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Defining characterization structure of interaction schemes

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Content

1. Introduction

The S3C project has an overall objective to "***foster smart energy behaviour*** […] ***via active user participation***", i.e. to enable and/or incite *end users* to take on more 'active' roles in the implementation and functioning of the future energy system. To that end, a selection of smart grid projects will be analysed from the point of view of their contribution to this overall goal[1]. An evaluation of which smart grid projects are successful in fostering smart energy behaviour or enabling end users to take on more active roles in the energy system should include a description of the instruments used within the project as well as the results achieved. Project-specific instruments or *combinations* of instruments such as different tariff structures or technological elements need to be mapped along with the project implementation processes and the context where the project is set. Understanding and documenting the existing "tool box" is vital as its contents affect the outcome of the whole project.

As stated in the description of work, task 3.1 aims to produce a structure for characterizing interaction schemes and their context. The description shall among other things include information on objectives and targets, end-use areas and technologies targeted, the period the scheme was active, available budget and information on the expected initial effect, the national context, etc. These characteristics will be used for the analysis of the projects in task 3.4, and the structure in which they are gathered will constitute a reporting format for the family of projects.

Task leader SP initiated the work in task 3.1 through an internal workshop, setting the baseline for the characterization structure. Desktop studies were conducted, resulting in a draft structure that was sent to all S3C consortium member organizations, reviewed and discussed in two face-to-face consortium meetings in Brussels. The outcome of these activities is an excel-based document which will be transformed into an online questionnaire to facilitate the documentation process. The online questionnaire can be filled out by S3C consortium members or by representatives from a smart grid project as part of task 3.2. The contents of the characterization structure might to some extent be changed when creating the online questionnaire or in the initial period of filling it with information from projects.

[1] The term 'smart grid project' refers to projects with an experimental set-up that includes at least one part of a set of socio-technical interventions that could lead in the future to the full deployment of a 'smart grid' (i.e. a grid able to carry out load control at high resolution – i.e. the remote and real-time control of individual appliances – in order to cope with fluctuations in supply as well as in demand). This set of socio-technical interventions is commonly held to include 'advanced' or 'smart' meters, in-home displays, smart appliances, home energy management systems, etc.

2. The characterization structure

2.1 Overall structure – Five Characterisation Classes

The descriptions in the excel document are listed under five different categories, or classes. Each class is divided into sub-classes, with methods and instances. The five classes in the structure are:

- **Project description**: Provides a general description of the project, with information such as duration, budget etc.
- **What**: Describes the actual elements of the scheme, the specific tools that have been used by the projects and is divided into sub-categories reflecting the most common types of end user interaction schemes: Economics, Technology and Information. Moreover, information about Feedback and Risk management and Integrity is included to further describe the schemes.
- **Where and when**: The context where the interaction scheme is implemented will have an effect on the results of the project. The European projects that will be analysed within S3C are set in different locations, which differ in climate and energy market features, for instance. As one project toolbox can achieve great results in one region, the same project toolbox can in another location be less successful. These variances must be captured and taken into account in the analysis.
- **Who**: Provides the baseline information about end users before entering the interaction scheme, such as electricity consumption and household size. The project organisation and involvement of other stakeholders is also described in this class.
- **Results**: Listing a few key results from the interaction schemes.

The five classes in the excel document are put in tabs in the excel sheet, which are further described in the sections below. The comprised characterization structure can be found in Annex I.

The structure indicates how to fill in the necessary replies. The most important units and measurements that will be used are:

☑
Text
Number
%
Ranking 1-3
EUR/kWh
EUR/month
EUR/kW
EUR
Time unit
Time interval
kWh/month
kg CO2/month

To render an easy-to-handle characterization structure, most replies can be given by ticking of information that apply to a project or filling in numbers, whereas text is to be used as limited as possible. Furthermore, all replies can be commented in a separate column, in case the reply is e.g. only based on intermediate results or the limitations of a certain criterion are to be marked.

2.2 Class 1 – Project description

The class Project Description provides general information on the project independent, of the customer involvement. The answers are to be provided in text format.

References for additional reading on the project can be made to inform the researchers performing the analysis about further methods or data.

General information	
Name of project	
Project start - end	
Current project phase	
Time table of the implementation of project	
Budget	
Funding	
References	
Stated goal of the project including concrete targets	

Figure 1: Class - General Information

2.3 Class 2 - What

This part of the characterization structure aims to characterize the interactions schemes and tools that have been used by the different projects in their individual occurrence. The differences between tools that might appear to be similar will thereby be made visible. That way, the individual components of the tools applied by different projects can be analysed in-depth and compared.

2.3.1 Sub-class 1 – Economics

Sub-class	Method	Instances		Unit/measurement
Economics				
	Name of tariff (TOU, CPP, CPR, RTP, net debiting or other)			Name
	Energy based tariffs [EUR/kWh] (energy and grid)	Time dependent	Number of different tariff structures	Number
			Net debiting for local production	☑
			Number of time blocks per day	Number
			Price update frequency	Number/time unit
			Average price	EUR/kWh
			Standard deviation of price	EUR/kWh
			Critical peak component	☑
			Critical consumption component	☑
		Non-time dependent	Fixed price contracts	☑
			Size of fixed price contract	EUR/kWh
		Break-point	Level	kWh
			Change of tariff at break-point	Text
	Power based tariffs [EUR/kW]	Size of power based component of tariff		EUR/kW
		Time period on which the peak load is calculated (day, week, month etc.)		Text
		Break-point	Level	kW
			Change of tariff at break-point	Text
	Fixed tariff [EUR]	Size of fixed tariff component		EUR
	Billing procedure	Separate energy and grid bills		☑
	Direct DSM contracting	Length of time period for contract		Time unit
		Actor executing direct DSM		Text
		Compensation to end-users being part of direc	Fixed payment	EUR/month
			Energy based component	EUR/kWh
			Power based component	EUR/kW
	Market organisation and design	Innovative energy markets (local markets etc.)		☑
		Aggregator		☑
		Energy service provider		☑
		Feed-in arrangements for local electricity production in scheme		Text
		Energy services offered in scheme		Text

Figure 2: Class 2 - Sub-class 1 Economics

Sub-class 1 is characterizes those interaction schemes that are based on economic incentives. In fact, not only different tariff structures, but also contracting arrangements and specific market organization set-ups underlying the implementation of these tools can be reflected in detail within the characterization structure (see Figure 2). Those instances that are to characterize tariff incentives apply to different tariff-types, such as TOU-, RTP- or consumption-based- tariffs or those feature a Critical Peak Pricing or Critical Consumption Pricing component and can highlight differences between individual occurrences of these tariff-types.

2.3.2 Sub-class 2 - Technology

Sub-class 2 captures the technological tools that provided the infrastructure which allowed for the use of the economic incentives. The methods captured in this sub-class include several metering-variations as well as different control systems that allow for automatic energy management on the hand, but also include a Prosumer-infrastructure, if e.g. Distributed Energy Resources (DER) or electric vehicles were part of the Smart Grid project set-up as well.

Sub-class	Method	Instances		Unit/measurement
Technology	Metering	Consumption metering		☑
		Injection metering		☑
		Automatic Meter Reading (AMR)		☑
		Metering time interval		Time interval
	Control systems	Individual equipment	Heating/cooling control system	☑
			Smart appliances	☑
		Home automation	Home Energy Management System (HEMS)	☑
			Customer Energy Management System (CEMS)	☑
		Area automation		☑
		Remote load control		☑
	Local generation	PV		☑
		Small-scale wind		☑
		Heat pump		☑
		CHP		☑
	Electric/hybrid vehicles	Home charging stations		☑
		Public charging stations		☑
		Charging control system		☑
	Building energy efficiency solutions	Thermal insulation of shell		☑
		Heating/cooling systems		☑
		Heat recovery systems		☑
	Competitions or energy challenges/game			☑

Figure 3: Class 2 - Sub-class 2 Technology

2.3.3 Sub-Class 3 – Feedback

Figure 4 renders an overview of different feedback instances that can be covered by different instruments in different combinations. Instrument types or feedback devices that will be analysed in terms of these instances are:

In-house Displays (IHD) – Ambient Displays – Web Pages – Informative Billing – E-Mail – Text Message – (Smartphone) Apps

In fact, the characterization allows to spot differences between e.g. apps used in different projects and can relate these findings to results achieved with these differently configurated apps. However, the table will allow for the analysis of the set-up of new feedback devices that do not fit one of the aforementioned categories as well.

Sub-class		Instances			Unit/measurement
Feedback					
	Feedback type	Electricity price			☑
		Environmental impact			☑
		Current usage rate (kWh)			☑
		Historical comparison of consumption and/or cost			☑
		Social comparison	Peer comparison		☑
			Similar household comparison	Housing type	☑
				Type of similar household	☑
				Neighbourhood average	☑
				Regional average	☑
			Competition comparison		☑
		Disaggregated consumption levels			☑
		Consumption aggregated over time			☑
		Costs over time			☑
		Cost aggregated over time			☑
		Cost reduction comparisons			☑
		Savings compared to previous periods			☑
		System effects (increased power quality)			☑
		Hints and tips			☑
		Relativity to targets	Targets defined by project		☑
			Targets defined by end user		☑
		Unusual usage alerts			☑
		Predictions of bill or usage			☑
		Feedback by request			☑
	Feedback frequency				Time

Figure 4: Sub-class 3 - Feedback

2.3.4 Sub-class 4 - Information

Sub-class	Method	Instances			Unit/measurement
Information					
	Knowledge-raising activities for strengthening energy consciousness	Channel	Public advertising		☑
			Direct advertising		☑
			Workshops & seminars		☑
			Home visit		☑
			Social media		☑
			Other		Text
		Content mainly related to	Environment		☑
			Energy		☑
			Costs		☑
			New technology		☑
			Other		Text
	Participant communication	Type of communication	Written information	E-mail	☑
				Regular mail	☑
				General information	☑
				Tailored information	☑
				Social media	☑
				Website	☑
				Other	Text
			Group meeting		☑
			Focus groups		☑
			Personal information		☑
			Service point/centre		☑
			Demonstration object		☑
			"Suggestions box"/consultations		☑
			End user training		☑
			Customer service and support	Phone	☑
				Email	☑
				Social media	☑
		Segmentation	End user segmentation method		Text
			Use of segmented messages in communication		☑
		Responses to engagement enquiry	Total number of enquiries		Number
			Reactions/replies registered		Number
		Evaluation	Interviews		☑
			Focus groups		☑
			Surveys		☑
			Integration of feedback for adjustment of project		☑

Figure 5: Sub-class 4 – Information

This sub-class deals with those interaction schemes that are meant to inform the customers, apart from the traditional ICT-based. The channels described in Figure 5 especially relate to the communication utilized for customer acquisition as well as to channels that help to maintain the interest and participation of the field test participants. How were people approached and educated? Were the communication options chosen personal or impersonal, individual or community-based?

2.3.5 Sub-class 5 - Risk Management and Integrity

Sub-class	Method	Instances		Unit/measurement
Risk management and integrity	End user control	End user can choose scheme contents/participate in the design of scheme		☑
		End user can change or override the settings in the scheme		☑
		End user can modify involvement in scheme		☑
		End user can opt in or out of scheme		☑
	Safeguard promises or guarantees made by the project owner before the scheme started			Text
	Data management & security	Transparancy of data use	Data storage in personal form	☑
			Data storage in anonymus form	☑
		Agreement with end user on data managemen	What data are collected and stored	Text
			The period of storage	Time
			What has data been used for?	Text

Figure 6: Sub-Class 5 - Risk Management and Integrity

Sub-class 5 relates to the specific arrangement of the tools applied in the smart grid trials and relates to the integrity of the final decision of the participants. To what extent do the systems used allow for a final end user control, can the end user override energy management schedules or opt-out? Recent research has shown that these questions relate to consumer acceptance issues strongly, Furthermore, the sub-class relates to privacy issues revolving around data management and security.

2.4 Class 3 - Where and When

Class 3 provides necessary background information for the analysis. The timeframe of a project and the country it was set up in can have extensive influence on the set-up of a project's infrastructure (e.g. regulation in different countries can have an impact on which tools can be applied and which data can be used) as well the results of the project (e.g. first Smart Grid pilots resulted in the finding that flexibility of electricity use decreases in autumn and winter months).

Sub-class		Instances			Unit/measurement
Location	Country/countries				Text
	Region				Text
	City				
	Project setting	Rural			☑
		Urban			☑
		Metropole region			☑
Context	Climate	Temperature zone			Text
		Season			Text
	Energy	Electricity market	Liberalized electricity market		☑
			Market share of the largest retailer in the electricity market		% of the total generation
			Number of retailers in country		Number
			Pricing mechnism		Text
			Average electricity price level on wholesale market during the project period		EUR/kWh
		Policy	Are there any legal obstacles to "prosumers"?		Text
			Energy policy mainly driven by…	Economy	Ranking 1-3
				Security of supply	Ranking 1-3
				Environmental issues	Ranking 1-3
		Technical development	Smart meter roll-out		☑
			Share of RES in electricity production		%
			Share of distributed electricity production		%
			Share of intermittent electricity production		%
			Percentage of vehicles being EVs in country		%

Figure 7: Class 4: Where and When

2.4.1 Subclass 1 – Location

The country as well as the regions and cities in which the field tests were carried out can be an influence on the set-up and the outcome. Whether the field tests were carried out in a rural, urban or metropolitan character can also have an influence

2.4.2 Sub-Class 2 – Context

This sub-class provides some more background information against which the results of a project have to be seen. Seasons and temperature zones can have an impact on the flexibility of field test participants. Political objectives as well as rules and regulations further impact the field tests.

2.5 Class 4 - Who

This class contains information about the parties that organized and set up the field tests and devised the tools that were applied. Also, data on the – *residential , commercial, industrial or Prosumer* - customers before they became part of a Smart Grid community are gathered here.

2.5.1 Sub-class 1 – End-Users: before entering scheme

This sub-class is to shed some light on the participants before they were integrated into a Smart Grid infrastructure and learned about load shifting and new energy saving mechanisms. Basic data such as number of households that took part in the field should be available and bring insight to the customers that agreed to take part in Smart Grid trials.

Sub-class		Instances		Unit/measurement
End users: before entering scheme	Residential end users	Total number of households in scheme		Number
		Electricity consumption (per household)	Average monthly consumption	kWh/month
			Average monthly consumption in country	kWh/month
			Share with consumption below average	%
			Share with consumption above average	%
		Average monthly electricity bill		EUR/month
		Persons in household	Share of 1 persons/hh	%
			Share of 2 persons/hh	%
			Share of 3-4 persons/hh	%
			Share of more than 4 persons/hh	%
		Household income (netto)	Average in country	EUR/month
			Share of households with income up to average	%
			Share of households with income above average	%
			Not known	%
		Building	Average size of flat/house	m2
			Share of rented apartments	%
			Share of rented houses	%
			Share of own property/apartment	%
			Other	Text

Figure 8 Sub-class 1 - End-users- before entering the scheme (basic data)

However, some projects went further and cannot only provide basic data, but data from quantitative as well as qualitative customer surveys and/or interviews. In fact, it would be possible to characterise Smart Grid-interested individuals by filling out the following part of the sub-class 1 map (see Figure 9). The information that could be gathered could e.g. be used as input for customer segmentation models that would help to develop targeted new tools.

	Information about end user answering to survey/interview (optional)	Sex of end user	Male	%
			Female	%
		Age of end users	Share of end users 0-20 years	%
			Share of end users 20-30 years	%
			Share of end users 30-50 years	%
			Share of end users 50+ years	%
		Education level (highest level completed)	Elementary/primary school	%
			High school/secondary school	%
			University	%
		Occupation	Full-time occupation (employment or studies)	%
			Part-time occupation	%
			At home	%
			Unemployed	%

Figure 9 Sub-class 1 - End-users before entering the scheme (individual data)

Furthermore, basic data on commercial or industrial customers that took part in Smart Grid trials have to be collected as well. Latest research considers commercial customers the "low-hanging fruits" of the Smart Grid market. In fact, they cannot be left out and success factors for raising awareness and acceptance for Smart Grid solutions with decision-makers in businesses and industries need to be analysed carefully. Furthermore, Prosumers are becoming more and more relevant within the European energy markets. Their dual role has to be accounted for in the characterization scheme.

	Industry/Commercial end users	Total number of industries/commercial end users in scheme		Number
		Electricity consumption	Average monthly consumption	kWh/month
			Average monthly consumption in country	kWh/month
			Share with consumption below average	%
			Share with consumption above average	%
		Average monthly electricity bill		EUR/month
		Type of industry/commercial customer	Manufacturing	%
			Process	%
			Other	Text and %
		Average annual turnover		EUR/a
		Building	Average size of property	m2
			Share of rented property	%
			Share of own property	%
			Other	Text
		Average number of employees	0-100	☑
			100-200	☑
			200+	☑
	Monthly carbon footprint from electricity use			kg CO2/month
	Prosumer	Average time of net electricity production		%
		Average monthly local production		kWh/month

Figure 10: Sub-class 1- End-users before entering the scheme (commercial, industrial, Prosumer end-useres)

2.5.2 Sub-class 2 – Project Organisation

In a second step, the parties responsible for the development and implementation of the smart grid trial have to be characterised as well. Consortiums for Smart Grid trials are made up of different stakeholders that each leaves their impact in the project design and resulting outcome. Consumer organisations or research institutes specialized in sociological/psychological effects of technological transitions have rarely been part of consortiums. In fact, it should be highlighted, if they were.

Project organisation	Total number of partners involved			Number
	Types of partners involved	Co-creation with end users		☑
		End user organisation	National level organisation	☑
			Local level organisation	☑
		Energy company	DSO	☑
			TSO	☑
			ESCO	☑
			Retailer	☑
			Other	Text
		ICT	Telecom company	☑
			IT provider	☑
			Other	Text
		Construction company		☑
		Authority	Local/city council	☑
			Regional	☑
			Province	☑
			National	☑
		Academy		☑
		Research institute		☑
		International partners		☑
		Other		Text

Figure 11 Sub-Class 2 - Project Organisation

2.5.3 Sub-class 3 – Stakeholders involved

Furthermore, the scope of stakeholders affected by Smart Grid trials is not limited to end-users and organisation parties. Other stakeholders, particularly in regional and local field, can be activated as well and thereby help the project by raising awareness and acceptance. Numerous specifically successful campaigns and projects were supported by regional government or city councils.

Stakeholders involved (other than end-users)	End user organisation	National level organisation	☑
		Local level organisation	☑
	Energy company	DSO	☑
		TSO	☑
		ESCO	☑
		Retailer	☑
		Other	Text
	ICT	Telecom company	☑
		IT provider	☑
		Other	☑
	Construction company		☑
	Constructor		☑
	Authority	Local/city council	☑
		Regional	☑
		Province	☑
		National	☑
	Academy		☑
	Research institute		☑
	International partners		☑
	Other		Text

Figure 12 Sub-class 3 - Stakeholders involved

2.6 Class 5 - Results

The results have to be seen in context with the aims of the S3C-projects. Loadshifts or energy conservation are not considered a success per se. Instead, the results are regarded through the eyes of the end-user. What benefits did the tools trialled in the field test deliver for them? Benefits are by far not limited to monetary means (Smart Consumer), but also to transparency increases and an increase in options (Smart Customer) or e.g. enhanced participation options (Smart Citizen). Furthermore, the Smart Grid trials can result in learning processes that change the long-term energy usage behaviour of an end-user and there might be further benefits that were not discovered during the research for this characterisation structure, but are deemed very relevant by stakeholders that carried out or took part in Smart Grid trials.

2.6.1 Sub-class 1 – End-user: after implementation of schemes

Sub-class	Instances		Unit/measurement
End users: after implementation of scheme	Residential end users (per household)	Average monthly electricity consumption	kWh/month
		Average monthly electricity bill	EUR/month
	Industry/Commercial end users	Average monthly electricity consumption	kWh/month
		Average monthly electricity bill	EUR/month
	Average % of energy demand shifted away from peak periods		%
	Average % of energy demand shifted towards consumption valleys		%
	Prosumer	Average time of net electricity production during scheme	%
		Average monthly local production during scheme	kWh/month

Figure 13: Sub-class 1 - End users: after implementation of scheme

2.6.2 Sub-class 2 – Attitudes among end-users

What effect did these benefits have on the attitudes and knowledge of the customers? If data on these questions was collected by means of qualitative surveys or interviews, it can be gathered in this sub-class of the characterization scheme (see Figure 14).

Attitudes among end users	Acceptance	Average dropout rate per month	Number/month
		Average number of complaints per month	Number/month
		Number of end users interested in keeping/buying the equipment	Number
		Number of end users interested in participating in follow-up schemes	Number
		Overall end user satisfaction of the scheme	Text
	Enhancing consciousness among end users		Text
	Change in end user attitudes towards the idea of a smart grid		Text

Figure 14 Sub-class 2 - Attitudes among end-users

2.6.3 Subclass 3,4,5 – System reliability, other effects, Project manager experiences

Nevertheless, results of Smart Grid trials are difficult to pinpoint and relate to individual tools or incentives. Furthermore, many projects have devised their own KPIs that differ from the results deemed particularly relevant in this characterization structure. To capture further result-categories, the characterisation structure provides the options to include more results that came up during trials and were not anticipated. These can be attributed to either specific topics such as system reliability or facilitated integration of renewable energies or to the personal experiences of project personnel. If project managers have a strong feeling about success factors, which are not present in the characterisation structure, they should be given the opportunity to write about the experiences and thereby enlarge the scope of the S3C-characterization structure.

System reliability	Average number of malfunctions reported per month	Number/month
Other effects	Market integration of system services	Text
	Market integration of decentralized generation	Text
	Market integration of end users	Text
	Other	Text
Project manager experiences	Success factors of the project according to the project manager	Text
	Success factors on communication and engagement of the project	Text

Figure 15 Sub-class 3, 4, 5 - System reliability, other effects, Project manager experiences