Distributed Renewable resources Exploitation in electric grids through Advanced heterarchical Management

D6.3	Industrialisation and Integration roadmap		
Project :	DREAM FP7 - 609359	**Start / Duration:**	01 Sep 2013 / 40 Months
Dissemination[1]:	PU	**Nature[2]:**	R
Due Date :	M40 (1 to 40 see DoW)		
Filename[3]:	D6.3_ Industrialisation and Integration roadmap_v1.doc[3]		

ABSTRACT:

This document corresponds to the Roadmap for integration and industrialization of the Dream concept and Vision.

It includes the presentation of the vision and the different steps related to technical, regulation barriers and challenges to overcome in a time step approach.

[1] PU = Public; PP = Restricted to other program participants (including the ECservices); CO = Confidential, only for members of the Consortium (including the EC services); RE = Restricted to a group specified by the Consortium (including the EC services).

[2] R = Report; R+O = Report plus Other. Note: all "O" deliverables must be accompanied by a deliverable report.

[3] Filename must follow the semantic defined in the Handbook (eg DX.Y_name to the deliverable_v0xx). v1 corresponds to the final release submitted to the EC.

Deliverable Contributors[4]:	Name	Organisation	Role / Title
Deliverable Leader[5]	Stavros Makrynikas	HEDNO	WP7 leader
Contributing Author(s)[6]	Iasonas Kouveliotis-Lysikatos	ICCS	WP4 Leader
	Raphaël Caire	Grenoble INP	WP1 Leader
	Emmanuelle Vanet	Grenoble INP	WP3 Leader
	Han Lemmens	DNV GL	Contributor
Reviewer(s)[7]	Maria Kouveletsou	HEDNO	Reviewer WP7 leader
	Juan Luis Garrote	TELVENT	Reviewer WP6 leader
	Aris Dimeas	ICCS	Reviewer WP4 leader
Final review and approval by Coordinator	Raphaël Caire	Grenoble INP	Coordinator

Document History:

Release	Date	Reason for Change	Status[8]	Distribution
V0	30/11/2016	Creation with the squeleton	draft	consortium
V01	12/12/2016	First draft of the document	draft	consortium
V02	13/12/2016	First draft of the document	draft	consortium
V03	16/12/2016	Additions by DNV-GL	draft	consortium
V04	20/12/2016	Final Draft	draft	consortium
V1	13/01/2017	Final Version	Released	European Commission

[4] Refer to the DREAM Management Handbook for more details on the IR Process and roles of contributors.
[5] Person from the lead beneficiary that is responsible for the deliverable.
[6] Person(s) from contributing partners for the deliverable.
[7] Typically person(s) with appropriate expertise to assess the deliverable quality.
[8] Status = “Draft”; “In Review”; “Released”

TABLE OF CONTENTS

Executive Summary

This document provides the proposed roadmap for Dream solution integration and industrialization. The vision for 2030 sets the required properties for the scalable and deployable coordination and control of the DERs in distribution networks. The Roadmap defines the objectives for three time horizons – the near, mid and long term. For each time horizon, objectives are given. Finally, the needs expressed by the stakeholders and the barriers that are the most probable difficulties and obstacles to be overcome, are analysed. The four categories are: Technical and industrial, Regulatory, Scientific and Societal as shown in Figure 1.

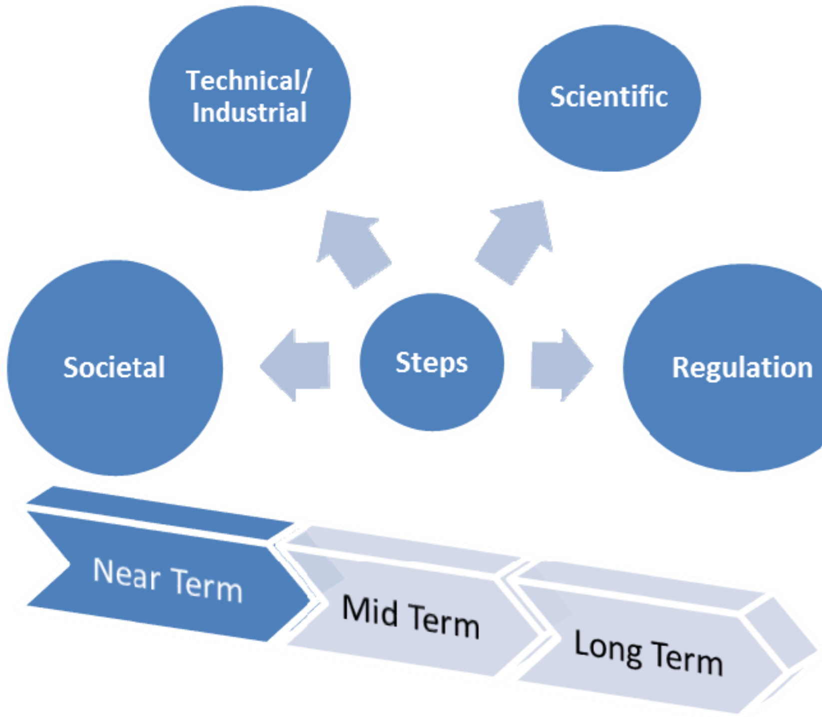

Figure 1 – The proposed roadmap Dream solution

List of Figures

List of Tables

List of acronyms / abbreviations used in this document

Acronym / Abbreviation	Description
BRP	Balance Responsible Partners
DER	Distributed energy resources
DSO	Distribution system operator
ESCO	Energy service company
HMI	Human Machine Interface
KPI	Key Performance Indicator
PM	Performance Metric
RES	Renewable energy systems
R&I	Research & Innovation
TSO	Transmission system operator
UC	Use Case
USEF	Universal smart energy framework
aRTU	Advanced Remote Terminal Unit
RES	Renewable Energy Resources
MAGIC	Multi-Agent Intelligent Controllers

Glossary of terms used in this document

Name	Description

1. Introduction

Innovative approaches for the management of the electrical power grids that would set the cornerstones of the future Smart Grid are becoming more and more attractive. More specifically, new mechanisms should be embraced that would allow an increased monitoring and controllability of the grid and would help the integration of storage technologies and demand response schemes. This way, by having a more accurate observability of the grid, a more efficient management of variable generation and loads would be possible in terms of decreasing the operating costs, deferring planning investments and providing market enabling solutions for the active participation of the end users.

Hence, it is in the responsibility of research activities (for both the societies of academia and industry) to develop, prove and demonstrate new principles and methodologies that will facilitate the transition towards the smart grid vision. However, this path is paved with extreme challenges regarding the modelling, developing and implementing new technologies in the real-word distribution grids. Such novelties include demand response tools in a fully integrated environment with energy storage systems. The underlying goals of these tools are to optimize the power system operation and validate the corresponding business models that encompass all the aforementioned advanced functionalities. It is becoming highly probable that new marketplaces will emerge in these domains providing numerous benefits for all the market players.

2. Industrial and Policy Context

European electrical networks are facing new challenges due to several factors such as power industry restructuring, unbundling of energy services and incentives in renewable energy sources. In addition, the democratization of Information and Communication Technologies (ICT) has impacted the technological and digital transformation of the power industry.

Traditionally, the organizational schemes were based on monopoly situations. Indeed, the high costs of deployment and maintenance of the electrical infrastructures have been favourable to vertically integrated utilities for production, transmission and distribution of electricity. This organization was allowing the system operators to guarantee the security and the reliability of their grids while searching its optimal operation.

The liberalization of the European energy market that started in Europe with the directive EC 92/96 [EC-96] led to the introduction of competition into the power industry, especially at the level of the wholesale market and gradually at the retail market side. All the new emerging unbundled actors can now participate in electricity trades depending on their own strategies. Transmission and distribution system operators have to ease these energy exchanges while preventing discrimination and guaranteeing a fair access to the grid to all participants.

In parallel and in line with the growth of environmental and sustainable awareness, the European Union has adopted a large number of directives targeting energy savings, increase of the proportion of renewable energy resources, and reduction of the greenhouse gas emissions. EU countries have recently agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. These targets aim to help the EU achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target. The targets are based on a thorough economic analysis that measures how to cost-effectively achieve decarbonization by 2050. The detailed targets for 2030 are the following: a 40% cut in greenhouse gas emissions compared to 1990 levels, at least a 27% share of renewable energy consumption, at least 27% energy savings compared with the business-as-usual scenario.

To meet the targets, the European Commission has proposed some ideas on a new governance system based on national plans for competitive, secure, and sustainable energy. These plans will follow a common EU approach. They will ensure stronger investor certainty, greater transparency, enhanced policy coherence and improved coordination across the EU.

These main concerns have implied the introduction of a large amount of high variable renewable sources into the generation mix, and have induced an important need of flexibility in the electrical networks to preserve the system stability at different time horizons. More particularly, due to regulatory incentives and subsidies that have been established for environmental concerns, investors and particularly end users are now encouraged to install small-scale distributed generations. The need for flexibility is even more significant especially at local levels, in order to ensure an optimized and efficient operation of distribution grids (including microgrids situations).

Improved network capacity management is thus required in order to maximize sustainable generation in the most economical way for the whole society, while maintaining network stability and reliability. Whenever it is a cost-effective and stable alternative to reinforcement's solutions, this capacity management can be increased via the operation of controllable sources and loads, allowing the grid to be more flexible at both demand and supply sides. If such solutions turn out to be more cost-effective and do not compromise security of supply and quality of service, grid operators should be able to postpone and even reduce their investments for capacity upgrading of the grid thanks to flexibility management solutions.

In the actual situation, these flexibility opportunities are used at national level for Balancing Responsible Parties (BRPs) portfolio optimization, for balancing mechanism and for transmission contingency management. With the increasing interconnection rate of Distributed Energy Resources (DERs), more and more flexibility opportunities are available in distribution systems, which have to be transmitted up to the transmission level.

The electricity system actor's roles and responsibilities need to evolve. New tools should be elaborated in order to permit the DSOs to better operate their network, as well as to allow better interactions between Distribution System Operators (DSOs) and other stakeholders, such as Transmission System Operators (TSOs). In a context where all unbundled actors are dealing with an increasing number of local flexibility opportunities, the DSOs have to play locally a new key role. They should try to give a complete access to markets to all distributed end users and enable the transmission of local flexibility offers in the national energy exchanges places, while guaranteeing acceptable network operation conditions and ensuring the quality of supply to their customers. To allow this paradigm, the underlying New Information and Communication Technologies (NICT) architectures have to be as well re-defined.

3. Definition and Terminology

In this section, some essential definitions and terminology used in the subsequent text are provided. Definitions are valid in the context of the present Roadmap, and may not always have a general validity. The following definitions represent the shared view of the participants of the DREAM project and hence the DREAM perspective on both energy markets and future distributed control strategies. The definitions use established definitions such as the ones from the SG-CG, the ENTSO-E role model, or EC-commissioned reports wherever possible.

Term	Definition
Actor	Any entity (people, organisations, systems or devices) that executes actions in the environment under consideration. Actors have predefined capabilities (functions) to act, and may perform them according to one more roles in specific use cases.
Agent-based coordination	The use of agent technology and ways of communication to implement flexible, autonomous control mechanisms for the electrical grid. The goal is to reach the common objective of all the agents; e.g. support market participation as well as to ensure system security/stability
Balancing Mechanism	All actions and processes through which responsible actors in the market ensure that total electricity withdrawals are equalled by total injections in a continuous way, in order to maintain the system balance. In the **DREAM** context, balancing mechanisms are also executed on lower network levels. The term then refers to actions and processes through which responsible actors on the distribution level manage and stabilize the grid area, e.g. by trading flexibilities in technical or commercial use cases that are obtained from customers' loads and preferences.
Balancing Market (BM)	The entirety of institutional, commercial and operational arrangements that establish a buyer/multi-seller market-based management of the function of System Balancing within the framework of a liberalised electricity market, and that consists of three main parts: - Balance responsibility, - Balancing services provision, and - Imbalance settlement. In the DREAM context, the meaning of this concept will be extended to actors on distribution / retail network levels and be complemented by new mechanisms such as flexibility management.

Balancing Reserves	Power capacities (MW) available to balance the system in real time. These capacities can be contracted with an associated payment for their availability and/or be made available without payment. Technically, reserves can be either automatically or manually activated [Mott McDonald & Sweco-2013]. In the **DREAM** context**,** real-time reserves may also be available to DSOs for their real-time optimization.
Balancing Power	Power (MW) activated to maintain the balance between injections and withdrawals. It is possible to balance active and reactive power. In the **DREAM** context**,** it may also be available to DSOs for their real-time optimization.
Day-ahead market	The possibly independently operated multi-vendor, multi-buyer market in which parties can submit bids and offers to secure energy and sometimes also capacity for delivery on the following day.
Demand Response (DR)	A "bottom-up" approach describing an incentivizing of customers by costs, ecological information or others in order to initiate a change in their normal consumption or feed-in pattern.
Demand Side Managemen t (DSM)	A "top-down" approach by which power companies/utilities take measures to reduce electricity consumption for energy efficiency in general and electricity system operation efficiency in times of high energy cost or network constraints. Demand-side management (DSM) includes energy efficiency and demand response (DR).
Direct control	The direct, top-down management of generation and consumption components of the grid to ensure grid stability, usually initiated by a central planning entity.
Cell concept	A logical split of the network in terms of network components
Energy Box	Associated with a customer and accommodating the functions required to subscribe to the energy network, the set of managed devices (load, storage, production) and associated characteristics, the commercial interfaces for the customer, and the communication to and from the customer's devices.
Flexibility	On an individual level, flexibility is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system. The parameters used to characterize flexibility include the amount of power modulation, the duration, the rate of change, the response time and the location.
Commercial Aggregator	Pools the small flexibilities from several energy boxes in order to make commercial use of them in the grid or on energy markets. Responsible for balancing the contracted position which he has in turn contracted with in a given bidding zone or DSO area/areas.

Heterarchical approach	The DREAM project's core idea of how the electricity grid should be managed or rather manage itself: as a decentralized network of autonomous yet interconnected elements on the level of the distribution grid. Grid actors are represented by agents that engage in negotiations in which the central planner role is substituted by a distributed one.
Intraday market	Market timeframe beginning after the day-ahead gate closure time and ending at the intraday gate closure time, where commercial transactions are executed prior to the delivery of traded products.
Role	A Role subsumes a specific set of activities and responsibilities fulfilled by an Actor in interaction with the system under consideration. The role-allocation may also be subject to regulation/legislation. Most Legal Entity/Business Actors carry out their activities by performing roles (e.g. System Operator, Trader).

4. The Scope of Smart Grid and Flexibility Usage

The European electricity markets and mechanisms had been principally thought to fulfil energy exchanges and capacity availabilities at transmission level. In the actual situation, flexibility opportunities are firstly used for the BRP portfolio optimization, for the balancing mechanism and for the transmission contingency management. With the increasing interconnection rate of DERs penetration, more and more flexibility opportunities are available in distribution systems, and have to be aggregated and transmitted up to the transmission level.

Therefore, with the growing number of local flexibility opportunities, the DSOs' roles and responsibilities need to evolve. New tools should be elaborated in order to make them able to validate the distributed flexibility opportunities and to enhance their transmission to national levels. New strategies are also needed to help the DSOs to operate their network in the best conditions, allowing them to use remaining local flexibility services for constraint management and for energy efficiency optimization.

In order to ensure that the entire distribution grid should be compatible with existing systems and standards, architectures and solutions applied in transmission systems could be used as guidelines to develop advanced control mechanisms in distribution systems. However, there are considerable differences between transmission and distribution systems implying that the replication could not be the best option.

In this context, an innovative and dynamic communication infrastructure is proposed for a better coordination and control of the DERs. The DREAM project is proposing innovative methodologies based on distributed coordination of local resources and grid components control, taking into account the intrinsic characteristics of the grid structure and of its existing operational regulation's components, and permitting the introduction of local market and balancing mechanisms and constraints management functions for the DSOs.

5. The Heterarchical Approach

In this context and in order to propose an innovative yet realistic solution, the DREAM project developed an innovative solution that allows the increased penetration of distributed energy resources (DERs), through an active distribution system management having as a concrete goal to deliver sustainable, economic and secure electricity to the end-user. The DREAM solution is based on the concept of heterarchical coordination of the grid entities using decentralized techniques, dynamic reconfiguration and aggregation.

The established integrated architecture creates new marketplaces at the distribution level of the power system and in different timeframes, i.e. the day ahead market that copes with the larger quantity of electricity trading and the hour ahead balancing market that handles deviations near the time of operation. Furthermore, real-time constraint violations that may occur unexpectedly, are solved primarily locally based on the concept of traded customer flexibility, while in cases of emergency, the DSO is able to take conventional measures. The technical solution uses decentralized agent-based systems (MAS), implementing algorithms ensuring the optimized and stable operation of the distribution grid.

In order to reduce the complexity of the optimization of the operation of the distribution system decentralized control schemes are utilized. This way, the grid is driven to a more reliable self-coordinated system, since the centralized intelligence is dispersed in the various controllable entities Although keeping the capability to apply general policies, a central coordination centre is no longer required to take action on local decisions. The robustness of the grid is increased since the control decisions are calculated using local interactions following strategies that lead to globally optimal solutions. The motivation for such a scope for the grid operation derives from its numerous advantages such as avoidance of the single point-of-failure, reduced computation and communication cost, privacy of the end-user, but most importantly increased scalability and the “Plug-and-Play” capability.

6. The vision 2030

The DREAM consortium has developed the following vision for the coordination and control of the DERs in distribution networks in 2030:

"The DREAM project aims to build and demonstrate an industry-quality reference solution for DER aggregation-level control and coordination, based on commonly available ICT components, standards, and platforms for every actor (DER owners, grid operators, etc.) of the Smart Grids."

Consequently, this vision implies the creation of a coordinated distributed architecture which will be highly scalable and replicable.

From an investments ICT costs point of view, the initial investment in a holistic system control might be more interesting than the one considering DREAM solutions, because of the smaller need of advanced devices spread over the grid. Moreover, once the investment is done in a holistic system control, there is a reduced need of investments in the system when its size is growing, until a certain point.

After this specific extension point, the evolution of the investments costs for both systems might be completely different. While the evolution of the investments costs should stay quite linear with the growing number of flexibility opportunities for the DREAM system development, it might be exponential for the holistic system development if the entire system control has to be updated and extended.

These reasons are leading to the fact that the DREAM functionalities deployment among the whole system network could be a good alternative for the future architectures of Smart Grids. Indeed, the heterarchical distribution of intelligence might permit a good share of computations among the network. This also could permit a better consideration of the DERs down to the lowest levels of the grid. Yet this is something that requires additional research and techno economic analysis and evaluations.

7. The research Roadmap

7.1. Done during the project

The DREAM partners dealt with the assigned objectives by accomplishing several actions:

- Identify the drivers for DREAM adoption and main scientific and practical barriers for DREAM framework development, implementation and deployment from a market-based perspective,
- Identify the main scientific and practical barriers that have to be overcome to enable distributed balancing market place at the distribution level for DREAM framework development, implementation and deployment,
- Identify the main scientific and practical barriers that have to be solved for a successful deployment and development of the DREAM framework from a real-time control perspective,
- Outline the main paths to address these barriers as related scientific and practical advances,
- Propose scientific and technical solutions as well as practical implementations to tackle the main barriers identified.

At the end of this process, the objectives to focus on and the next difficulties and barriers to face were identified.

7.2. Presenting the next time horizon

The vision for 2030 defines the required properties for the scalable and deployable coordination and control of the DERs in distribution networks. The objective of the Roadmap is to show how to achieve those properties. For this purpose, the Roadmap defines objectives for three time horizons – the near, mid and long term, as illustrated in Figure 2.

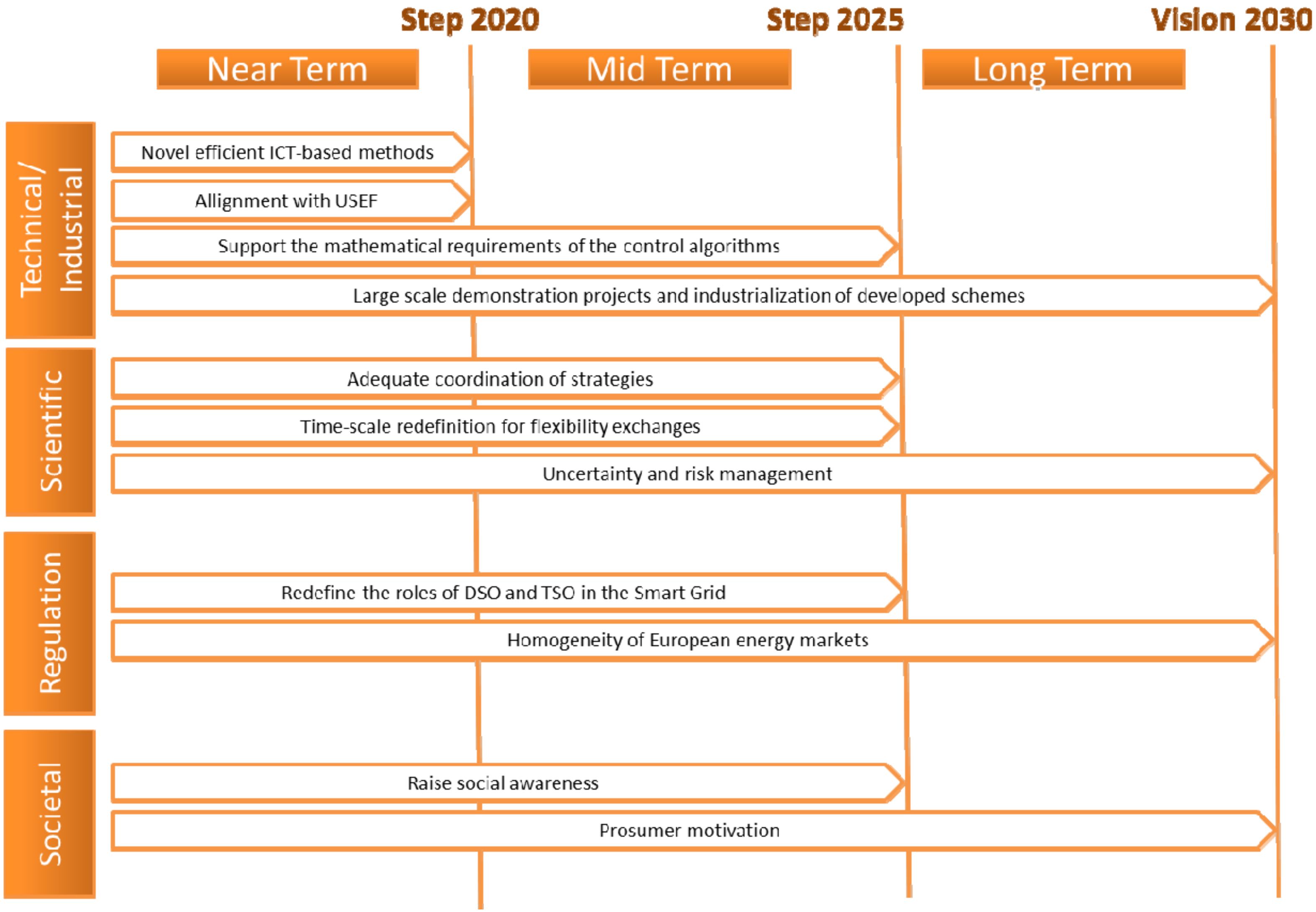

Figure 2 – DREAM roadmap objectives over time horizon

8. Detailed steps

For each time horizon, objectives are defined for each of the priorities or pillars.
The following chapter details for each pillar, the needs expressed by the industrial stakeholders, and the difficulties or barriers that are the most probable difficulties and obstacles to be overcome, knowing the context, the present state, the objectives and the nature of the problem to be solved.

They are classified in four categories:

- Technical and industrial,
- Regulatory,
- Scientific,
- Societal.

8.1. Technical and industrial

8.1.1. Use and adoption of ICT

Smart operation of electricity grids requires more active distribution grids. Distribution grids can be made more active, if they can consume or produce electricity in a more context aware fashion; e.g. an electricity consuming heat pump or an electric vehicle charging unit may sense a current or approaching congestion in the grid pre-emptively. The context awareness relates to perception of the current status of the grid from an electricity distribution perspective as well as from a market perspective. Agents, software programs interfaced to electricity demand and supply devices, operating in a distributed ICT network, can attribute to introducing the concept of more active distribution grids.

Life cycle periodicities of power systems components and ICT assets however are differing. From a distribution system perspective, investment decisions on ICT technology are relatively new as compared to investments in traditional power system components like cables and transformers. Also, DSOs, as owner of the most dependable infrastructure in society, focus on having proprietary communication and computing infrastructures, shielded from mainstream public communication networks.

The DREAM packages target at realizing smart power systems according to the requirements for the new infrastructures, new markets and the new types of users in a possibly changing heterarchic context. The flexibility of design and usage of infrastructure components is increased within the DREAM framework. A higher response to realize the required dynamics of the power system from an asset management and an operational perspective then currently available can be realized. DREAM provides for a platform, that features a number of packages with each its own functionality. The granular and localized character of the DREAM framework allows the introduction of market mechanisms suitable for also realizing more localized and real-time active and incentivising participation of DG-RES in energy systems. In these market mechanisms for simultaneously serving the market and also grid-friendliness requirements are mandatory. The coordination mechanisms in DREAM are changeable on-the-fly depending on the current status of the electricity network. Via the agent mechanism DREAM allows the role of the consumers/producers to be automated as much as possible according to their individual preferences.

ICT and data collected should increase the awareness of users for individual appliances on total network operation. Distribution of these data is not only required for DSO-operation but also for the other stakeholders to be used for evaluation of VPP-operation and forecasting. In this way, direct coordination of Virtual Power Plants as services to satisfy grid objectives comes within reach. Due to the strong distributed nature of data storage the impact on security and privacy is more limited and responsibilities can be managed more easily.

8.1.2. DREAM framework algorithm alignment with USEF (Universal Smart Energy Framework)

Both DREAM and USEF[9] deal with future markets on flexibility. Both propose a new role: the Aggregator. In DREAM and USEF, the roles dealing with flexibility are similar:

- The Aggregator accumulates available flexibility from the Prosumers and sells it when necessary to Supplier / BRP or DSO through several markets (balancing market, planning & capacity allocation market)
- The DSO is responsible for cost-effective energy distribution and grid stability of the distribution grid. For the latter, the DSO can be active on the flexibility market
- The Supplier / BRP acquires flexibility for own capacity planning and schedule optimization through the markets from the Aggregator

Because of this similarity, DREAM algorithm framework development will gain competitive advantage when carried out in compliance with USEF. It is therefore strictly recommended to align the DREAM algorithm framework with USEF standards for integration and interoperability with leading open source smart grid development standards for software (processes) and hardware components (e.g. grid control devices). Beneficiaries from this alignment will be at least the following smart grid

[9] See https://usef.energy

stakeholders: governments, DSOs, TSOs, BRPs, Prosumers, ESCOs, Aggregators, Power Grid related Products and Technology Providers.

8.1.3. Support the mathematical requirements of the control algorithms

Considering large network size and operation systems of distribution networks, the flexibilities of small prosumers are aggregated depending on geographical locations and voltage level, and then exploited. In consequence, the algorithms should be implemented only in a distributed and heterarchical way. Meanwhile, the short-term time scale means that the algorithms have to be implemented without the centralized supervision of DSOs. Therefore, the coordination between the different algorithm agents must be dealt with care so that they can achieve the satisfying global control effects.

In addition, the proposed control algorithms should be enough robust, since the balancing market will be operated under different system states. The algorithms should give good solutions in any kind of system states. Finally, the design of algorithms should consider the computation capacity and communication channels of existing distribution networks. Considering the short-term time scale, these algorithms should be able to finish in time the computation based on existing hardware resources. The involved information exchange should not cause much communication burdens, or even communication congestions.

The algorithms rest on a distributed mode of network operation, with an architecture where functionalities are distributed among the whole system network. The distribution of intelligence permits a repartition of computations among the network and avoids the reporting of all the data at a centralized level. This permits also to better consider all the available DER flexibilities down to the lowest level of the grid.

8.1.4. Large scale demonstration projects and industrialization of developed schemes

In order to assess and evaluate the DREAM architecture in real distribution grids, larger scale demonstrations should be prepared and executed. Moreover, execution of tests should not be disrupted as well as their duration should be favourably prolonged enough so as to efficiently capture the seasonal changes, especially in distribution grids that comprise a considerable capacity of renewable generation.

Prior to investing in a large amount of aRTUs and Intelligent Load Controllers that would be necessary for this kind of extended demonstration activities, a good idea is to utilize data from areas of distribution grids equipped with energy metering infrastructure. The close to real-time data from the energy meters can be gathered and subsequently used in realistic simulations of the DREAM algorithms providing a better approximated evaluation.

The final step of preparing large scale demonstrations would be the extended deployment of load controllers and aRTUs in the pilot sites. For the preparation of those pilot sites the industrialization of the DREAM solution is mandatory and the major obstacles for achieving this are the industrialization of the hardware parts such as the advanced RTU and the Intelligent Load Controller (MAGIC) as well as the industrialization of the DREAM software. In order to achieve the latter, the customization of DREAM framework with its algorithms for grid operation and control should be handled in a way that the need of specialized staff for the adoption of DREAM software in different environments (e.g. in different distribution feeders) would be eliminated and the procedure could be performed by technical personnel of the DSO company. Additionally, the implemented HMIs could be developed in more generalized form for the same reasons as discussed before.

8.2. Scientific

8.2.1. Adequate coordination of strategies

The DREAM framework will be realized as a distributed agent-based system that can evolve between distinct operation modes. So, a closer look has to be taken on developments concerning agent-based grid management and the use of different operation modes to coordinate the behaviour of the system.

One of the most relevant tasks when developing such an agent-based management system is the design of a suitable coordination concept that allows several operation modes, depending on the situation in the grid. According to this operation mode, the methods that are executed are adjusted. The coordination concept should also allow a system where different parts of the grid can be in different operation modes, without leading to instability or oscillation problems.

8.2.2. Time-scale redefinition for flexibility exchanges

On transmission level, the forecast and reserve needs are assessed at relatively long time scales (long term, day-ahead, intraday). In the long term, electricity can be traded within electricity markets in advance. In the middle-term, electricity can be traded on the day-ahead and on the intraday markets. The objective here is to introduce availability objectives in a short-term optimization process.

Taking the advantages of the distributed control, it could be possible to establish local flexibility markets (with short-term bids which are declared too late to be transmitted up till the TSO). This concept is not possible for a network controlled in a centralized approach, where all bids have to be transmitted to the TSO who is the only user of the flexibility.

In the DREAM framework, access to the balancing market will be available for all the different market players offering bids of reserves capacities. Bids will be aggregated at different levels in order to permit all actors to have access to the markets. Offers could be sent by large power producers with large and fast overproduction capacities (through spinning/non-spinning reserves), by energy suppliers or also by end users (through demand response). These flexibility bids can be proposed and planned during the day-ahead or intraday process, but other bids can also be sent during a more short-term process. Finally, in real-time, after receiving the non-declared flexibilities, the activation process of reserves capacities can be done.

8.2.1. Uncertainty and risk management

As the installation in the distribution network of generation units with variable production increases, and in combination with the increasing involvement of the consumers, system stability is more difficult to be maintained. Different levels of penetration of various types of loads (e.g. flexible or shiftable loads) and distributed generation technologies will transform the current distribution networks and increase the complexity in actively managing such networks. Furthermore, balancing of supply and demand becomes more challenging as it will be performed locally.

With a decentralized approach as adopted within the DREAM project, transmission level mechanisms for uncertainty and risk management could be transposed to the distribution network. Transmission system operators and distribution system operators' coordination will be essential in operational timeframes. Restricted visibility will limit the ability to prepare contingency plans for critical and emergency situations. Some tools for relevant forecasting and risk management are still needed to ensure the robustness of the DREAM solutions.

8.3. Regulation

8.3.1. Redefine the roles of DSO and TSO in the Smart Grid

From a regulation point of view many milestones need to be conquered. The TSOs and DSOs need to find their ways in developing roles and interactions for the benefit of the consumers. The transition to a Smarter Grid calls for an increased grid reliability and a more efficient RES integration. In order to achieve these goals, it is becoming more and more evident that the definition of both DSOs' and TSOs' roles and responsibilities should allow the DSOs to manage their evolving networks in a transparent and reliable way and simultaneously fulfil the TSOs' requirements. This way, the newly raised problems introduced by the higher penetration of renewables into their grid could be addressed locally and the customer flexibility could be exploited efficiently near the problem.

The regulations should therefore provide the possibility and in some cases define roles, in additional actors such as the Aggregators and BRPs that will enable the customer engagement in the context of ancillary services provision at the level of distribution grid. Other obstacles that must be taken care of are the formal definition of consumer Flexibility (in the context of the nationwide energy markets) as well as the formalization of flexibility markets and pricing mechanisms. The DREAM framework is an example for such a market framework that unlocks the aforementioned potential of consumers transforming them in actively participating “prosumers”.

DSOs will be key players for enabling the successful transition from the traditional passive grid to a more active network. DSOs need to become neutral market facilitators since they will have to manage more active grid elements, for example, distributed generation, storage facilities, demand-side response, smart charging for e-vehicles and apply ICT solutions. For that they need efficient technological innovation. The DSOs shall guarantee system stability, preventing local interruptions, and enabling markets and services for all actors and customers in a neutral and non-discriminatory manner.

8.3.2. Homogeneity of European energy markets / National regulation

The European electricity markets are still shaped by national and European regulation. The different distribution of DG/RES and regulation for smart grid infrastructure, the different taxes and electricity prices and the regulatory impediments for market actors across Europe are other barriers for the deployment of DREAM solutions. The share of renewable energy sources differs across the European countries because of environmental policy and topography/geographical conditions.

Similarly, smart grid infrastructure such as smart meters is also heterogeneously distributed across the markets. This is relevant for DREAM's economic considerations because it complicates the assessment of the potential (and need) for aggregation in the distribution grid and the expected adoption in different countries.

DREAM cannot directly influence those barriers stemming from regulatory differences while it is likely that they will prevail in the near future. To cope with them and achieve project success, the suggested approach is to be aware of those differences and explicitly state which assumptions will be taken for any economical (as well as technical) evaluation. This approach entails

- designing the DREAM framework and market mechanism in a "best possible way" that is desirable according to long-term national and EU policy regardless of the existing regulatory environment (meaning that existing barriers shall not limit solutions developed in DREAM, which instead fit more ambitious views of future electricity markets)
- presenting a number of realistic scenarios
- discussing the viability of results keeping the diverse EU situation in mind.

The goal is to make transparent for which type(s) of market the DREAM scenario is likely to be most valuable for member states and future research.

8.4. Societal

8.4.1. Raise social awareness

One of the main goals of the DREAM project is to increase the capabilities to integrate distributed renewable energy resources (RES) and the objective is to reduce the emission of CO2 from thermal stations and curtail the 'greenhouse effect' (EEGI level 2 B.1 goal). The participation of the customers to the DREAM solution will increase the Social, environmental and sustainable awareness.

In this respect, the incentive for a customer to participate to a DREAM solution should be both monetary and non-monetary. The participation for non-monetary incentive also means that there is an environmental and social awareness; the scale of this awareness depends on the psychology and the cultural background of the customers.

To realize an optimum network load management and increase RES hosting capacity, it is important to have load flexibility (load curtailment or shifting). The Meltemi demonstrations indicate that the social and environmental awareness and thus the wiliness of the customers to participate and make the required effort are essential.

For that reason, DSOs shall safeguard to the end users, customers and prosumers, transparency, security, power quality and the actors shall propose a reliable system. In the relative use cases the DREAM framework proved that it is a comprehensive system that can provide the solutions for a complete decentralized system.

Thus, to meet the EU the long-term 2050 greenhouse gas reductions target, the usage of novel reliable tools like the DREAM framework as well as raising the environmental and social awareness of the customers and the DSO are very important factors.

8.4.2. Prosumer motivation

One barrier for widespread diffusion of smart grid solutions in the distribution market is the lacking motivation of consumers to participate in such initiatives (given that the proposed smart grid solution is not enacted by regulators). As DREAM assumes the existence of “energy boxes” (extended smart metering devices that manage all communication between the customer’s manageable load, storage, and production devices and the aggregator) in all households, the question of how to implement these boxes and encourage customers to become prosumers is central to DREAM’s success.

Besides the smart meters, DREAM and the EU energy directives build on growing adoption of distributed energy resources, which require substantial prosumer motivation to invest as well. The barrier has both economic as well as social aspects. The main problems that equally apply to smart metering and DER investments are that customers fail to see the advantages of the smart grid initiatives, fear of comfort loss, and privacy concerns (in case of smart metering).

The planned strategy includes targeting prosumers with known attachment to the electricity system and “green energy”, which includes utility employees and customers with prior experience in smart grid initiatives which are expected to be more willing to participate. Regarding the long-term realization of the DREAM concept, both monetary and non-monetary incentives are again relevant. Unless smart meters and the necessary management powers for DSOs are implemented extensively by law, consumers should be able to see real benefits from smart grid participation.

9. Conclusion

In this document the Roadmap for integration and industrialization of the Dream solution was presented. Starting from nowadays (i.e. the current state) steps were defined, for three time horizons – the near, mid and long term in order to reach the vision of 2030. For each time horizon, objectives were proposed for each domain (or category) that action should be taken. The four categories are: Technical and industrial, Regulatory, Scientific and Societal.

10. References

- [DREAM DoW 2016]: DREAM project “Distributed Renewable resources Exploitation in electric grids through Advanced heterarchical Management”, *Grant agreement no: 609359, Annex I – Description of Work*, Version date: 2016-02-15
- [Grid+ 2013 D 3.4]: GRID+ project “Supporting the Development of the European Electricity Grids Initiative (EEGI)”, Grant agreement no: 282794, *Deliverable D 3.4: Define EEGI Project and Programme KPIs*, Version date: 2013-01-30.
- DREAM D5.1