) - Even in case of clusters malfunction, the HPCE system does not stop.,(Re),3,4)-c)
Cons	- (all) Overhead (i.e. initial cost, physical space for equipments, administration load, and hardware maintenances) may run over merits from the architecture.

Table B.2.2.2 - Project Survey Sheet for UK SSH Applicability: HiPerDNO

UK SSH Applicability	
UK SSH applicability and rationale	Applicable. We recognise no factor against.
Possible application	In distribution networks in UK, because current capacity of ICT system (communication bandwidths, computational performance, and et.al) is rather modest, there will be capacity issues along with future low carbon network. Low carbon means increasing use of intermittent renewable energy, highly penetration of smart meters, smart appliances, distributed heating and highly electricity of transportation (EV) and heating (heat pump). Thus, the ICT system architecture of UK SSH requires cost-effective, scalable and secure performance to cope with such future challenges (Af, Ad, Se and Pf). In addition, replacement or renewal of ICT infrastructure will not be achieved in short period because penetration of future low carbon network entities is incremental and capacity issue is then also incremental. So the architecture should permit incremental replacement of DNO infrastructure (Ad, In and Af). In addition, because the ICT system is social infrastructure, including even the scene of replacement, stable and secure operation is necessary (Re and Se). The HiPerDNO project develops novel distribution management system functionality relevant to the UK. So its ICT architecture is developed considering above requirements. Thus from these view point, the HiPerDNO overlaps distribution network and distribution management system of SSH system. From another viewpoint, with reference to envisioning use cases of UK SSH, capability of DNOs is required to be enhanced; especially in a scene of balancing mechanism, checking distribution network capacity more frequently and precisely than now. The ICT architecture of HiPerDNO could cope with the scene with distributed bridging module and HPC platforms. Thus, from above both viewpoints, we think that renewed DNO system with HiPerDNO can play a role of distribution network manager which UK SSH use cases suppose to involve.

B.3 I2: The OpenNode

B.3.1 Project Basic Information

Table B.3.1.1 - Project Survey Sheet for Basic Information: the OpenNode

Project Basic Information			
Reviewer	Tsutomu Nemoto	Date	28/12/2012
ID	ETI-SSHP-WA3-WP1-H-2	Revision	1.4
Initiative(or project) name (or system name)	The OpenNode - Open Architecture for Secondary Nodes of the Electricity SmartGrid		
Application domain	Smart grid		
Organisation (developed or operated by)	ATOS, IBERDROLA, EDP, EDF Group, SIEMENS Germany, NUCLEO, KEMA, ITE, and SIEMENS Austria		
Nation delivered	Spain		
Delivered or trial	The lab tests in Clamart, The field test in Madrid		

Delivered or trial year	The lab tests finished by July 2012, The field test was done in September 2012
Reference	http://www.opennode.eu/ [12]

What the system intends to achieve	**1) Project overview (Figure B.3.1.1)**
	- Established the architecture of Middleware and SSN (open Secondary Substation Node) on the same CIM (Common Information Model).
	- The tests were executed on two SSN (Siemens and Nucleo) fast prototype implementations.
	2) ICT system overview (Figure B.3.1.2)
	- Establishing the common CIM for the communication between Middleware and SSN layers.
	- Communication interfaces is;
	  - IEC 61850 for the enhanced prototype
	  - IEC 60870-5-104 for telecontrol applications in the fast prototype
	  - DLMS/COSEM for the enhanced and fast prototype
	- Distribution control by an Open Secondary Substation as control node

Scope	- Secondary Substation - Middliware with the Utilities system.
Typical use case	- Command to shed the load from energy management system to control centre. - Depending on the status of the grid, designate the disconnection of load through a command from the control centre (Middleware) to SSN - SSN executes the load disconnection commands. - The result of the disconnection at SSN is reported from SSN to Control Centre (Middleware). - The result of the disconnection at SSN is reported from Control Centre to Energy management system.
Scale	- Started on Jan 2010, has a duration of 33 months and a budget of 5.3 million Euro.
Cost (if available)	No available information.

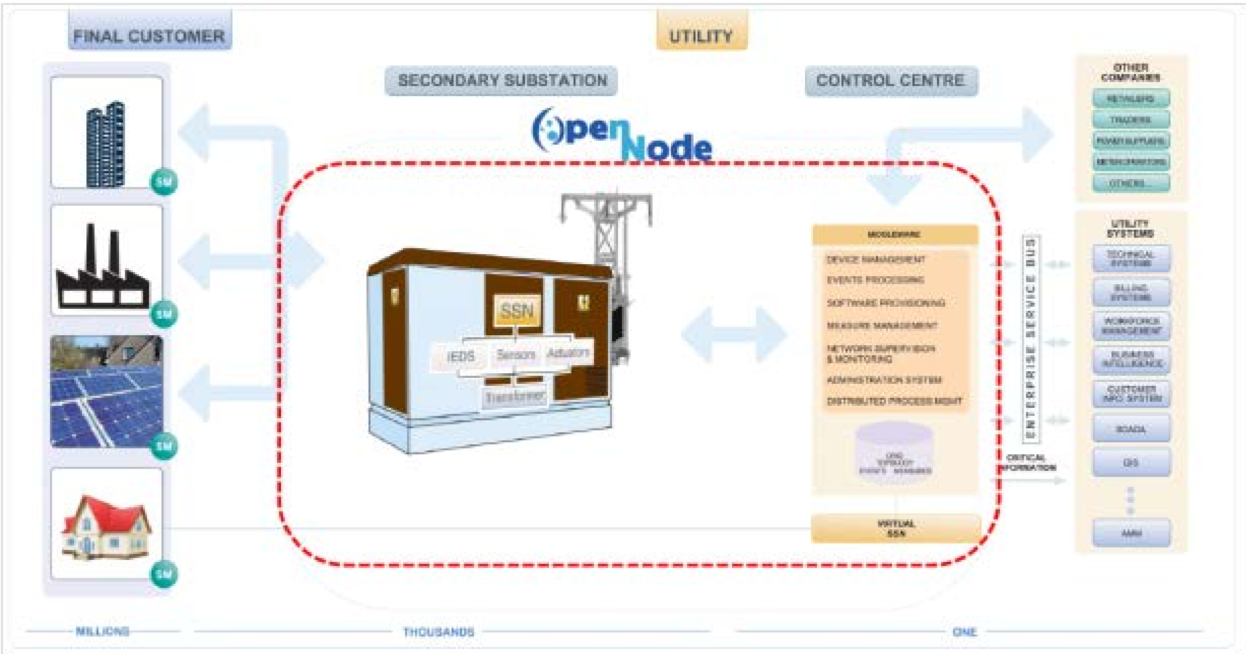

Figure B.3.1.1 - the OpenNode System Overview [12]

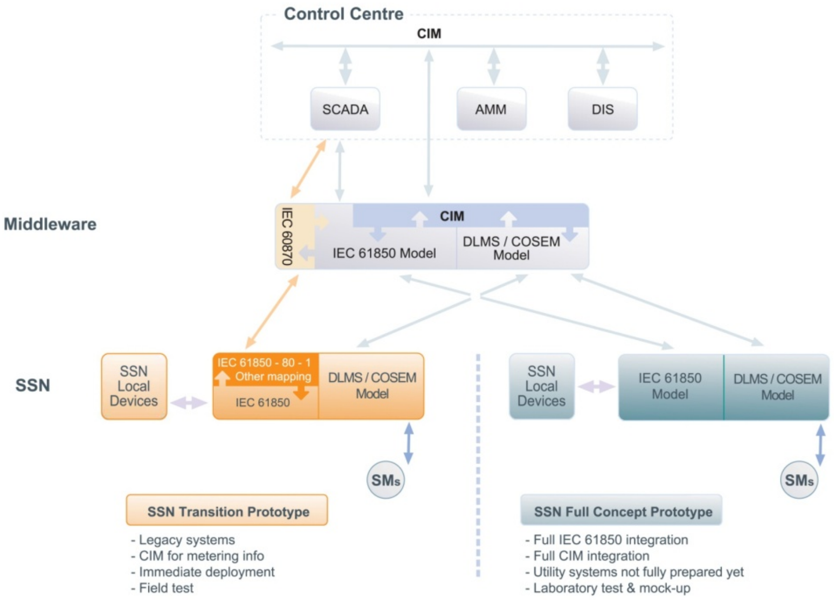

Figure B.3.1.2 - the OpenNode Communication Architectures [12]

B.3.2 Findings

Table B.3.2.1 - Project Survey Sheet for Findings: the OpenNode

Findings	
Quality aspect	Interoperability(In), Affordability (Af), Adaptability (Ad)
Featured system architecture	The architecture has the following key characteristics (Figure B.3.1.2 and B.3.2.1): - (Ad) Overall there are three layers: applications in control centre, middleware, and SSN functionalities, - (Ad) Middleware is rich in terms of functionality. One of the important roles is protocol conversion between control centre and SSN, and - (In, Af) SSNs are basically open. - (Ad) Distributed controls with distribution substations as control nodes.
Design aspect	- (Ad) Layered structure: Separated by middleware that translates different data models. - (Ad) Degree of standard adaptation: Middleware and SSN functionality layer. - (In, Af) Communication architecture for standards: Use of common CIM at Middleware and SSN functionalities layers.
Pros	- (In) Communication amongst SSN products especially produced by different suppliers. - (In) Communication with IT-system independent on vendor’s inherent specification. - (Af) Reduction in the development for cost, time at Control Centre, Middleware, and SSN layers.

	- (Ad) The development can be done separately for each layers; Control Centre, Middleware, and SSN layers. - (Af) Simplification in SM (Smart Meter) specification (because the connection between the SM and SSN depends only on the standards applicable to the SSN.) - (Ad, Af) Incremental extension of SSN with common CIM. - (Af) Applying standards of communication between SSN and Middleware reduces information system vendor restrictions for the SSN thereby reducing the cost of procurement. - (Ad) By monitoring the status of the grid (under the Control Centre) with the information from the SSN, continuous control of the system as close as possible to the optimal state is enabled.
Cons	- Generally performance is degraded due to additional middleware between functionality. - There is a decline in the communication performance between layers. - Not possible to optimise for individual cases (decline in performance for individual cases)

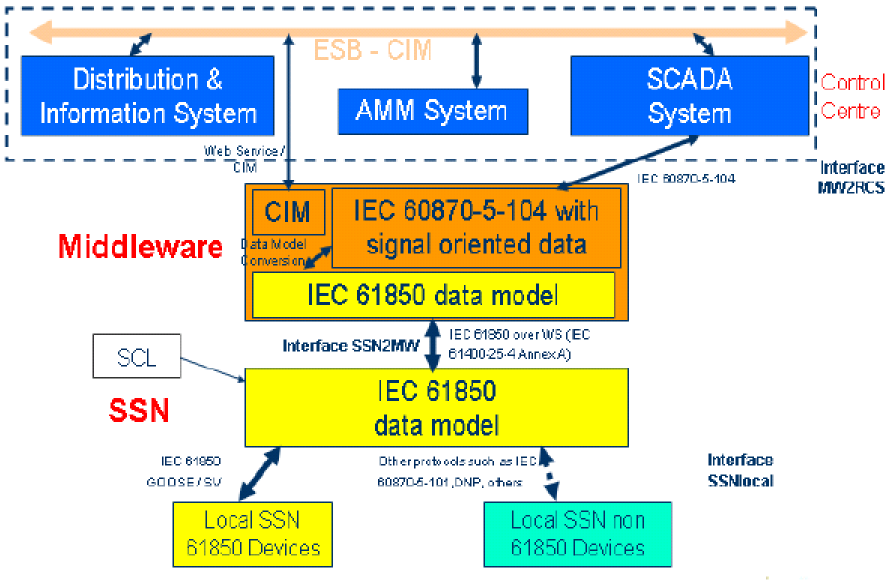

Figure B.3.2.1 - Data paths and interfaces [12]

Table B.3.2.2 - Project Survey Sheet for UK SSH Applicability: the OpenNode

UK SSH Applicability	
UK SSH applicability and rationale	Applicable.
Possible application	The prototype is similar to UK systems and so this technology is suitable for application in the UK. By applying the SSN and middleware structure to standards, it enables incremental extension of the SSN (Ad) and introduces flexibility in supplier selection for the SSN and control centre applications. This may bring

	affordability by avoiding vendor lock-in. The middleware is however costly by itself as an initial investment. In order to achieve payback it is advised to plan how to obtain benefits from more SSNs and their interactions. By transforming the existing distribution substation in to the intelligent form (SSN), it provides the interface with the energy management systems as a master, and operates the distributed controls via the SSN. (Ad) The objective of this system is to automatically control the whole system at the optimal condition by monitoring and controlling the grid via the SSN

B.4 I3: NIST Smart Grid Cyber Security

B.4.1 Project Basic Information

Table B.4.1.1 - Project Survey Sheet for Basic Information: Smart Grid Cyber Security

Project Basic Information			
Reviewer	Tadashi KAJI	Date	26/12/2012
ID	ETI-SSHP-WA3-WP1-H-3	Revision	1.0
Initiative(or project) name (or system name)	US NIST IR 7628: Guidelines for Smart Grid Cyber Security		
Application domain	Smart city		
Organisation (developed or operated by)	National Institute of Standards and Technology (USA)		
Nation delivered	United States of America		
Delivered or trial			
Delivered or trial year	Aug. 2010		
Reference	Main Reference: - NIST, "Guidelines for Smart Grid Cyber Security: Vol. 1, Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements" [13] Additional References: - NIST, Computer Security Division - Computer Security Resource Center, http://csrc.nist.gov/publications/PubsNISTIRs.html [14] - EPRI SmartGrid Resource Center Use Case Repository, http://www.smartgrid.epri.com/Repository/Repository.aspx [15]		
What the system intends to achieve	This report presents an analytical framework that organizations can use to develop effective cyber security strategies tailored to their particular combinations of Smart Grid-related characteristics, risks, and vulnerabilities. Organisations in the diverse community of Smart Grid stakeholders—from utilities to providers of energy management services to manufacturers of electric vehicles and charging stations—can use the methods and supporting information presented in this report as guidance for assessing risk and identifying and applying appropriate security requirements. This approach recognises that the electric grid is changing from a relatively closed system to a complex, highly interconnected environment. Each organisation's cyber		

	security requirements should evolve as technology advances and as threats to grid security inevitably multiply and diversify.

Typical use case	- Interaction between control systems and equipment with high availability, and with compute and/or bandwidth constraints, for example:
	  - Between transmission SCADA and substation equipment
	  - Between distribution SCADA and high priority substation and pole-top equipment
	  - Between SCADA and DCS(Distributed Control System) within a power plant
	- Interaction between control systems and equipment without high availability, but with compute and/or bandwidth constraints, for example:
	  - Between distribution SCADA and lower priority pole-top equipment
	  - Between pole-top IEDs(Intelligent Electronic Devices) and other pole-top IEDs
	- Interaction between control systems and equipment with high availability, without compute nor bandwidth constraints, for example:
	  - Between transmission SCADA and substation automation systems
	- Interaction between control systems and equipment without high availability, without compute nor bandwidth constraints, for example:
	  - Between distribution SCADA and backbone network-connected collector nodes for distribution pole-top IEDs
	- Interaction between control systems within the same organisation, for example:
	  - Multiple DMS systems belonging to the same utility
	  - Between subsystems within DCS and ancillary control systems within a power plant
	- Interaction between control systems in different organisations, for example:
	  - Between an RTO/ISO EMS and a utility energy management system
	- Interaction between back office systems under common management authority, for example:
	  - Between a Customer Information System and a Meter Data Management System
	- Interaction between back office systems not under common management authority, for example:
	  - Between a third-party billing system and a utility meter data management system
	- Interaction with B2B connections between systems usually involving financial or market transactions, for example:
	  - Between a Retail aggregator and an Energy Clearinghouse
	- Interaction between control systems and non-control/corporate systems, for example:
	  - Between a Work Management System and a Geographic Information System
	- Interaction between sensors and sensor networks for measuring environmental parameters, usually simple sensor devices with possibly analogue measurements, for example:
	  - Between a temperature sensor on a transformer and its receiver
	- Interaction between sensor networks and control systems, for example:

	- Between a sensor receiver and the substation master
	- Interaction between systems that use the AMI network, for example:
	  - Between MDMS and meters
	  - Between LMS/DRMS and Customer EMS
	- Interaction between systems that use the AMI network with high availability, for example:
	  - Between MDMS and meters
	  - Between LMS/DRMS and Customer EMS
	  - Between DMS Applications and Customer DER
	  - Between DMS Applications and DA Field Equipment
	- Interaction between systems that use customer (residential, commercial, and industrial) site networks which include:
	  - Between Customer EMS and Customer Appliances
	  - Between Customer EMS and Customer DER
	  - Between Energy Service Interaction and PEV
	- Interaction between external systems and the customer site, for example:
	  - Between Third Party and HAN Gateway
	  - Between ESP and DER
	  - Between Customer and CIS Web site
	- Interaction between systems and mobile field crew laptops/equipment, for example:
	  - Between field crews and GIS
	  - Between field crews and substation equipment
	- Interaction between metering equipment, for example:
	  - Between sub-meter to meter
	  - Between PEV meter and Energy Service Provider
	- Interaction between operations decision support systems, for example:
	  - Between WAMS and ISO/RTO
	- Interaction between engineering/maintenance systems and control equipment, for example:
	  - Between engineering and substation relaying equipment for relay settings
	  - Between engineering and pole-top equipment for maintenance
	  - Within power plants
	- Interaction between control systems and their vendors for standard maintenance and service, for example:
	  - Between SCADA system and its vendor
	- Interaction between security/network/system management consoles and all networks and systems, for example:
	  - Between a security console and network routers, firewalls, computer systems, and network nodes

Cost (if available)	No available information.

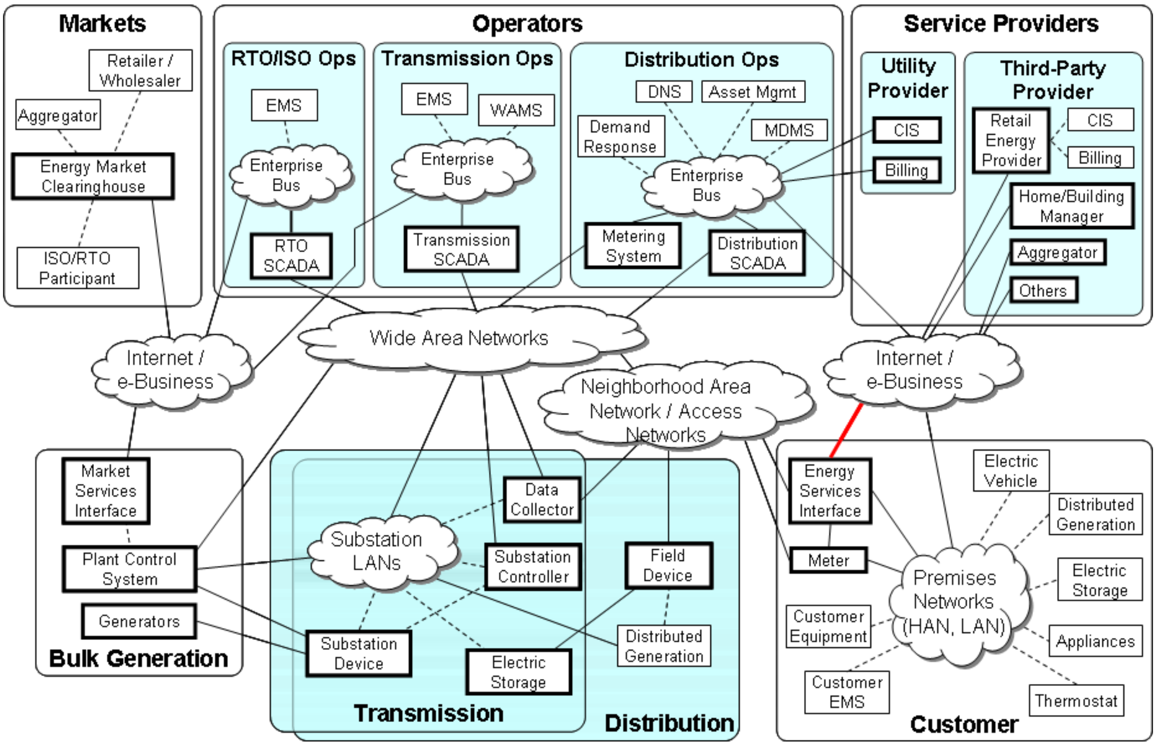

Figure B.4.1.1 - Baseline Conceptual Reference Diagram for Smart Grid Security.

Table B.4.1.2 - Definition of Impact Levels.

Potential Impact Levels			
	Low	Moderate	High
Confidentiality Preserving authorised restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information.	The unauthorised disclosure of information could be expected to have a **limited** adverse effect on organizational operations, organizational assets, or individuals.	The unauthorised disclosure of information could be expected to have a **serious** adverse effect on organizational operations, organizational assets, or individuals.	The unauthorised disclosure of information could be expected to have a **severe or catastrophic** adverse effect on organizational operations, organizational assets, or individuals.
Integrity Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity.	The unauthorised modification or destruction of information could be expected to have a **limited** adverse effect on organizational operations, organizational assets, or individuals.	The unauthorised modification or destruction of information could be expected to have a **serious** adverse effect on organizational operations, organizational assets, or individuals.	The unauthorised modification or destruction of information could be expected to have a **severe or catastrophic** adverse effect on organizational operations, organizational assets, or individuals.
Availability Ensuring timely and reliable access to and	The disruption of access to or use of information or an information system	The disruption of access to or use of information or an information system	The disruption of access to or use of information or an information system

use of information.	could be expected to have a **limited** adverse effect on organizational operations, organizational assets, or individuals.	could be expected to have a **serious** adverse effect on organizational operations, organizational assets, or individuals.	could be expected to have a **severe or catastrophic** adverse effect on organizational operations, organizational assets, or individuals.

Table B.4.1.3 - Smart Grid Impact Levels.

Smart Grid Impact Levels																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Conf.	L	L	L	L	L	L	**H**	**H**	L	L	L	L	**H**	**H**	L	**H**	L	L	L	L	L	**H**
Integ.	**H**	**H**	**H**	**H**	**H**	**H**	M	M	M	**H**	M	M	**H**	**H**	M	M	**H**	**H**	**H**	**H**	**H**	**H**
Avail.	**H**	M	**H**	M	**H**	M	L	L	M	M	M	M	L	**H**	M	L	M	L	M	M	L	**H**

Conf: Confidentiality, Integ.: Integrity, Avail.: Availability

B.4.2 Findings

Table B.4.2.1 - Project Survey Sheet for Findings: Smart Grid Cyber Security

Findings	
Quality aspect	Security
Featured system architecture	A Smart Grid's logical security architecture is constantly in flux because threats and technology evolve. The followings are key concepts and assumptions that were the foundation for the logical security architecture. **1. Defence-in-depth strategy**: Security should be applied in layers, with one or more security measures implemented at each layer. The objective is to mitigate the risk of one component of the defence being compromised or circumvented. This is often referred to as "defence-in-depth." A defence-in-depth approach focuses on defending the information (including customer), assets, power systems, and communications and IT infrastructures through layered defences (e.g., firewalls, intrusion detection systems, antivirus software, and cryptography). Because of the large variety of communication methods and performance characteristics, as well as because no single security measure can counter all types of threats, it is expected that multiple levels of security measures will be implemented. **2. Power system availability**: Power system resiliency to events potentially leading to outages has been the primary focus of power system engineering and operations for decades. Existing power system design and capabilities have been successful in providing this availability for protection against inadvertent actions and natural disasters. These existing power system capabilities may be used to address the cyber security requirements. **3. Levelled Security**: Impact levels for each security objective (confidentiality, integrity, and availability) shown in Table B.3.1.2 are specified based upon the expected adverse effect of a security breach upon organizational operations, organizational assets, or individuals. The

	impact levels are used in the selection of security requirements for each use case category. The impact levels (low [L], moderate [M], and high [H]) presented in Table B.4.1.3 address the impacts to the nationwide power grid, particularly with regard to grid stability and reliability. Consequentially, the confidentiality impact is low for these use cases. Use cases 7, 8, 13, 14, 16, and 22 have a high impact level for confidentiality because of the type of data that needs to be protected (e.g., sensitive customer energy usage data, critical security parameters, and information from a HAN to a third party.)
Design aspect	Based on the defence-in-depth strategy, security should be applied in zones, with one or more security measures implemented at each zone, which is defined from impact levels.
Pros	- Confidentiality: Preserving authorised restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information. A loss of confidentiality is the unauthorised disclosure of information. - Integrity: Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity. A loss of integrity is the unauthorised modification or destruction of information. - Availability: Ensuring timely and reliable access to and use of information. A loss of availability is the disruption of access to or use of information or an information system
Cons	- Strengthening security can often mean a reduction in performance and increase in cost.

Table B.4.2.2 - Project Survey Sheet for UK SSH Applicability: Smart Grid Cyber Security

UK SSH Applicability	
UK SSH applicability and rationale	Applicable.
Possible application	NIST IR 7628 is reference architecture for smart grid standardization around the world. This requirement is expected to be satisfied in standardization in M/490 and IEC as basic requirements.

B.5 I4: A Prototype for Island-type Smart Grid

B.5.1 Project Basic Information

Table B.5.1.1 - Project Survey Sheet for Basic Information: A Prototype for Island-type Smart Grid

Project Basic Information			
Reviewer	Akira Kobayashi	Date	19/12/2012
ID	ETI-SSHP-WA3-WP1-H-4	Revision	1.1
Initiative(or project) name (or system name)	Japan U.S. Island Grid Project		
Application domain	Smart City (Smart Grid, Cyber Security, Direct Load Control, EV)		
Organisation (developed or operated by)	The consortium leads by Hitachi, Ltd. (Solution Provider). Maui Electric Company (System Operator). The project is founded by NEDO (New Energy and Industrial Technology Development Organization)		
Nation delivered	Japan, United States of America		
Delivered or trial	Trial (Business Model and technology demonstration)		
Delivered or trial year	2011 - 2015 (includes FS and construction. Operation will be started in the summer of 2013.)		
Reference	1) The overall project introductions. http://www.nedo.go.jp/english/whatsnew_20111129_index.html http://www.ct-si.org/events/APCE2011/sld/pdf/85.pdf [16] <Japanese> http://www.hitachihyoron.com/2012/03/pdf/03_topics01.pdf [17] 2) The Use Case is registered in EPRI Use Case Repository. http://www.smartgrid.epri.com/Repository/Repository.aspx (can be searched by "NEDO C1" and "NEDO C2") [15] 3) Cyber Security specification the system based on. http://www.nerc.com/filez/standards/Project_2008-06_Cyber_Security_Version_5_CIP_Standards_.html [18]		
What the system intends to achieve	**1) Project overview** (Figure B.5.1.1) To achieve energy independent from Oil, the price of which is the highest in all states in USA, the state of Hawaii and utility company are eager to introducing Renewable Energy (RE). The RE penetration is already over 15% in 2012 and long term target is 25% by 2020, 40% by 2030. The high variable RE penetration has already been causing electric power quality issues in Frequency and Voltage in Low Voltage (LV) LV level. This project is for the electric power grid control technology and business model demonstration under massive penetration of renewable energy. Also, because cooperative work between utility company energy system and multi business entities systems include domestic resident in-home system is essential, ICT Platform (ICTPF) for multi business entities support is implemented. The main points of achievement are The main points of achievement are (a) The electric power grid control system is designed to mitigate the issue cause by RE variability. - Imbalance issue by DLC (Direct Load Control). The main load control target by DLC is Electric Vehicle (EV) charging and water heater. The targets are selected on the idea of almost no impact no the customer's quolity of life. - PV (Photovoltaic) related voltage issues along with the service feeder under LV transformer by Smart Power conditioning system (SmartPCS). (b) The system has the multi Business entity connection capability with the		

	latest high level of cyber security and privacy protection along with the latest standard North American Electric Reliability Corporation Critical Infrastructure Protection version 5 (NERC CIP v5). (c) The consortium confirms the business model sustainability. The consortium is doing not only technical evaluation by Hitachi, but also doing economic evaluation by the specialist Mizuho Corporate Bank. The economic evaluation is based on the cost and benefit analysis among the stake holders include local government, utility company, fossil fuel provider, EV related service provider, consumer. (d) The consortium also thinks that the acceptance of the resident is one of most important items to get project start. To get the acceptance, the consortium is doing customer outreach activities to make common understanding of the benefit provided by the system.
Scope	- The electric power grid control by Smart Grid technology (EMS, DMS, μDMS, SmartPCS, Home Area Network control gateway control gateway, and EV) - The economic evaluation by the specialist of economic evaluation Mizuho Corporate Bank.
Typical use case	The system architecture is the hierarchical control architecture (*) consists of Energy Management system (EMS), Electric Vehicle Energy Control Centre (EVECC), Advance Distribution Management system (ADMS that includes DLC functions in this project), μDMS, Home Area Network control gateway (HAN control gateway or the HAN controller embedded in SmartMeter) and SmartPCS for PV. (*)Regarding hierarchical control architecture, there are four (4) levels of control as following. - Island level: EMS that monitors and controls supply and demand by ADMS - Island level: EVECC that monitors and controls EV charging by Car Makers Control system - Distribution Grid Level: ADMS that monitors and control the load of domestics by μDMS - LV transformer - Demand side Level: μDMS that monitors and controls LV side voltage level by SmartPCS -Demand side - Demand side Level: μDMS that monitors controls the LV side load by HAN control gateway The use case of the main functions along with the architecture is following. 1) Maximizing RE usage by mitigate excess energy of Wind Power Generator during night By using EVECC data about the state of charge in EV battery, ADMS make up EV charging schedule and send commands to EVECC. EVECC makes EV chagrin turn on along with the schedule by Car Maker control system. 2) Island Wide Electric Power quality support function for frequency issue especial along with the night time wind power down ramp. By the command of EMS operator, ADMS sends commands to μDMS. μDMS sends commands to HAN control gateway to control of EV charging and water heater load. 3) LV Level Electric Power quality support function. LV side Voltage and overload issue especially along with PV and widely deployed EV charger. a) By using the LV voltage level sensors of μDMS. μDMS sends commands to mitigate the voltage issue by SmartPCS reactive power output. b) By using the LV load level sensors of μDMS. μDMS sends command to

	cut the load of EV charging and water heater load by HAN control gateway. 4) Multi-business Entity communication and cyber Security and Privacy protection a) ICTPF supports information sharing among Utility and EV related service entity to make their business more efficient and RE energy utilization maximum. b) The system is based on NERC CIP V5
Scale	- Information about budget of the project is around 300 million JPY (roughly equal 15 million GBP) - Load control target EV car 200 - DLC controlled Volunteer houses 40
Cost (if available)	Not available

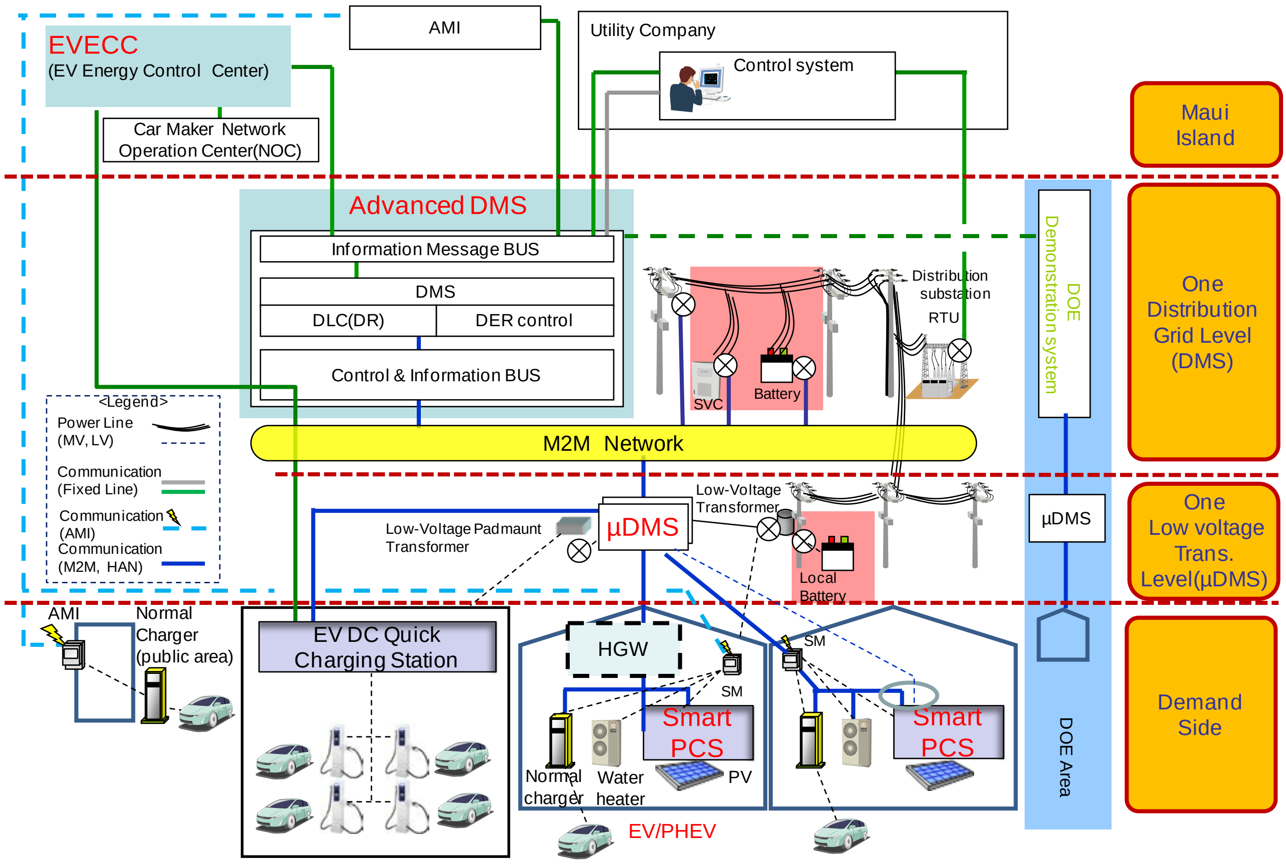

Figure B.5.1.1 - System Overview (hierarchical control architecture)

B.5.2 Findings

Table B.5.2.1 - Project Survey Sheet for Findings: A Prototype for Island-type Smart Grid

Findings	
Quality aspect	Performance (Pf), Reliability (Re), Interoperability (In), Cyber Security (Se). Adaptability (Ad), and Affordability (Af)
Featured system architecture	1) The hierarchical control architecture enables multi layer energy management capability for RE better use and RE related electric power quality issue mitigation. 2) By enabling multi business entity corroborative work, EV charging schedule can be match to RE generation prediction to maximize usage of RE energy. 3) By using autonomous control manner and latest field area network technology M2M, Short turn around can be archived. (a) When the window power down rapid ramp happened and the frequency issue is expected, EMS operator send the command to ADMS (include DLC function) to turn off the appropriate amount of load in domestic. The system is well aliened by layers and using low latency M2M. (b) When the LV voltage level is exceeds predefined level, μDMS controls smartPCS as autonomous control manner to mitigate over voltage issue. (c) When the LV load level exceeds predefined level, μDMS controls HAN control gateway as autonomous control manner to mitigate overload issue. 4) By using ICT PF the part of the functions implemented as Information Message BUS for enterprise network and control & Information BUS for field device control network, the complexity of the application depending communication interface can be hide. Also the cyber security counter measures embedded into the ICT PF make the governance control for the cyber security over the application easy.
Design aspect	-The hierarchical control architecture and embedded ICT PF for multi business communication with high level of cyber security and privacy protection. - The economic evalutation is lead by the specialist to ensure the business model sustainability.
Pros	- One day ahead EV charging load control schedule making for maximizing RE usage by mitigate excess energy of Wind Power Generator during night (Pf) - Short turn around control for mitigation to frequency issue by ADMS include DLC (Pf) - Short turn around control for LV voltage level control by μDMS along with SmartPCS (Pf) - Short turn around control for LV load level control by μDMS along with HAN control gateway (Pf) - Application depending interface is hide behind ICT PF to enable multi-business entity communication and data sharing (Ad) - The system cyber security and privacy protection design is based on NERC CIP V5(Se) - Interoperability is kept by ICTPF (In) - Hierarchical architecture enables incremental settlement of ADMS, μDMS, HAN control gateway. (Af) - It is possible to use less expensive commodity computational resources

	for the system. (Af) - The system is robust because of the hierarchical architecture.(Re)
Cons	- If the precondition of the system such as High level of penetration of RE and EV is not the issue for the application, limited portion of the system such as ICTPF is applicable.

Table B.5.2.2 - Project Survey Sheet for UK SSH Applicability: A Prototype for Island-type Smart Grid

UK SSH Applicability	
UK SSH applicability and rationale	Applicable. We recognise no factor against.
Possible application	Regarding SSH project, energy efficiency and RE utilization is the key to reduce the total energy usage and CO2 emission. The system architecture of this project has the applicable points as follows. - Hierarchical architecture allows aligned control from wide area to demand side. This architecture allow you to get system wide optimised control and autonomous local control simultaneously. - ICT PF architecture that makes multi business collaboration easier allows better energy usage control and keep cyber security and privacy governance over the collaboration work Also the ICT system architecture of SSH requires cost-effective, scalable and secure performance to cope with the future challenges. The architecture can be build up on commodity computer equipment and communication services. The µDMS supports both of centralized control by ADMS and autonomous control to achieved scalability to the system.

B.6 I5: A Traffic Management System for Mass Transit

B.6.1 Project Basic Information

Table B.6.1.1 - Project Survey Sheet for Basic Information: Traffic management system for mass transit in Tokyo

Project Basic Information			
Reviewer	Soichi Furuya (chief) and Chiaki Hirai	Date	27/12/2012
ID	ETI-SSHP-WA3-WP1-H-5	Revision	2.2
Initiative(or project) name (or system name)	Traffic management system for mass transit in Tokyo		
Application domain	Transportation		
Organisation (developed or operated by)	JR East (Japan) and Hitachi, Ltd. (Japan)		
Nation delivered	Japan		
Delivered or trial	Commercial operation and still extending coverage		
Delivered or trial year	1996/12		
Reference	Database on noteworthy contributions for science and technology (Japan), research information (#534), Development of autonomous decentralised		

	transport operation control system (ATOS) regulating highly frequent train services (in Japanese). http://dbnst.nii.ac.jp/pro/detail/534 [19]
What the system intends to achieve	The system of interest is in commercial use supporting the following railway operation: **<u>1) Project overview</u>** The aim of developing new train traffic control system, ATOS, is to support super high-density transportation in the Tokyo metropolitan area. ATOS has many features, including a decreased load on central controllers; increased operating efficiency, energy efficiency, and safety in station work; the ability to provide passengers with an adequate information service; and a step-by-step modular construction making initiation of independent station operations possible. [20] The objective of this project is to improve the flexibility of inserting or modifying new subsystem(s) by adopting the ATOS. The key points are listed below: - Commuter-train operation system in Tokyo area: i. 1000+ km, still expanding coverage since 1996, ii. 300+ stations iii. 30 trains per hour. - Very limited duration for maintenance. The timeframe of the initiative is not mentioned in the reference. (ATOS have first been adapted in a train line in Tokyo in 1998 and have been introduced to other lines since then.) **<u>2) ICT system overview (Figure B.6.1.1)</u>** Main functionalities are summarised as the following three: - train monitoring and interlocking control at station, - passenger information, and - station staff support regarding train operation. These ICT functionalities are realised by autonomous coordination between relevant stations.
Scope	- Fully automated train traffic control system
Typical use case	Traffic-management network connects multiple subsystems each of which represents a station. Due to train operator's operations such as maintenance and change of infrastructure and services, the configuration of subsystems changes frequently, i.e. subsystems are added, modified, and deleted. In this system each subsystem monitor whether or not there is a train on the rail segment. This detection is shared amongst neighbouring substations which control responsible signals and interlock mechanisms based on detection data from neighbouring subsystems. These necessary data are autonomously exchanged amongst subsystems via a Traffic-management network. In order to resolve train IDs each detection subsystems downloads on-the-day plan in an offline manner which is distributed by train schedule management system. The configuration of a subsystem is depicted in Figure B.6.1.2. Functionality of each component is as follows: - **The Atom Structure**: each subsystem (Atom) has its own management system, Autonomous Control Processor (ACP), which manage the Atom and coordinates with other Atoms. - **Data field**: in the ADS, all of the Atoms are connected only through the data field, which is a logical channel to exchange data amongst Atoms. - **Data-driven mechanism**: the application module is specified only by input and output content codes, and it is executed by the ACP only when

	all of the necessary data with the proper input content codes is received from the data field.
Scale	- Covers 19 lines (total length: approximately 1,050 km) by Mar. 2008. - Uses 100 Mbps optival fibre network. - Operates 24 hours per day.
Cost (if available)	No available information.

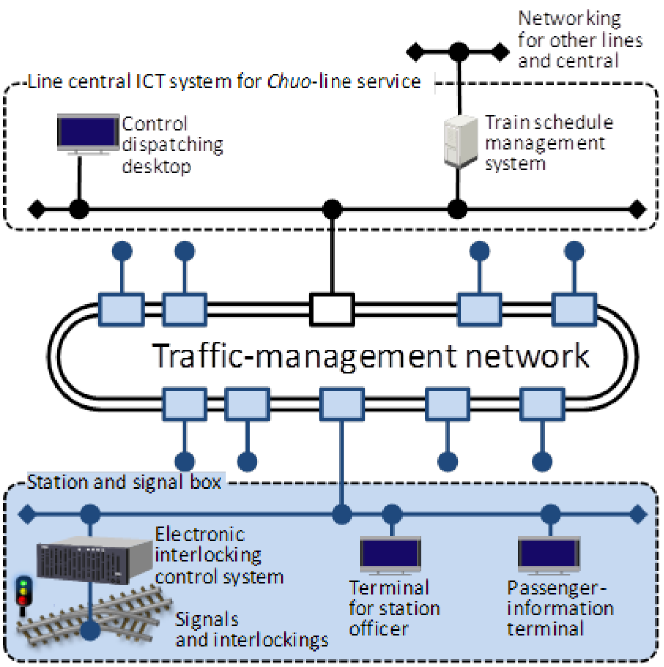

Figure B.6.1.1 - Configuration of Overall System of the Traffic Management System.

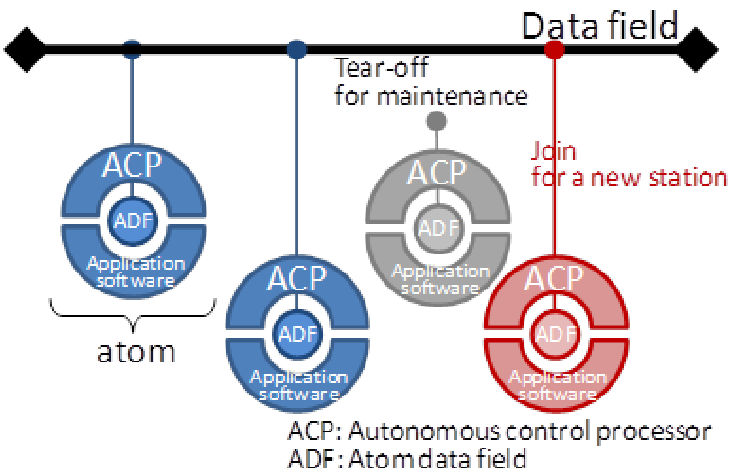

Figure B.6.1.2 - The Architecture of Autonomous Decentralised System.

B.6.2 Findings

Table B.6.2.1 - Project Survey Sheet for Findings: Traffic management system for mass transit in Tokyo

Findings	
Quality aspect	Adaptability and reliability.
Featured system architecture	We find the abstract architecture had the following characteristics (Figure B.6.2.1): - A subsystem (representing a station in this case) is data-driven mechanism, - There is a data field, through which a subsystem communicates to another, and - Transmitted data are tagged in order for a subsystem to identify whether or not it needs it. In case of inserting a new subsystem into the naive Pipes-and-Filter architecture, additional work is more-or-less necessary, i.e. affecting surrounding sub-systems. But in this architecture, there is no effect on other subsystems even in the case of inserting a new subsystem (right in Figure B.6.2.1).
Design aspect	Autonomous decentralised system with data-driven subsystems.
Pros	- Cost and work load necessary to change services and infrastructure are small. - In case of failure in a subsystem its effect propagates little to other subsystems. - Replacement does not require system suspension, which leads to a smaller duration of outage of the subsystem. It consequently improves availability.
Cons	- The architecture originally comes from the well-known pipe-and-filter architecture, which is said to be inherently unsuitable for an interactive system. Therefore, the autonomous decentralised system, which does not affect the neighbouring systems even in the case of adding new subsystem, is required.

Table B.6.2.2 - Project Survey Sheet for UK SSH Applicability: Traffic management system for mass transit in Tokyo

UK SSH Applicability	
UK SSH applicability	Applicable. We recognise no factor against.
Possible application	This architecture is most beneficial where online-maintenance is needed; facilities are frequently updated while other facilities irrelevant to the update are used for continual service. From this property it takes little time to replace a faulty component, which leads to higher availability. The similar requirement may be found in following two scenarios. One is configuration management of power demand-side facilities. The power demand-side facilities are considered to be the subsystems of ADS. While it is allowed for the demand-side to change the configuration of those facilities, the demand-side still monitors the status of them, which have no core relationship with the configuration, and control the DR.

	The other is membership management of a nega-watt aggregator. For aggregators, the resource of DR is the large number of demand-side customers (represented by a home gateway). In this application, the subsystem is the home gateway of the demand-side. The demand-side can chose the right aggregator on the basis of their offers (such as incentives from aggregator), and this means each subsystem can autonomously mount or dismount with the main system. Through this management, aggregators execute the DR to the home gateways connected to the system.

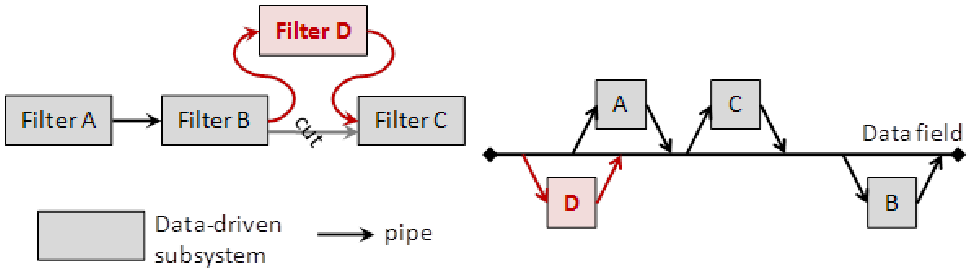

Figure B.6.2.1 - Naïve implementation of Pipes-and-Filter architecture (left) compared with the autonomous decentralised system (right)

B.7 I6: A Traffic Management System for Bullet Train

B.7.1 Project Basic Information

Table B.7.1.1 - Project Survey Sheet for Basic Information: Traffic Management System for Bullet Train

Project Basic Information			
Reviewer	Soichi Furuya (chief) and Chiaki Hirai	Date	27/12/2012
ID	ETI-SSHP-WA3-WP1-H-6	Revision	2.2
Initiative(or project) name (or system name)	Traffic management system for *Kyushu Shinkansen* (bullet train)		
Application domain	Transportation		
Organisation (developed or operated by)	JR Kyushu (Japan) and Hitachi, Ltd. (Japan)		
Nation delivered	Japan		
Delivered or trial	Commercial operation from 3/2004.		
Delivered or trial year	Delivery in 2004.		
Reference	"Shinkansen Traffic Management System to Achieve Mutual Direct Operation of Sanyo Shinkansen and Kyushu Shinkansen,'' Hitachi Hyoron (in Japanese), http://www.hitachihyoron.com/2012/06/pdf/06a08.pdf [21]		
What the system intends to achieve	The system of interest is commercial use supporting the following railway operation: **<u>1) Project overview</u>** The aims of this project are;		

	a) To connect two different bullet train operation systems together, and b) To adopt a highly reliable and fault tolerant model. The objectives of this project are to introduce the falt tolerant system, which is fundamental requirement for the operation of the bullet trains, and the interoperation of two different operation systems, which enables two different lines to run on each other's trucks. The key aspects of this project are; - Bullet-train (at 260 km/h (160 mph)) operation system. - Budget limited because it is local train operator. The timeframe of the initiative ends in Mar. 2012. (The biginning of the timeframe is not mentioned in the reference.) **<u>2) ICT system overview (Figure B.7.1.1)</u>** - Planning, e.g. rolling-stock operation, crew roster, and train-service operation, - Train monitoring and interlocking control, and - Engineering support, e.g. power monitoring and rolling-stock maintenance.
Scope	- Train operation (traffic control) system of bullet train
Typical use case	We describe a typical use case from the understanding of the system functionality (Figure B.7.1.1). - A train plan is sent from an IT system within the IT-system network. This train plan and train location data detected from rail-side equipment are used to control signals and interlocks. The interface to signals and interlocks is Centralised Traffic Control (CTC). The control data is generated by Programmed Route Control (PRC) and sent to CTC system through CTC management system. - PRC on a highly reliable IT platform with cutting-edge design of architecture, which is depicted in Figure B.7.1.2. - There are other critical systems, e.g. speed-advisory system, anti-disaster system, and driver communication system. They are all connected to control network to transmit data with PRC. - The bullet train operation interoperates with other operator. PRC therefore need to exchange data with PRC of other operators. This communication is through External gateway.
Scale	No available information
Cost (if available)	No available information.

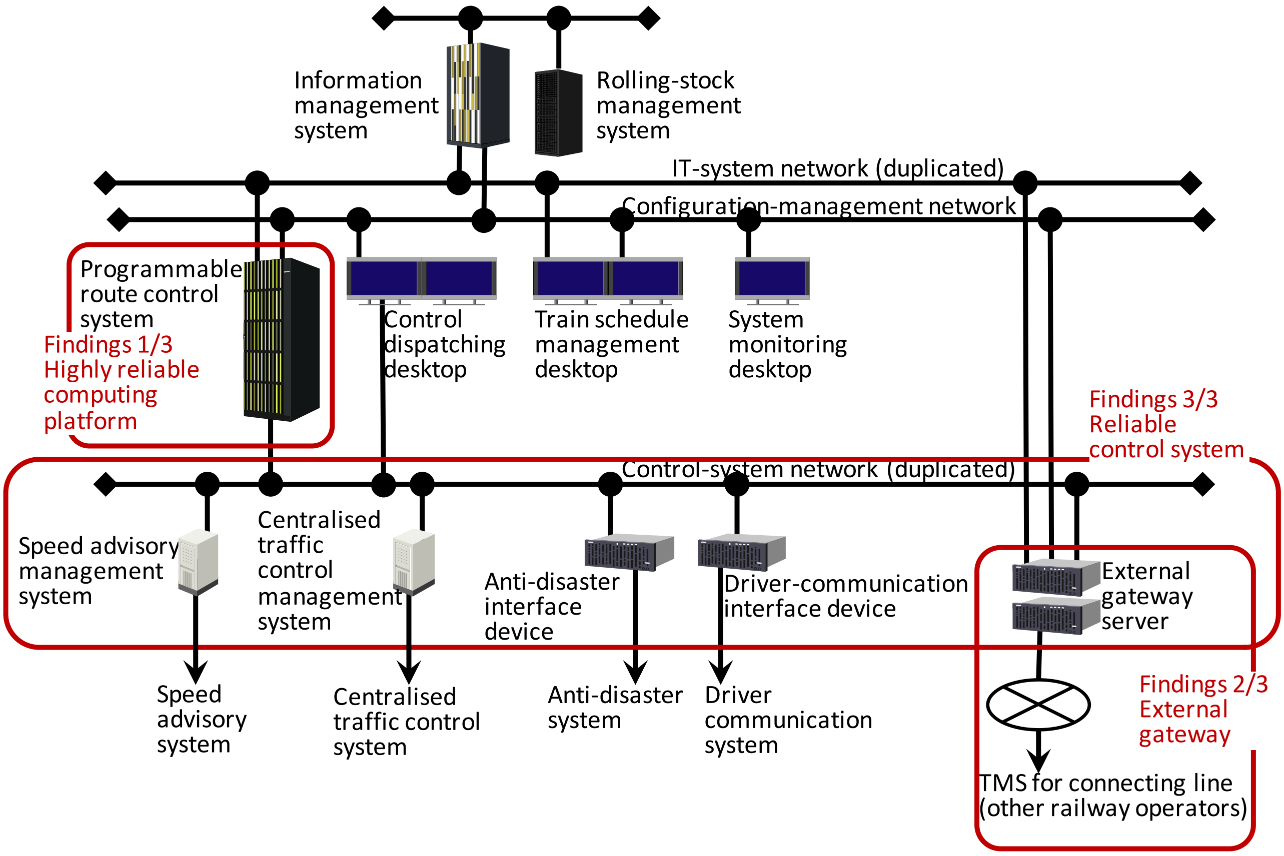

Figure B.7.1.1 - System Overview of the Surveyed project 6: Traffic Management System for Bullet Train.

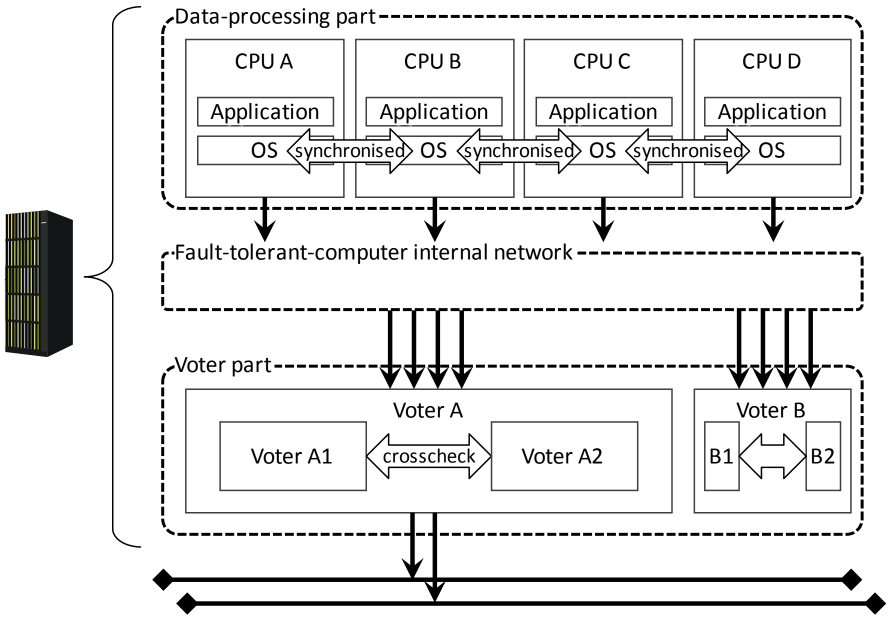

Figure B.7.1.2 - The Architecture of the Highly Reliable Processing Component.

B.7.2 Findings (1/3)

Table B.7.2.1 - Project Survey Sheet for Findings (1/3): Traffic Management System for Bullet Train

Findings	
Quality aspect	Availability (reliability) and adaptability.
Featured system architecture	The implementation of interest is depicted in Figure B.7.1.2, characterised by the following configurations: - Quadruple loosely-coupled system, - Software synchronisation system at the operating system level which relieves constraints on hardware such as CPUs, - A voter set consists of two voters to detect voter error, and - Fault-tolerant network. Replication based voting is the reliability tactic adopted in this architecture. Ordinary replication requires identical subsystems to protect hardware faults. It means that the system always requires identical or compatible parts, which is not ideal for a system of a very long life time. The solution found in this project is that the identical voters had an additional software layer so that every voter can have an identical interface to the decision component. By this abstraction layer, replication voting can evolve to a heterogeneous voting system (Figure B.7.2.1).
Design aspect	Replication based voting with abstract interface layer.
Pros	- High availability. - High adaptability to change of market-available hardware, e.g. CPU.
Cons	- Adverse impact on developing time due to the abstract layer. - Possibly adverse impact on Performance.

Table B.7.2.2 - Project Survey Sheet for UK SSH Applicability (1/3): Traffic Management System for Bullet Train

UK SSH Applicability	
UK SSH applicability and rationale	Applicable.
Possible application	The most beneficial case of this architecture is a system where high availability is required and its components are volatile in terms of market availability. SSH is expected to have several services and functionalities to be highly available and also to have a very long lifetime. Control systems are highly reliable but its components are rather market available for longer time in nature of the industry. Technologies for IT systems progress fast. It is generally hard to find exactly the same replacement to a faulty component. We conclude highly reliable system based on IT technologies should take the merit most. One possible example is the information processing platform for power markets.

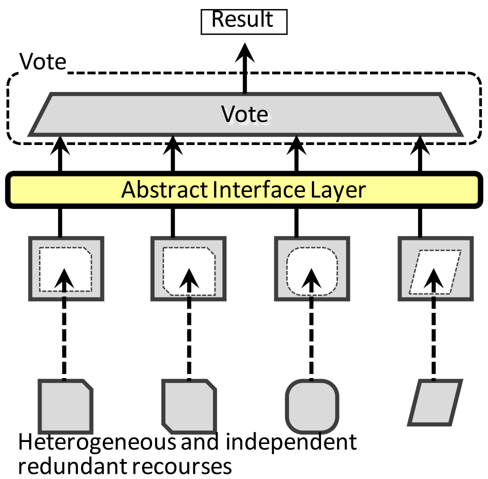

Figure B.7.2.1 - The Abstract Architecture.

B.7.3 Findings (2/3)

Table B.7.3.1 - Project Survey Sheet for Findings (2/3): Traffic Management System for Bullet Train

Findings	
Quality aspect	Adaptability and interoperability.
Featured system architecture	Internal functions including PRC must exchange data in a highly reliable manner with an external function. In this architecture these communicate through the external gateway (Figure B.7.3.1). In the case of modifying protocols and hosts to communicate externally, it is sufficient to modify only the external gateway that has been designed with high adaptability, instead of functions which can be difficult to suspend and maintain.
Design aspect	Taylor interface.
Pros	- Adaptability. It is highly adaptable in the case of necessary modifications on communications with external entities while there are multiple internal functions communicating externally. - Interoperability. It is relatively easy to add a new function which is required to communicate externally. The new function is able to inherit part of the current communication channel.
Cons	- Adverse impact on development time due to the abstraction layer when the number of internal functions communicating externally is small. - Possibly adverse impact on Performance.

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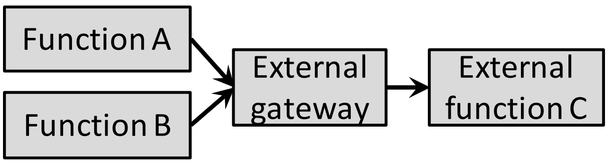


Figure B.7.3.1 - The Abstract Architecture for interoperability and adaptability.

Table B.7.3.2 - Project Survey Sheet for UK SSH Applicability (2/3): Traffic Management System for Bullet Train

UK SSH Applicability	
UK SSH applicability	Applicable. We recognise no factor against.
Possible application	The architecture is most beneficial where (1) there are multiple functions exchanging data externally, (2) a function exchanging data has low maintainability, or (3) frequent changes are made to the external channel, e.g. logical address and protocol. In SSH there will be many actors to communicate with external functions from the view point of the actor's organisation. Case (3).is highly likely in SSH. There are some actors with high reliability, which are inherently less maintainable. Typical actors are market-dealing systems and connecting dealer systems. Aggregators and retailers are also typical actors with condition (2), communicating to numerous external functions. It may be beneficial to adapt this network architecture to overall network architecture in such an enterprise.

B.7.4 Findings (3/3)

Table B.7.4.1 - Project Survey Sheet for Findings (3/3): Traffic Management System for Bullet Train

Findings	
Quality aspect	Availability (reliability).
Featured system architecture	High availability is required for functions critical to train operation, i.e. CTC, Speed advisory, anti-disaster, driver-communication, external-gateway, and their data-exchange with PRC. For the other functions, such as information management and rolling-stock management, failures may be allowed to some extent in the interests of affordability. If the topology of all systems is designed in a naive manner, all systems may be connected to a single universal bus, which enables any communications between systems. It is not only highly interoperable for a connecting system, but also highly adaptable to a future functionality that needs to interact with other systems. On the other hand this is weaker with respect to reliability of a critical system. For instance one system implemented with moderate reliability may cause exceptional effects to other systems or the universal bus: virus infection or system failure causing system failure. This may result in more risk to a critical function itself or it may lead to shutdown of the universal bus. In either case the critical function suffering the effect may not function. In this architecture all functions requiring high reliability are isolated from the functions with moderate reliability. This prevents exceptional effects from functions implemented on moderate reliability. This consequently improves reliability of critical functions.
Design aspect	Logical isolation depending on levels of reliability, i.e. graceful degradation.
Pros	- High reliability of multiple functions.
Cons	- More constraints to exchanging data amongst subsystems.

Table B.7.4.2 - Project Survey Sheet for UK SSH Applicability (3/3): Traffic Management System for Bullet Train

UK SSH Applicability	
UK SSH applicability	Applicable.
Possible application	This architecture is most beneficial where a system consists of many components some of which are highly available. In other words availability for some components is high and that of the others are not required necessary to be. Those two types of components co-exist in a system. In general ICT utilisation of non-core systems, planning system for longer term, and systems mainly processing batches rather than online require less availability. On the other hand power and heat industry utilise highly reliable ICT systems for control devices. These are not only legacy mature value chain including generation, transmission and distribution, but also power market systems.

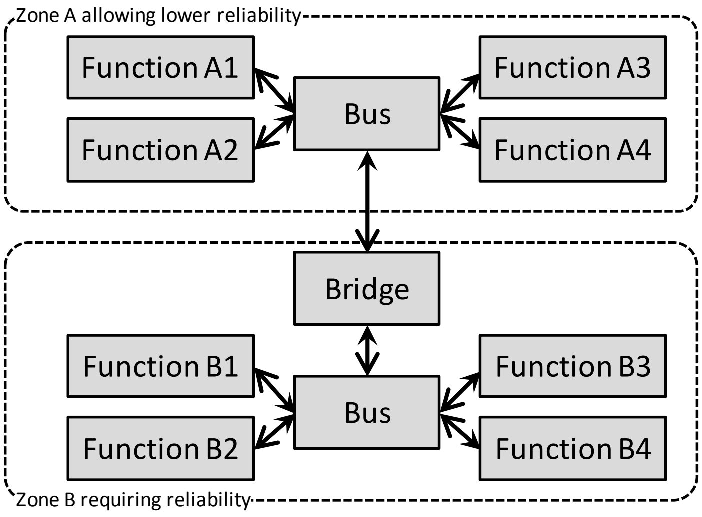


Figure B.7.4.1 - The Abstract Architecture for availability.

B.8 I7: Danish Cell-controller Pilot Project

B.8.1 Project Basic Information

Table B.8.1.1 - Project Survey Sheet for Basic Information: Danish Cell-controller Pilot Project

Project Basic Information			
Reviewer	Soichi Furuya	Date	27/12/2012
ID	ETI-SSHP-WA3-WP1-H-7	Revision	1.1
Initiative(or project) name (or system name)	Danish Cell-controller Pilot Project (CCPP)		
Application domain	Smart grid		
Organisation (developed or operated by)	Energinet.dk (Danish TSO)		

Nation delivered	Denmark
Delivered or trial	Trial.
Delivered or trial year	Trialled in 2011.
Reference	The Cell Controller Pilot Project, http://energinet.dk/EN/FORSKNING/Energinet-dks-forskning-og-udvikling/Celleprojektet-intelligent-mobilisering-af-distribueret-elproduktion/Sider/Celleprojektet-fremtidens-intelligente-elsystem.aspx [22]
What the system intends to achieve	**1) Project Overview:** The power systems of Denmark are characterised by a high penetration of distributed generation (DG) comprised of small to medium scale combined heat and power plants (CHP) and wind turbines (WTs). 75% of all Danish WTs are situated in the western part of Denmark. In 2004 local CHP made up 30% and WTs 23% of the electricity consumption of that area. Today, more than 50% of the total production capacity is dispersed throughout local distribution grids of 60 kV voltages and below. As a consequence, it has become more difficult to predict and to control the total electricity generation. Coordinated smart control of existing distributed assets such as wind turbines, co-generation facilities and managed loads can support transmission operations during an emergency condition, while also enabling enhanced market-based control over these assets during routine operations. The aim of the Cell Project is to develop the controllers and the data-acquisition, command, and communication infrastructure necessary to realise such wide-area control of a distribution grid. The objectives of the project are listed as the following: - To develop and demonstrate the capability to use distributed generation and other energy connected to distribution networks, - To provide ancillary services, and - Local distributionnetworks to operate autonomously using local resources in the case of transmission emegency. The timeframe of the initiative is from 2005 to 2011. **2) ICT overview** The functions of the ICT for the CCPP are listed below: - On-line monitoring the total load and production within the cell. - Active power control of synchronous generators. - Active power control of wind farms and large wind turbines. - Reactive power control by utilising capacitor banks of wind turbines and grid. - Reactive power or voltage control by activating automatic voltage regulators (AVR) on synchronous generators. - Frequency control by activating speed governing systems (SGS) on synchronous generators. - Capability of remote operation of 60 kV breaker on 150/60 kV transformer. - Capability of remote operation of breakers of wind turbines and load feeders. - Automatic fast islanding of entire 60 kV Cell in case of severe grid fault. - Automatic fast generator or load shedding in case of power imbalance. - Voltage, frequency and power control of islanded Cell.

	- Synchronising Cell back to parallel operation with the transmission grid. Black-starting support to transmission grid in case of black-out.
Scope	- Distributed generation
Typical use case	By connecting and managing power plant systems all together, It is possible to control the electricity over the area of each separate power plant. (Figure B.8.1.1)
Scale	- three sub-regions for the test area of the CCPP. - Monitors 47 wind turbines
Cost (if available)	No available information.

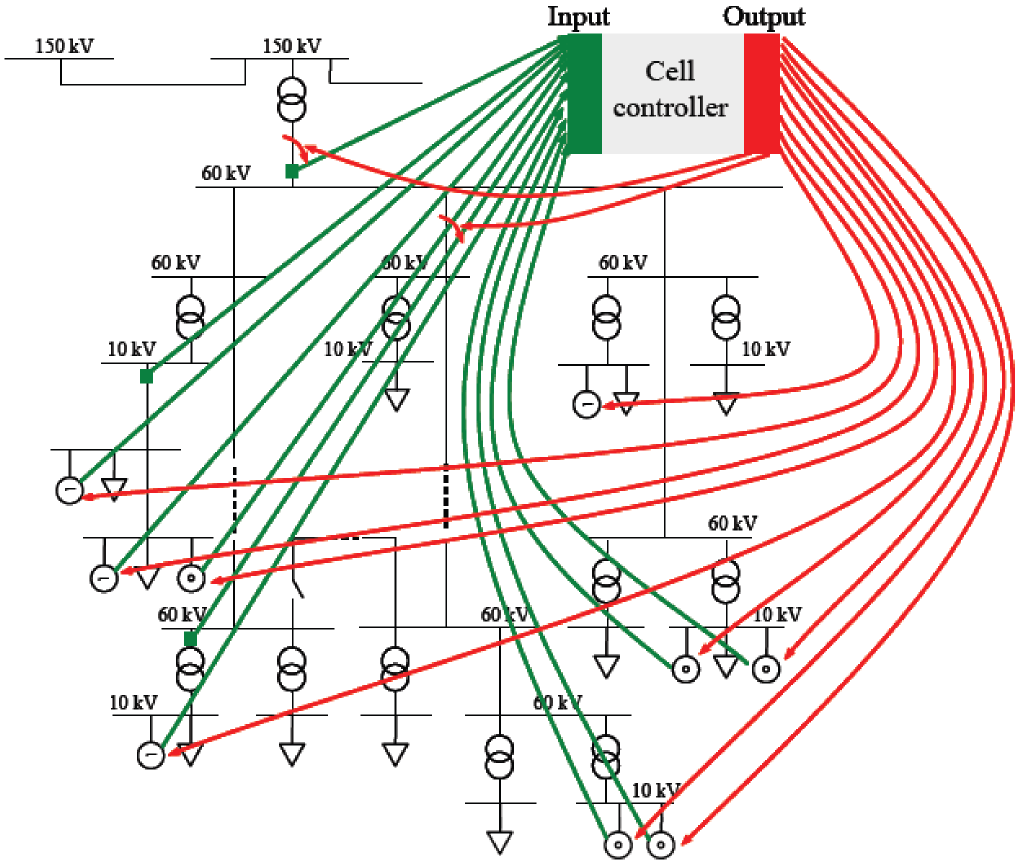


Figure B.8.1.1- Cell Controller functionalities

B.8.2 Findings

Table B.8.2.1 - Project Survey Sheet for Findings: Danish Cell-controller Pilot Project

Findings	
Quality Aspect	Interoperability, Reliability, and Adaptability
Featured system architecture	Using distributed agent technology and high speed fibre network, the SCADA system comprises a layered control hierarchy, and it enables construction of the Virtual Power Plants. Since agents are embedded between virtual power plants in the SCADA system, it enables larger Virtual Power Plants. (Figure B.8.2.1)

Design Aspect	- A layered control hierarchy of Virtual Power Plants - Coordinated control of local assets and load control, which could mimic the operation of a single large power plant (ancillary service). - Autonomous operation of local distribution networks in a transmission system emergency.
Pros	- Optimal distribution of surplus energy. - Providing ancillary services at selected locations within the distribution system. - Contributing to rapid recovery from transmission system emergency. - Reducing impact on consumers in transmission system emergency
Cons	No available information.

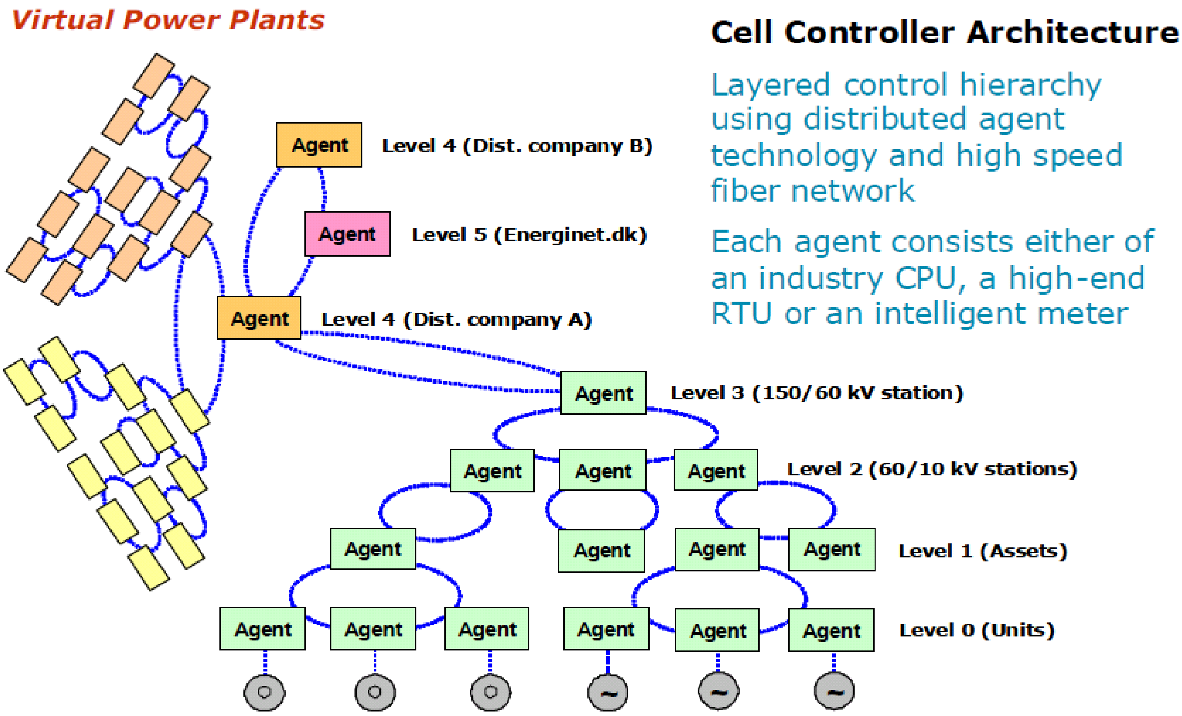


Figure B.8.2.1 -Cell Controller architecture

Table B.8.2.2 - Project Survey Sheet for UK SSH Applicability: Danish Cell-controller Pilot Project

UK SSH Applicability	
UK SSH applicability	Applicable.
Possible application	This is a pilot project investing how to connect dispersed power plants as a smart grid, and from the point of view, this project has a high interoperability and adaptability. And the autonomous operation of local distribution networks is highly beneficial in a transmission system emergency. In the emergency, by isolating the local distribution network from transmission network, each distribution network can be operated by itself using local energy resources (islanding). Therefore, it enables reduction in the impact on the consumer and contributes to a quicker recovery from the emergency. This is why it is more reliable.

B.9 I8: M/490 Smart Grid Information Security working group

B.9.1 Project Basic Information

Table B.9.1.1 - Project Survey Sheet for Basic Information: M/490 Smart Grid Information Security working group

Initiative Basic Information			
Reviewer	F. Ennesse	Date	21/01/2013
ID	ETI-SSHP-WA3-WP1-H-8	Revision	1.1
Initiative name (or system name)	M/490 Smart Grid Information Security working group		
Application domain	Smart city		
Organisation (developed or operated by)	M/490 Smart Grid Information Security working group		
Nation delivered	European Union		
Delivered or trial	Draft - A Summary Report as well as an expanded one are available.		
Delivered or trial year	Approved end 2012. Work will continue in 2013-2014 to consolidate the approach.		
Reference	https://www.enisa.europa.eu/activities/Resilience-and-CIIP/workshops-1/2012/eu-us-open-workshop/11th-presentation [23]		
What the system intends to achieve	In order to ensure proper protection of energy infrastructures, which are critical national assets, the SGIS report identifies the available security requirement standards and coordinates the work plan to provide missing pieces to address security and privacy at the level of organizations, products/systems and services, throughout the manufacturing, integration, deployment, operation and maintenance phases. Given a technical use case, the SGIS report further provides an approach based on risk assessment to derive the privacy and security requirements that need to be satisfied by organizations and products/systems involved, as well as to identify the level of security required for the involved data transfers.		
Typical use case	Smart Metering, DSM		
Cost (if available)			

B.9.2 Findings

Table B.9.2.1 - Project Survey Sheet for Findings: M/490 Smart Grid Information Security working group

Findings	
Quality aspect	Cyber Security
Featured system architecture	The Reference Architecture used by M/490 is the layered conceptual

	model based on domains and zones (Figure B.9.2.1)
Design aspect	**Risk assessment method using SGIS** 1. Identify a specific use case 2. Identify the domains, zones and systems covering the use case. Add or change systems were needed 3. Perform Risk Assessment to identify applicable Security Levels (from 1 to 5 in Table B.9.2.3) and Data Protection Classes 4. Link the use case to standards containing security requirements and identify gaps
Pros	Identifies sets of available security requirements for all smart grid actors, product and systems. Provides a methodology to identify the requirements applicable to an organization or system, in the context of a specific use case. In 2013/2014, the approach will be further adapted to several EU countries regulations, including UK, and assessed on several use cases including demand-response management and Distributed Energy Resources management. Some good insight to perform Risk Assessment in a smart grid context is also provided. The approach is not tied to any specific formal methodology of Risk Assessment so it can perfectly fit in the UK environment.
Cons	Specific security requirements standards for some smartgrid domains are still lacking, so the requirements at this stage remain largely based on NIST 7628 and ISO 27000 series. Efforts to consider applicability of further standards such as IEC 62351, parts of IEC 62443, ISO 15408 and ISO 19790 are planned for 2013 - 2014.

Table B.9.2.2 - Project Survey Sheet for UK SSH Applicability: M/490 Smart Grid Information Security working group

UK SSH Applicability	
UK SSH applicability and rationale	The UK SSH situation is a good opportunity to experiment with the approach developed by SGIS.
Possible application	This approach can be used to assess the security requirements to apply in the UK SSH context,

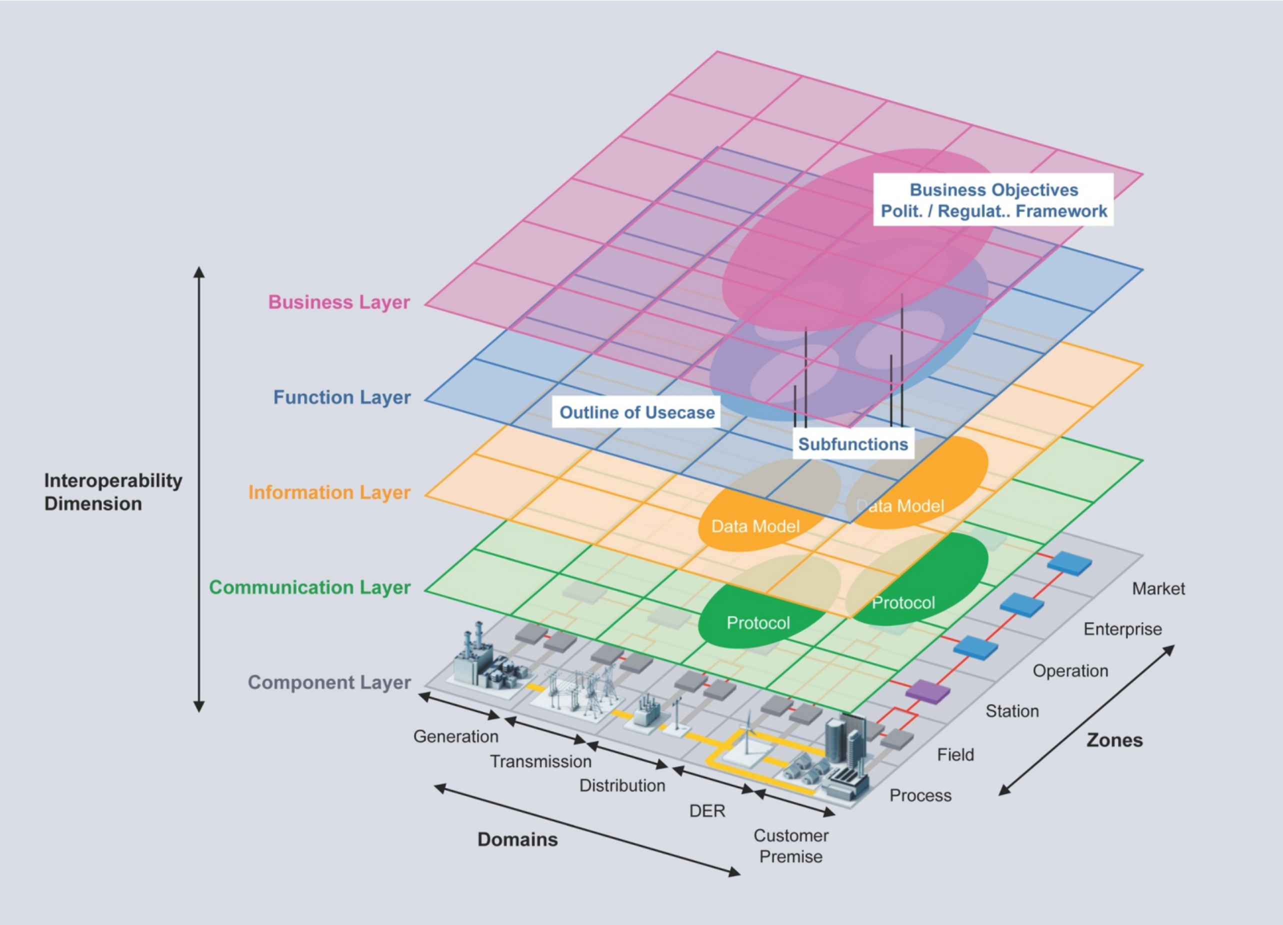


Figure B.9.2.1 -Smart Grid Architecture Model.

Table B.9.2.3 -Security Level

Security Level	Security Level Name	European Grid Stability Scenario - Assuming low likelihood Security Level Examples
5	Highly Critical	Assets who disruption could lead to a power loss above 10 GW Pan European Incident
4	Critical	Assets who disruption could lead to a power loss from above 1 GW to10 GW European/Country Incident
3	High	Assets who disruption could lead to a power loss from above 100 MW to 1 GW Country/Regional Incident
2	Medium	Assets who disruption could lead to a power loss from 1 MW to 100 MW Regional/Town Incident
1	Low	Assets who disruption could lead to a power loss under 1 MW Town/Neighbourhood Incident

B.10 I9: EU-Commission Smart Grid Task Force (SGTF)

B.10.1 Project Basic Information

Table B.10.1.1 - Project Survey Sheet for Basic Information: EU-Commission Smart Grid Task Force

Project Basic Information			
Reviewer	F. Ennesser	Date	21/01/2013
ID	ETI-SSHP-WA3-WP1-H-9	Revision	1.1
Initiative name (or system name)	Data Protection Impact Assessment Template for Smart Grids and Smart Metering Systems		
Application domain	Any smart grid domain where individuals personal data are handled (i.e. privacy is at stake), and especially smart metering		
Organisation (developed or operated by)	European Commission DG ENER Smart Grid Task Force Expert Group 2: Regulatory recommendations for Privacy, Data Protection and Cyber-security in the Smart Grid environment		
Nation delivered	European Union		
Delivered or trial	Draft, to be submitted to the Article 29 Working Party (where the Data Protection Authorities of each member states are represented) for approval at their next meeting in February 2013		
Delivered or trial year	07/01/2013		
Reference	Gemalto internal source		
What the system intends to achieve	A Smart Grid is supported by a communications network that collects and processes an increasingly high quantity of sensing data and makes it available to entitled stakeholders and systems. This data is collected from everywhere in a Smart Grid infrastructure, which includes consumers' homes (and especially heating systems). Hence individual's privacy needs to be protected. The Data Protection Impact assessment template will contribute to organisations that initiate smart grid deployments as well as changes to existing smart grid architecture platforms in assessing the privacy risks of these initiatives. As such the DPIA shall be considered as complementary to or part of a wider risk management process an organisation has to implement and perform. Indeed, although it is called an "assessment", the DPIA goes beyond the simple analysis of data protection risks, by describing adopted or envisaged safeguards and control measures in proportion to the risks identified, thereby being based on a risk management procedure, rather than a mere risk assessment one.		
Typical use case	Protection of the privacy of individuals (i.e. "personal data") in the smart grid context		
Cost (if available)			

B.10.2 Findings

Table B.10.2.1 - Project Survey Sheet for Findings: EU-Commission Smart Grid Task Force

Findings	
Quality aspect	Security(Privacy preservation)
Featured system architecture	The conceptual Reference Architecture developed under M/490 is used

	as a model.
Design aspect	The purpose of this template is to provide guidance for performing a Data Protection Impact Assessment (DPIA) to Smart Grid and Smart Metering systems. It describes a documented process comprising the following important steps: - Step 1 - Pre-assessment and criteria determining the need to conduct a DPIA; - Step-2 - Initiation; - Step 3 - Identification, characterisation and description of Smart Grid systems / applications processing personal data; - Step 4 - Identification of relevant risks; - Step 5 - Data protection risk assessment on privacy targets; (Table 9.2.3) - Step 6 - Identification and Recommendation of controls and residual risks; - Step 7 - Documentation and drafting of the DPIA Report; - Step 8 - Reviewing and maintenance.
Pros	There exist a number of important benefits when performing a DPIA. The following benefits are identified when using this DPIA: - Preventing costly adjustments in processes or system redesign by mitigating privacy and data protection risks - Prevention of discontinuation of a project by early understanding the major risks. - Reducing the impact of law enforcement and oversight involvement - Improving the quality of personal data (minimisation, accuracy) - Improving service and operation processes - Improving decision-making regarding data protection - Raising privacy awareness within the organisation - Improving the feasibility of a project - strengthening confidence of customers, employees or citizens in the way which personal data are processed and privacy is respected - Improving communication about privacy and the protection of personal data. The DPIA process can be used by involved smart grid stakeholders to demonstrate to customers and regulators that due diligence has been made toward protecting personal data.
Cons	Performing a DPIA seriously involves significant cost and workload for an organization, with a strict process to follow and documentation to produce.

Table B.10.2.2 - Project Survey Sheet for UK SSH Applicability: EU-Commission Smart Grid Task Force

UK SSH Applicability	
UK SSH applicability and rationale	Applicable- Even in the absence of specific enforcement, involved actors have to comply with EU privacy regulations and a DPIA is a necessary step.
Possible application	Risk assessment to preserve customers' privacy in the ETI project.

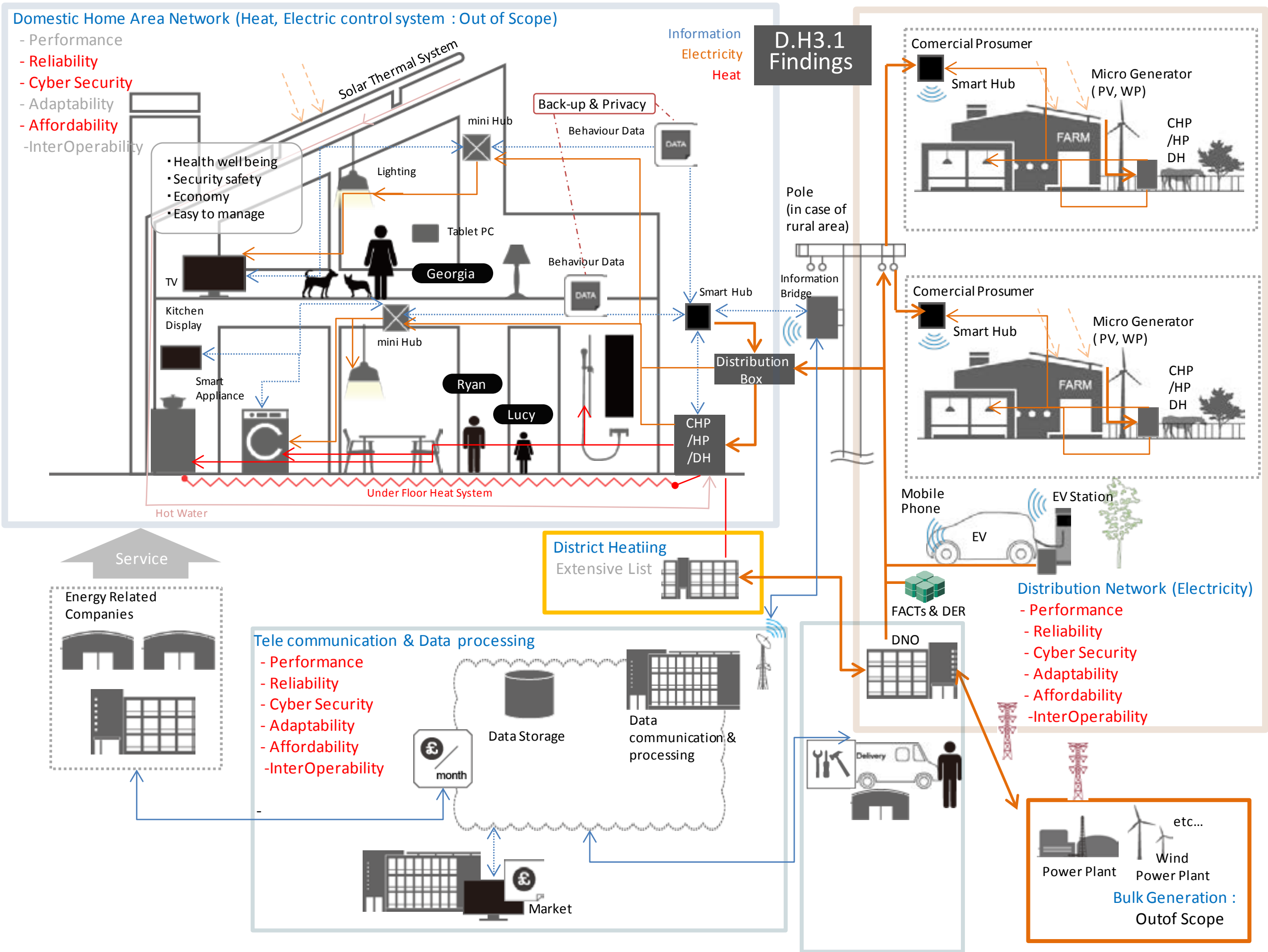
Table B.10.2.3 - Description of Privacy targets

Privacy targets	Description
Safeguarding quality of personal data	Data avoidance and minimisation, purpose specification and limitation, quality of data and transparency are the key targets that need to be ensured.
Legitimacy of processing personal data	Legitimacy of processing personal data must be ensured either by basing data processing on explicit consent, contract, legal obligation, etc.
Legitimacy of processing sensitive personal data	Legitimacy of processing sensitive personal data must be ensured either by basing data processing on explicit consent, a special legal basis, etc.
Compliance with the data subject's right to be informed	It must be ensured that the data subject is informed about the collection of his data in a timely manner.
Compliance with the data subject's right of access to data, correct and erase data	It must be ensured that the data subject's wish to access, correct, erase and block his data is fulfilled in a timely manner. Implementation of the right to be forgotten and the right to data portability should be encouraged
Compliance with the data subject's right to object	It must be ensured that the data subject's data is no longer processed if he or she objects. Transparency of automated decisions vis-à-vis individuals must be ensured especially in the case of profiling.
Safeguarding confidentiality and security of processing	Preventing unauthorized access, logging of data processing, network and transport security and preventing accidental loss of data are the key targets that need to be ensured. Breach notification procedure should be promoted
Compliance with notification requirements	Notification about data processing, prior compliance checking and documentation are the key targets that need to be ensured. DPIA shall be considered as a determinant tool for this target
Compliance with data retention requirements	Retention of data should be for the minimum period of time consistent with the purpose of the retention or other legal requirements.
Privacy by design	Having regard to the state of the art and the cost of implementation, technical and organisational measures and

	procedures shall be designed both at the time of the determination of the means for processing and at the time of the processing itself in such a way that they fully respect privacy and data protection rights of the data subject.
Privacy by default	Mechanisms shall be implemented for ensuring that, by default, only those personal data are processed which are necessary for each specific purpose of the processing and are especially not collected or retained beyond the minimum necessary for those purposes, both in terms of the amount of the data and the time of their storage.

Appendix C: SSHP Entity Visualisation Chart

The diagram below shows the key findings described in Section 5.3 mapped onto a SSHP entity visualisation chart. The image contains three categories: domestic (including the Home Area Network), distribution network (including small commercial prosumer, public facilities like EV charger, DNO properties like pole, FACTS and DER) and data centre (telecommunications and data processing). Each category has six quality aspects. The highlighted quality aspect items are described in Section 5.3.



Quality aspects are in red: these are described in detail in the project survey sheets in Appendix B.