SMARTENERGY (874399) - Grow faster with energy clusters towards energy transition

WP4 – D4.1 - Cross-Sectoral and Trend Analysis

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Executive Summary

Executive Summary

The SMARTENERGY project implements a set of integrated actions aimed to enforce the cooperation level of 5 different but leading energy clusters in their respective countries (i.e. Environment Park – Italy, Tenerrdis - France, Archenerg - Hungary, Flux50 - Belgium, Cluster Tweed - Belgium) and 1 major cluster for digital technologies (Minalogic - France).

Within this project, the work package 4 aims at reaching the following specific objectives:

- Find synergies among different energy-related products, processes and services provided by the Energy clusters in cross-fertilization with the digital technologies and KETs provided by Minalogic and by the experience of all cluster partners,
- Strengthen the 6 individual cluster strategies thanks to the partnership implemented in the project, including in their strategies and implementation roadmaps specific target related to cooperation between energy and IT, which is one of the main Energy innovation driver,
- Foster subsequently the access for SMEs to various markets such as the mobility sector, the building and construction sector, the agricultural sector, etc.
- Cope better with crucial challenges such as the cybersecurity issues, the smart aspects of the Energy transition,
- Develop a common strategy for the ESCP-4x, focused on the design of a sustainable metacluster or at least an alliance at EU level for energy transition.

The work package 4.1 aims at providing the consortium with Cross sectoral and trends analysis of the role of the emerging industry of digital energy in relation to the objectives of decarbonisation and circular economy at EU level, in the form of a report (D4.1 report, this document).

The challenge of the cross-sectoral analysis is to break down both the Energy and the Digital sector so that the result had the following characteristics:

- To be in relation with the sub-sectors covered by the consortium members
- To be granular enough to cover all the aspects of each sector, but not too much to remain practically operational for further works inside the consortium or with external stakeholders.

To this purpose, a breakdown of the energy sector in 37 basic "energy challenges" has been proposed. These energy challenges are all of interest for at least one member of the consortium.

The digital sector has been broken down into 33 basic digital technologies, grouped into 8 major digital technology sub-sectors.

From this breakdown of both the energy and the digital sector, we set-up a questionnaire to ask to each consortium member:

- To assess the importance of each energy challenge from its perspective using a 3-level scale: Its top 10 priorities, challenges of secondary importance and unimportant challenges.

- For the energy challenges listed in the top 10 priorities, to assess the interest of each technology sub-sector to help solving this challenge, using a 4-level rating: High interest, moderate interest, low interest, no interest.

In order to create a database of actors, we also invited consortium members to provide examples of actors working on each energy challenge they had selected in their top 10 priorities, and actors working in each technology sub-sector found relevant to help solving the challenge.

Minalogic and Tenerrdis answered jointly to the questionnaire, Tenerrdis focusing on the energy part and Minalogic on the digital part. Therefore, we got five respondents: Archenerg, ENVIPARK, Flux50, Tenerrdis-Minalogic and Tweed.

One interesting result of the questionnaire is that the assessments of the consortium members converges to a set of 5 energy challenges that can be considered as the focus of future interclustering works:

- Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities.
- Develop innovative solutions for local renewable generation of thermal energy (heating, cooling)
- Store energy along the grid
- Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)
- Software for smart mobility : Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability

To finish, the documents introduces some ideas on the potential contribution of digital technologies at solving these 5 energy challenges and more generally the 37 initial basic energy challenges.

02

Introduction

Introduction

The “SMARTENERGY” project

The SMARTENERGY project implements a set of integrated actions aimed to enforce the cooperation level of 5 different but leading energy clusters in their respective countries (i.e. Environment Park – Italy, Tenerrdis - France, Archenerg - Hungary, Flux50 - Belgium, Cluster Tweed - Belgium) and 1 major cluster for digital technologies (Minalogic - France).

The specific objectives of the SMARTENERGY project are:

- To increase the business support capacity of the clusters in the partnership, with a special focus on supporting SMEs to bring to the market new products and services which need to increase their maturity and readiness level from the final prototype level (TRL 7) to the production/ commercialization level (TRL 9);
- To support at least 42 SMEs, 10 clusters and 8 technology centres/ scaling up support organisations in accessing the global market;
- To develop a common strategy for the ESCP, focused on the design of an alliance or metacluster for energy transition at EU level.

To successfully achieve these objectives, the SMARTENERGY project integrated approach consist of a range of activities:

- A detailed benchmark of the services offered,
- Several capacity building and peer to peer activities for cluster managers aimed to develop new skills in providing customized support services,
- Testing and implementing activities aimed at providing these services in the most effective manner through the new ‘ClusterxChange’ pilot scheme.

Activities mainly target SMEs (i.e. members of the clusters and of other clusters being part of the network), European cluster management staff, regional authorities involved in S3 implementation in the respective regions, and the innovation actors being part of their ecosystem for innovation.

The improved skills and cooperation level of the SMARTENERGY ESCP-4x will result in a stronger capacity of supporting market outreach of innovation in the emerging industry of digital energy towards energy transition.

Targets of the Work package 4

The WP4 aims at reaching the following specific objectives:

- Find synergies among different energy-related products, processes and services provided by the Energy clusters in cross-fertilization with the digital technologies and KETs provided by Minalogic and by the experience of all cluster partners,
- Strengthen the 6 individual cluster strategies thanks to the partnership implemented in the project, including in their strategies and implementation roadmaps specific target related to cooperation between energy and IT, which is one of the main Energy innovation driver,
- Foster subsequently the access for SMEs to various markets such as the mobility sector, the building and construction sector, the agricultural sector, etc.
- Cope better with crucial challenges such as the cybersecurity issues, the smart aspects of the Energy transition,
- Develop a common strategy for the ESCP-4x, focused on the design of a sustainable metacluster or at least an alliance at EU level for energy transition.

Work package 4 is split in 3 tasks:

- WP4.1 Cross sectoral and trends analysis of the role of the emerging industry of digital energy
- WP4.2 Adaptation of individual cluster strategies and implementation roadmaps
- WP4.3 Development of a comprehensive joint strategy for the all SMARTENERGY partnership at ESCP level

Purpose of this document

The target of the WP4.1 task is to provide to the consortium the framework for an integrated analysis of the role and potential of the emerging industry of digital energy technologies, in relation to the objectives of decarbonisation and circular economy at EU level, in the form of a report (D4.1 report)

This D4.1 report has two main objectives:

1. To perform a mapping and benchmark of each ecosystem in order to identify:
    a. Synergies between members' technologies
    b. Members' needs
    c. The most promising market segments to concentrate the future activities of the cluster alliance to be formed

2. The results of this analysis will be the input to the process of adaptation of the individual strategies and roadmaps of all the clusters participating to the project.

We paid attention to the fact that the validation of these strategy and roadmap adaptations would involve the regional authorities of each cluster in charge of the cluster policy and the S3 implementation and monitoring, through a workshop that each cluster will organize with its regional authorities.

03

Methodology

Methodology

Challenge of the cross sectoral analysis

Energy and Digital have many common points: First, it is difficult to find a single sector of the economy that does not rely on the supply of energy, and it becomes harder and harder to find a single one that does not rely on digital technologies.

Then, both sectors rest on top of each other: No Digital without Energy to supply data centers, computers and telecommunications of any kind. Conversely, the energy sector, and more particularly the electricity sector adopted digital technologies very early on: As soon as they became available, Supervisory, Control and Data Acquisition systems (SCADA) took place in energy production facilities. The blossoming of nuclear power plants between the seventies and the nineties led to the development of state-of-the-art control systems at the time, based on redundant architectures and software developed and validated using formal methods. Transmission System Operators started to operate their grids through control systems relying on the very accurate time provided by Global Positioning Systems. Medium Voltage circuit breaker protections became digital and finally digital technologies percolated up to the energy meter installed at our door.

Finally, they are both very vast and clusters participating to the SMARTENERGY project do not cover the whole spectrum of both sectors. For example, none of the consortium members addresses nuclear and fossil energies. In the digital sector, Minalogic is the only pure digital player in the consortium. Although it covers a wide variety of digital technologies ranging from micro- and nano-electronics to immersivity and interactivity (for example, advanced man-machine interfaces, augmented and virtual reality), it may be stronger or weaker on some technologies

Therefore, the challenge of the cross-sectoral analysis was to break down both the Energy and the Digital sector so that the result had the following characteristics:

- To be in relation with the sub-sectors covered by the consortium members
- To be granular enough to cover all the aspects of each sector, but not too much to remain practically operational for further works inside the consortium or with external stakeholders.

In other words, the proposed breakdown does not pretend to be a universal breakdown of both Energy and Digital sectors. It is adapted to the consortium situation and to the WP4.1 goal to map and benchmark each ecosystem and to be the input to the process of adaptation of the individual strategies and roadmaps of all the clusters participating to the project.

Energy sector breakdown

Challenges of the energy transition

The energy dilemma is here to stay. The world's population is expected to increase by 2 billion persons in the next 30 years, from 7.7 billion currently to 9.7 billion in 2050, according to the last "World Population Prospect 2019" [1] published by the United Nations. Because it is a matter of justice and of conflict prevention as well, this population will have to access to a certain level of development and this will only be guaranteed through the access to energy and therefore to an increase of the global energy consumption.

On the other hand, we are facing the absolute necessity to reduce greenhouse gases emissions, in particular carbon dioxide (CO_2) linked to human activities, including the production and the consumption of energy in its different forms to keep the climate change in sustainable limits.

The following table displays global CO2 emissions in 2018 according to the International Energy Agency [2]:

Table 1: Global CO2 emissions by sector in 2018

Sector	Mtons of CO2
Electricity and Heat producers, other energy industries	15 591
Transport	8 258
Industry	6 158
Buildings (commercial, public, residential)	2 883
Others (agriculture, fishing, others)	624

The demographic growth is not actually a matter of concern for the European Union. However, giving access to energy and to development remains an issue for some territories or some categories of the population.

Looking at climate change control, its energy production and consumption is still widely relying on CO2 emitting sources, though the situation is quite different between each EU member.

Finally yet importantly, the European Union owns a leading energy sector with large Utilities and equipment manufacturers that, together with smaller innovative actors, can develop innovative solutions to both meet the challenge of economic development coupled with the reduction of greenhouse gases emissions across the World.

One could easily think that reducing the carbon-footprint of electricity and heat production just requires introducing more renewable energy in the energy mix. However, this generates a certain number of technical constraints. For example:

- Grids were originally designed to operate in a pure “top-down” flow of energy e.g. from a relatively small number of high capacity production facilities to a high number of disseminated consumers. One needs to adapt then to new operating modes where the historical “top-down” mode will coexist with a bottom-up and eventually a bottom-bottom mode through the set-up of micro grids.
- The less predictable character of these new sources make the production – consumption balance more difficult to manage. It requires to have more flexibility in the consumption or to find ways to store energy along the grid to avoid having to invest in expensive reserve capacities.
- Some of these new sources do not provide the inertia to help supporting the grid in case of incident
- New uses of electricity, like the replacement of fossil fuels by electricity in transport (provided this electricity is produced thanks to decarbonized means) generate also new challenges like high variation of the consumption at certain locations (for example parking lots) at certain hours (for example working hours).

Constraints are not only technical, but also economic and societal. Utilities may be reluctant to invest in new production facilities and sometimes in new transmission and distribution lines because of a low return On Investment. New installations may endanger the biodiversity. Populations may not welcome them (NIMBY - Not in My Backyard - syndrome).

Consequently, meeting the challenge of reducing greenhouse gases emissions requires at the same time:

- To reduce the carbon footprint of the energy production,
- To consume less and in a smarter way, because each kilowatt-hour not consumed reduces technical, economic and societal constraints,
- To adapt energy grids to challenges posed by the two previous objectives.

This must be done at every level, and for the sake of the SMARTENERGY project, we decided to split the energy sector in 6 large sub-sectors defined as follow:

Table 2: Energy sub-sectors retained for the cross sectoral analysis

Sub-sector	Definition
A – Decarbonized production	Production of electricity and heat from renewable energy sources (hydro, wind, solar, geothermal, tidal, biomass, etc.)
B – Smart Grids	Networks of any kind used to carry electricity or heat from their production location to their consumption location.
C – Smart Buildings	Commercial, tertiary, residential, for entertainment, for healthcare, etc.
D – Smart Industry	Production and processing of any kind of goods, services, and associated data, not considering the building that may host them.
E – Smart Mobility	Transportation of people, goods, and related infrastructures (airport, harbours, railway stations, refuelling stations, etc.).
F – Smart Communities	Entities (cities, district, territories) organizing the interactions between production, grids, buildings, industry and mobility at the local scale.

Energy Challenges addressed by the project members

Based on these 3 main challenges (reduce the carbon-footprint of the production, consume less and better, adapt grids) and the 6 sub-sectors, we selected a number of specific areas of work that we called "energy challenges". These energy challenges have been determined using participants inputs as well as the analysis of each participant's key challenges highlighted on their website.

The result of this analysis is a list of 37 "energy challenges" presented in the table below:

Table 3: List of Energy Challenges

N°	Energy System Component	Main challenge	Energy Challenge
1	A - Decarbonized Production	1 - Production carbon-footprint reduction	Deploy massively renewable energies
2	A - Decarbonized Production	1 - Production carbon-footprint reduction	Improve the carbon balance of renewables
3	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop new renewable production process (including CO2 capture)

N°	Energy System Component	Main challenge	Energy Challenge
4	A - Decarbonized Production	1 - Production carbon-footprint reduction	Explore Power-to-X technologies
5	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop innovative solutions for local renewable generation of thermal energy (heating, cooling)
6	A - Decarbonized Production	1 - Production carbon-footprint reduction	Integrate large-scale renewable generation parks in specific contexts (for example harbors, airports, etc.)
7	B - Smart Grids	3 - Adapt grids	Develop more accurate production forecasts
8	B - Smart Grids	3 - Adapt grids	Address technical issues resulting from renewable intermittency
9	B - Smart Grids	3 - Adapt grids	Store energy along the grid
10	B - Smart Grids	3 - Adapt grids	Explore the coupling of STEPs with renewables
11	B - Smart Grids	3 - Adapt grids	Secure the energy supply with regards to external attacks, cybersecurity
12	B - Smart Grids	3 - Adapt grids	Develop technologies and systems for thermal transformation, transport and storage
13	B - Smart Grids	3 - Adapt grids	Make electricity, gas, hydrogen, etc. infrastructures interoperable
14	C - Smart Buildings	1 - Production carbon-footprint reduction	Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)
15	C - Smart Buildings	2 - Consume less and better	Lower the carbon footprint of building construction processes
16	C - Smart Buildings	2 - Consume less and better	Develop more efficient appliances (lighting, heating, ventilation, air conditioning)
17	C - Smart Buildings	2 - Consume less and better	Optimize building consumption with respects to external (temperature, solar irradiance) and internal (occupancy) parameters
18	C - Smart Buildings	2 - Consume less and better	Develop smart building envelope components (sunblinds, windows with low-emission coatings, etc.)
19	C - Smart Buildings	3 - Adapt grids	Develop self-consumption management associated with storage systems in buildings
20	D - Smart Industry	2 - Consume less and better	Develop the measurement of consumption at the finest possible scale

N°	Energy System Component	Main challenge	Energy Challenge
21	D - Smart Industry	2 - Consume less and better	Reduce energy losses in manufacturing processes
22	D - Smart Industry	2 - Consume less and better	Recover the heat of processes to use it for other applications
23	D - Smart Industry	3 - Adapt grids	Develop self-consumption management associated with storage systems in industry
24	E - Smart Mobility	1 - Production carbon-footprint reduction	Develop regional hydrogen sectors of excellence
25	E - Smart Mobility	1 - Production carbon-footprint reduction	Support the development of Bio-NGV
26	E - Smart Mobility	2 - Consume less and better	Reduce energy losses in mobility (frictions)
27	E - Smart Mobility	2 - Consume less and better	Develop energetic optimization of vehicles (energy recovering, …)
28	E - Smart Mobility	2 - Consume less and better	Develop new generations of electric motors limiting the use of rare materials
29	E - Smart Mobility	2 - Consume less and better	Develop battery second life use and recycling at their end of life
30	E - Smart Mobility	2 - Consume less and better	Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability
31	E - Smart Mobility	2 - Consume less and better	Know better the operating and filling status of refueling stations
32	E - Smart Mobility	3 - Adapt grids	Develop technologies limiting the impact of high power refueling stations on grid infrastructures
33	E - Smart Mobility	3 - Adapt grids	Develop new generations of energy storage solutions for mobility
34	E - Smart Mobility	3 - Adapt grids	Explore interactions between vehicles and networks (“Vehicle-to-Grid”)
35	F - Smart Communities	2 - Consume less and better	Reduce the consumption of public lighting with smart adaptive or traffic adaptive systems
36	F - Smart Communities	2 - Consume less and better	Raise awareness among regional actors (in particular, communities) of good practices for the territorial deployment of smart communities

N°	Energy System Component	Main challenge	Energy Challenge
37	F - Smart Communities	3 - Adapt grids	Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities.

Digital sector breakdown

As Minalogic is the only pure digital cluster in the project, the breakdown of the digital sector relies widely on Minalogic's areas of strategic activities:

- Micro- electronics, nano- electronics and electronics
- Software
- Optics and Photonics: All the components allowing the generation, transmission, processing (modulation, amplification) or conversion of optical signals, from the terahertz band to X-rays.
- Contents and Uses: Technologies that help processing images, sounds, speech and texts coupled with creativity and design to unleash the creative imagination in projects guided by uses.

However, as software is a very wide area, it appeared necessary to break it down in 5 sub-sectors:

- Data Sciences and Artificial Intelligence
- Digital Trust and Cybersecurity
- Digital Engineering
- Digital Infrastructures and Internet of Things
- Applications and Tools

The 8 resulting sub-sectors have been split in a number of technologies, these technologies being selected according to their potential of interest for the energy sector. This results in a list of 33 digital technologies.

Table 4: List of Digital Technology Sub-sectors

Digital Technology Sectors	What does it cover? (Digital Technologies)
A – Datasciences and Artificial Intelligence	A-01 : Big Data A-02 : Cloud Computing A-03 : Artificial Intelligence
B – Digital Trust and Cybersecurity	B-01 : Biometry B-02 : Cybersecurity B-03 : Criptography B-04 : Distributed Ledger Technologies (Blockchain and equivalent)
C – Digital Engineering	C01 - High Performance Computing C02 - High Performance Data Analytics C03 - Modeling and Simulation C04 - System Engineering C05 - Quantum Computing

Digital Technology Sectors	What does it cover? (Digital Technologies)
D – Digital Infrastructures and Internet of Things (IoT)	D01 - Real-Time Systems (control, monitoring) D02 - Global Positioning Systems D03 - Mobile phone technologies (5G) D04 - Low-Power Wide Area Networks (LoRA, SigFox, …) D05 - Low-Power Local Area Networks (Bluetooth, Zigbee, etc D06 - Distributed sensors (lighting, temperature, presence, etc.) DO7 - Energy harvesting for distributed sensors
E – Applications and Tools	E01 - Business-oriented applications on PC E02 - Mobile and Web Applications E03 - Open Source Software E04 - Software Tools
F – Optics and Photonics	F01 - Solar technologies (PV material, BIPV, …) F02 - Low consumption Lighting (LED, …) F03 - Optic & Photonic Sensors (infrared, …) F04 - Imaging & Machine Vision F05 - Low consumption Displays F06 - Surface Engineering
G – Micro- and nano-electronics	G01 - Low-loss electronic components (SiC, GaN, InP, crystals …) G02 - IoT / AI oriented processors G03 - MEMS
H – Immersivity and Interactivity	H01 - Augmented and Virtual Reality H02 - Audio & Sound diffusion H03 - Vocal Assistants, Natural Language Processing H04 - Social Robots, Cobots H05 – User Experience, User Interface (UX / UI)

Assessment of energy challenge importance and digital technology interest

First step : Questionnaire

From this breakdown of both the energy and the digital sector, we set-up a questionnaire to ask to each consortium member

- To assess the importance of each energy challenge from its perspective using a 3-level scale:
  - The top 10 priorities for the cluster
  - Challenges of secondary importance for the cluster
  - Challenges not important for the cluster.

- For the energy challenges listed in the top 10 priorities, to assess the interest of each of the 8 technology sub-sector to help solving this challenge, using a 3-level rating:
- High interest (+++)
- Moderate interest (++)
- Low interest (+)
- No interest (no assessment)

In order to create a database of actors, we also invited consortium members to provide examples of actors working on each energy challenge they had selected in their top 10 priorities, and actors working in each technology sub-sector found relevant to help solving the challenge.

Minalogic and Tenerrdis answered jointly to the questionnaire: Tenerrdis focusing on the energy part and Minalogic on the digital part. Therefore, we got five respondents: Archenerg, ENVIPARK, Flux50, Tenerrdis-Minalogic and Tweed.

Second step: Determination of the most relevant energy –digital crossings

We processed the answers to the questionnaire as follows:

- Energy challenges were ranked according to the number of time it had been placed “in the top 10 priorities”, then according to the number of time it had been assessed of “secondary importance”.
- As far as the interest of each technology sector is concerned, we computed the average number of “+” awarded to each technology sector.

Then we kept the most interesting crossings and each consortium members provided for some of the crossings of interest for it some examples of working axis.

04

Results and Analysis

Results and analysis

Complete results of the questionnaire

The complete results of the questionnaire are available in the appendices of this document.

Appendix 1 details the assessment of each energy challenge by each consortium.

Appendix 2 presents a series of graphics where, for each technology sub-sector, each energy challenge is positioned according to its importance on the X-axis and on its potential interest for the said energy challenge on the Y-axis. For a given digital sub-sector, the more an energy challenge is to the upper right of the graphics, the more the crossing between the digital sub-sector and the energy challenge is potentially interesting.

Appendix 3 displays the actors cited by each cluster for each energy challenge.

Appendix 4 displays the actors cited by each cluster for each digital technology.

5 energy challenges could become the focus of the interclustering

From these results, we identified a subset of 5 energy challenges that are particularly interesting because of the following reasons:

- Each one is in the top 10 priorities of at least 3 of the 5 respondents.
- None has been rated "not important" by any of the respondents

Table 5: The 5 core energy challenges for the consortium

N°	Energy System Component	Main challenge	Energy challenge	# of ratings "In the top 10"	# of ratings "Secondary Importance"
37	F - Smart Communities	3 - Adapt grids	Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities.	4	1
5	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop innovative solutions for local renewable generation of thermal energy (heating, cooling)	3	2
9	B - Smart Grids	3 - Adapt grids	Store energy along the grid	3	2
14	C - Smart Buildings	1 - Production carbon-footprint reduction	Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)	3	2

N°	Energy System Component	Main challenge	Energy challenge	# of ratings "In the top 10"	# of ratings "Secondary Importance"
30	E - Smart Mobility	2 - Consume less and better	Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability	3	2

It is interesting to observe that these 5 challenges cover

- 5 of the 6 energy system components. The only one not represented is D – Smart Processes. The first representatives of this category are only ranked 15th.
- The 3 main energy challenges

It is also interesting to observe that each member cluster has nominated several of these challenges in its top 10, and that almost each challenge offers a different configuration. Assuming these challenges could be the base for future common works, it guarantees the consortium will not be split in 2 or 3 groups operating independently.

Table 6: Importance of each of the core energy challenge for each member of the consortium

Cluster	Challenge #37	Challenge #5	Challenge #9	Challenge # 14	Challenge #30
ARCHENERG	In the top 10	In the top 10	In the top 10	In the top 10	
ENVIPARK		In the top 10	In the top 10		
FLUX 50	In the top 10				In the top 10
TENERRDIS MINALOGIC	In the top 10			In the top 10	In the top 10
TWEED	In the top 10	In the top 10	In the top 10	In the top 10	In the top 10

Therefore, these 5 energy challenges look to be at the same time a good sample of the different challenges of the energy transition and a common base to all members of the consortium, and therefore, a common base for future interclustering works.

The table below provides a list of players working on each of these 5 challenges. For the reminder, this list is far to be exhaustive.

Table 7: Examples of players in the 5 core energy challenges

N°	Energy challenge	ARCHENERG	ENVIPARK	FLUX 50	TENERRDIS MINALOGIC	TWEED
37	Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities.	Vilometric 3 Com Line		SDM Group, YouPower, Enervallis, I.Leco, ABB	Schneider Electric, Ausar Energy, Enogrid	CE+T Energrid
5	Develop innovative solutions for local renewable generation of thermal energy (heating, cooling)	Energotest, Kiss Ltd., Thermoszerviz Ltd., Cozero Ltd.	Ago Renewables, Asja Ambiente Italia, E++		Inddigo, Cylergie, Caeli Energie	Haulogy
9	Store energy along the grid	3Com Line, Vilometric, Asianet	Electro Power System		GE, Artelia, McPhy, Storengy, Wattmen, RTE, Atos	Tractebel, Restore
14	Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)	3 Com Line, Vilometric, Asianet, AeroEnergi, Pannonsolar Ltd.	Enecom		Schneider Electric, Vesta System	Issol, CRM
30	Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability	Tandofer informatikai Ltd., BerényiSoft Ltd.	Metatronix	VUB, Enervalis, Powerdale, Leasing companies,	Enedis	Enersol, Powerdale

Potential contribution of digital technologies to the 5 core challenges

Data Sciences & Artificial Intelligence

General introduction

The massive introduction of intermittent renewable energy sources in the energy mix requires shifting from a unidirectional supply of electricity (from power plants to consumers) toward an increasingly decentralized, bidirectional and complex network. It results in a rapid growth in the number of points of energy injection. Coping with the intermittency requires to implement storage systems along the grid and to consume energy in a smarter way. The introduction of smart meters at network endpoints and ubiquitous sensors in homes, buildings and factories creates a digital layer comprising a myriad of sensors and providing large amounts of data. This data availability and the increasing diversification and distribution of energy sources and applications call for an equivalent distribution of intelligence throughout the grid, to maximise network.

Until recently, data were stored in large centralized datacentres (cloud computing) and artificial intelligence techniques had been developed to process them and to discover non-obvious relationships between them. Artificial Intelligence (AI) can be defined as “the simulation of human intelligence processes by machines, especially computer systems. These processes include learning, reasoning and self-correction. One subfield or application of AI is machine learning” [3].

Although a consensus on a global AI roadmap is likely utopian, experts agree on the fact the pure dominance of cloud computing should likely end. To exploit the full potential of AI, data processing solutions will run on distributed edge computing nodes, interconnected by next-generation IoT platforms and communications. In future functionality, energy consumption, robustness and safety constraints will define their features [5].

The large amounts of data concerning energy demand and supply accumulated at individual network nodes could be processed more efficiently at the edge to exploit their full value. Utilities and cloud service providers could use machine-learning applications, including classification and clustering models, to group consumers according to their usage patterns and apply predictive models for future demand [6]. Weather forecasts could be incorporated in prediction models to forecast renewable energy production. Some applications potential optimisations can only be fully unlocked using edge AI. Cognitive applications of edge computing in smart grids include intelligent agents used both for energy market issues (management, pricing and scheduling) and for network management (security, reliability, fault handling and efficiency). Possible use cases include:

- Combination of AI and blockchain technology for the integration of electric vehicles in power management platforms for Smart Grids [7].
- Dynamic pricing to balance demand and supply [8].
- Pre-processing strategy of hierarchical decision-making to optimize resource usage based on service level requirements.

Buildings are a major contributor to the overall energy consumption. Smarter buildings [9] could enable further improvements in energy efficiency. Since the components of the building energy systems are integrating more sensors and embedded systems, buildings are becoming networked cyber-physical energy systems – especially larger objects like airports, shopping malls or office buildings. The objectives of building energy control systems are multi-dimensional and complex. Their goal is at the same time to use a minimum of energy (preferably generated on-site from renewable sources), to reach a prescribed level of comfort that is not always easy to specify, and a healthy indoor climate. A high number of multivariate sensors are required to exploit the full potential of model predictive control schemes besides standard parameters such as temperature, humidity, CO^2 and the occupation of rooms, which are usual inputs to the control system.

Today, the building control systems rely generally on a centralized controller. Data analytics and AI on edge devices and smart image sensors could allow for example determining the number of persons inside a room, which is a relevant input parameter for building control. However, spreading raw image data among open data networks could compromise the required level of privacy. Implementing AI algorithms directly on the device could help analysing the image in order to extract the relevant information for the control system.

Sensors in energy system components, like fans or air filters, are an enabler for predictive maintenance schemes, allowing higher efficiency and reduced maintenance costs. Using wireless technology, easy installation or retrofitting would be possible - especially at places that are hard to reach by the tethered data network. However wireless data transmission from basements can be difficult due to the metal structures in heating, ventilation and air conditioning systems. Data could be reliably transmitted, with a reduced bandwidth, by using data analytics at the sensor to provide only the relevant information on the status of the component instead of time series data from pressure sensors etc.

MaMuET, an example of Machine learning for real-time Advanced Multi-Energy Trading

Developed by the consortium SDM-Projects, PowerPulse, Priva Building Intelligence, ABB, VUB (University Brussels), The main essence of the innovation of the MAMûET project is on research enabling the co-design optimization and the smart management, control and exploitation of a multi-energy microgrid. Inside this collaborative scenario, three main goals have been described for MAMûET (i) Cost effective exploitation of a microgrid by optimal co-design and real time control of the assets. (ii) Optimization of multi-energy management for increased Total System Efficiency, and (iii) Standardize, Scalable and Replicable Proof of Concept of the Cooperative Eco Platform.

https://www.greenenergypark.be/project/machine-learning-for-real-time-advanced-multi-energy-trading/

Contribution to the 5 core energy challenges

Data sciences and Artificial Intelligence have been found more particularly interesting for the energy challenges [9] "Store energy along the grid" and [37] "Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities".

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 8: Sample of consortium members in the field Data Sciences and Artificial Intelligence

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
A01 - Big Data	MIX_R_LTD.	cws simularia ors_group		Hurence Inouid Ryax_Technologies Sky Computing	Opinum
A02 - Cloud computing			AE Option	Hurence Inouid Oslandia Piwio Ryax_Technologies	

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
A03 - Artificial Intelligence		orbyta aimage ermes cws santer_reply aizoon	Tangent_Works Ferranti	Amiral_Technologies Cynapps Data_Science_Experts DATA&Co DataGenius Inceptive INVENTHYS LEVIATAN Nehoov Neovision Parcoor ProbaYes	N-Side EMAX,

Digital Trust & Security

General introduction

Electric grids, oil and gas pipelines are of vital importance for any country. From the moment the operation of production units and energy transmission and distribution networks began to rely more and more frequently on digital technologies, the question of cybersecurity arose.

This question becomes even more important with the introduction of intermittent renewable energies driven by the need to reduce the energy production carbon-footprint and the development of electric mobility. Having a constant balance between the production and the consumption is key to guarantee the stability of electrical grids, and the whole system was originally designed in order to adapt permanently the production to the consumption. This was possible because the behaviour of production resources was completely predictable and controllable, apart from incidents. The characteristics of intermittent renewable energy sources leads to revise this paradigm and to be able to adjust at least a part of the consumption to the production, for example by differing some non-priority uses.

This is possible because objects (in a broad sense: machines, vehicles, appliances, etc.) that consume electricity are becoming smart and connected (see Digital Infrastructure and IoT). However, as stated in the International Energy Agency (IEA) report “Digitalization and Energy” [3] of 2017, the growth of the IoT increases the potential of cyber-attacks. If there is one suspect device at the edge of a network, this can be a weak point for the whole system. A study led in 2016 by the European Parliament concluded: “The development of smart energy has also led to exponential growth of networked intelligence throughout the energy grids and also consumer premises. The result is that a massively expanding ‘attack surface’ now forms the operational foundation of the energy ecosystem. As the energy system is also fundamentally interconnected with every other critical infrastructure network, the cybersecurity threat to the energy sector impacts every aspect of our modern society”.

Another characteristic of the new energy system is the development of energy communities. The Directive on common rules for the internal electricity market ((EU) 2019/944) includes new rules that enable active consumer participation, individually or through citizen energy communities, in all markets, either by generating, consuming, sharing or selling electricity, or by providing flexibility services through demand-response and storage. The directive aims to improve the uptake of energy communities and make it easier for citizens to integrate efficiently in the electricity system, as active participants [4].

Technically speaking, this can go through the development of micro- or minigrids at a district or city scale. Expected benefits would be to have more investment in renewable energies from local actors but also a better system resilience and less losses. Districts could for example continue to be supplied with local renewable energy sources in the event of an incident on the main grid. Using locally the energy produced by local energy sources could contribute to reduce losses in distribution networks.

This requires organizing the trading of electricity between local producers and consumers, and technologies like blockchain (also known as distributed ledger technologies) would be of great interest for this. Blockchain is a decentralised data structure in which a digital record of events (such as a transaction, or the generation of a unit of solar power) is collected and linked by cryptography into a time-stamped "block" together with other events. This block is then stored collectively as a "chain" on distributed computers. Any participant to a blockchain can read it or add new data. As no single computer system that could fail or be compromised is relied upon, data written to the blockchain is very secure against hacking [3].

Blockchain and similar technologies could be used to certify peer-to-peer transactions between local producers and consumers, to certify the origin of renewable energy or to manage billing for electrical vehicle parking and charging.

Contribution to the 5 core energy challenges

Digital Trust and Security has been found more particularly interesting for the energy challenges [5] "Develop Innovative solutions for local renewable generation of thermal energy (heating, cooling)", [30] "Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability" and [37] "Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities".

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 9: Sample of consortium members in the field Digital Trust and Security

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
B01 - Biometry				ID3 Technologies Tiempo	
B02 - Cybersecurity	Szekely_Family_CO.	ermes cws dgs aizoon	Toreon	Fieldcloud AlgoSecure Cybersecura Serenicity	CETIC
B03 - Cryptography			KULeuven NXP_semiconductors _Belgium		UCL

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
B04 - Distributed Ledger Technologies (Blockchain, …)			Fluvius KBC EMAX	iExec Blockchain Dappsnation Leviatan	WeSmart

Digital Engineering

General introduction

Simulation and modelling tools have been used for a very long time in the energy sector, for example to model the behaviour of a network in case of incident or to model the energetic behaviour of a building.

However, the energy transition provides new use cases such as: What should be the control laws of a micro-grid? How to manage storage under various constraints such as consumers' electricity needs, electricity pricing, future production that depends on a more or less predictable weather? Which proportion of locally generated renewable energy, for example on the roofs of connected buildings, can be injected on a low voltage network without causing a voltage excursion beyond the acceptable limits? How to ensure that utility-scale solar power plants comply with the local grid code? Etc.

The developments in this area come from the increased computing power, the so-called High Performance Computing, sometimes coupled with the use of artificial intelligence. Increasingly powerful supercomputers are capable of detailed data modelling and computational case studies, making them invaluable and transformative as invention and problem-solving tools. Researchers might be looking for new types of coatings for a solar panel to minimize dust accumulation that will degrade the performance of the panel over time, or a new surface for wind turbines that would resist weathering that degrades performance. A supercomputer could mock up hundreds of thousands of types of compounds that might work to create a surface that is impervious or resistant to dust build-up, a few of which could be created and tested in a lab and eventually deployed.

The U.S. Department of Energy (DoE) has for example launched in November 2019 a program called High Performance Computing for Energy Innovation (HPC4EI). HPC4EI is the umbrella initiative for different programs called HPC for Manufacturing, HPC for Materials, and HPC for Mobility. HPC for Manufacturing aims to advance innovative clean energy technologies, reduce energy and resource consumption, and infuse advanced computing expertise and technology into the manufacturing industry. The program seeks proposals that require HPC modelling and simulation to overcome impactful manufacturing process challenges resulting in reduced energy consumption and/or increased productivity. HPC for Materials aims to enhance the U.S. materials-development, fabrication, and manufacturing industries; and to investigate, improve, and scale methods that will accelerate the development and deployment of materials that perform well in severe and complex energy application environments. The program seeks proposals that will address key challenges in developing, modifying, and/or qualifying new or modified materials using HPC modelling, simulation, and data analysis.

In a longer term, but maybe not so far away, quantum computing could dramatically increase our capacity to solve complex problems such as improving weather forecasts for renewable energies, optimizing energy systems [12] or designing more efficient batteries for storage [13]. Quantum computers exploit the non-binary behaviour of fundamental particles. While classical computing relies on bits that can only be in two states noted 0 and 1, quantum computing relies on qu-bits that may be at the same time in several states such as 0, 1 or any linear combination of 0 and 1 (superposition phenomenon). Additionally, the state of a qu-bit may be completely dependent from the state of another qu-bit through the so-called entanglement phenomenon.

MODELISCALE, an example of project at the crossing between Energy and Digital Engineering

Developed by Dassault Systemes, CYLERGIE (Engie Lab), INRIA, CEA, EDF, DPS, Eurobios, Phimeca, the ModeliScale project focuses on the modelling, the simulation and the analysis of large cyber-physical systems. ModeliScale aims at enabling the Modelica technology to fit for the modelling & simulation of very large models of energy systems, in a multi-mode and reconfigurable context. It considers different time and space scales, multiple sources of energy production (classic and alternative), and various forms of energy transport consumption (buildings, vehicles, storage).
https://team.inria.fr/modeliscale/overview/
https://www.3ds.com/modeliscale/

Contribution to the 5 core energy challenges

Digital Engineering has been found more particularly interesting for the energy challenges [9] "Store energy along the grid", [37] "Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities" and [5] "Develop innovative solutions for local renewable generation of thermal energy (heating, cooling)"

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 10: Sample of consortium members in the field Digital Engineering

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
C01 - High Performance Computing		Aethia		Atos	
C02 - High Performance Data Analytics			AE ENEOS Research centers	Sky Computing	NRB Centrica Energis Ingestic

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
C03 - Modelling and Simulation	BME University	simularia experientia emisfera edilclima comai_torino	Research_centers	Comsol Nexio ARSKAN BIMData.io bY_Ze_Touch EAB_Engineering My_Digital_Buildings Vrtice TwInsight	Canaero Samtech Numeca V2I
C04 - System Engineering			Statik Ferranti	Cadfem Halias Technologies	Multitel Haulogy
C05 - Quantum Computing				CEA	

Digital Infrastructure & IoT

General introduction

According to the International Telecommunication Union, the Internet of Things (IoT) is a “global infrastructure for the information society, which provides advanced services by interconnecting objects (physical or virtual) using existing or evolving interoperable information and communication technologies”.

According to the U.S. research and advisory company Gartner, the number of connected IoT devices was set to reach over 20 billion by 2020 [10] . As already mentioned in previous paragraphs, the installation of smart and connected sensors at every stage of the energy system (production, grid, homes and buildings, processes, vehicles, infrastructures) can contribute to make the system more flexible and to increase the share of renewable energy in the energy mix. Smart thermostats directly connected to the power market and to weather forecast providers could decide whether it is, or not, the right moment to heat or cool depending on the price of energy (supposedly linked to its availability) and on the evolution of the external temperature in the hours to come. Depending on the state of charge of the battery, on the hour of the day and on the capacity of the local grid (lines, transformers), smart charging systems could in the same way define how to charge electric vehicles connected to them.

However, one should pay attention to the fact that these smart devices are also new energy consumers. Improving device efficiency and reducing standby power consumption will be critical to limit energy demand growth. This can be achieved using more energy efficient electronic components (see G – Micro- and nano- electronics) and Low Power Wide Area Networks (LPWAN).

Energy harvesting is a promising set of technologies that consist in feeding all these connected devices with energy tapped in the environment instead of energy tapped from the grid or from batteries. Energy can be scavenged for example from the solar irradiation if the sensors are located close to a window, from the flow of air to monitor ventilation ducts, from the flow of water in water pipes, or from a difference of temperature to monitor heating or cooling pipes.

ELF, an example of project at the crossing between Energy and Digital Infrastructure and IoT

Developed by ARDEA Energia srl, Eurix srl and the consortium member ENVIPARK, the ELF project (stands for Improving **E**fficiency of street **L**ighting through intelligent dimming and radio **F**requency data connection) aimed at developing a new intelligent infrastructure for public street lighting. This infrastructure is equipped with innovative sensors that can optimize energy savings and increase the reliability of lighting systems, adjusting the luminous flux according to the traffic situation, the reflection of the road surface and weather conditions. Monitoring and analysing captured data allows improving the reliability and safety of lighting systems and optimizing maintenance operations. An interesting collateral fallout is that the capillarity of public lighting is suitable to extend the network of associated sensors, enabling additional services such as environmental monitoring (air quality, pollution, flooding) and public safety audits (traffic situation, accidents, deterioration of horizontal road signs). https://www.poloclever.it/it/servizi-attivita/progetti/

Contribution to the 5 core energy challenges

Digital infrastructures & IoT have been found more particularly interesting for the energy challenges [37] "Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities", [30] "Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability" and [5] "Develop Innovative solutions for local renewable generation of thermal energy (heating, cooling)"

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 11: Sample of consortium members in the field Digital Infrastructure and IoT

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
D01 - Real-Time Systems (control, monitoring)	Energotest MIX R	orbyta midori enerbrain capetti kamelogic ors_group comai_torino	June Bagaar Smappee Ferranti Bausch_Datacom Condugo ABBCentrica_Business_Solutions Calculus E_Company November_Five iLeco	Automatismes_&_Industrie ACOEM Cohorte_Technologies Domnexx Exotic_Systems ido-data INESO IoTize Kalkin rTone	Dapesco Cegelec_CCS Meterbuy Micromega
D02 - Global Positioning Systems	3 COM LINE	digisky			GIM

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
D03 - Mobile phone technologies (5G)			Proximus Nokia Bausch_Datacom Commscope tranzcom	Orange Labs	
D04 - Low-Power Wide Area Networks (LoRA, SigFox, …)			Proximus Bausch_Datacom	Adeunis Atim _Radiocommunications EBDS_Wireless rTone Wirepas	Iniwan
D05 - Low-Power Local Area Networks (Bluetooth, Zigbee, …)				Atim _Radiocommunications Linkio	
D06 - Distributed sensors (lighting, temperature, presence, etc.)	Energotest SZTE engineering	enerbrain eurix capetti comai torino	BagaarE_Company	Meesens Moïz Terabee Wormsensing	Memoco
DO7 - Energy harvesting for distributed sensors			Thermovault Centrica_Business_Solutions	BeFC Dracula_Technologies Enerbee ITEN Moïz	

Applications & Tools

General introduction

Applications and Tools is a wide area covering in our case:

- Professional applications for all the sub-sectors of the energy sector
- Mobile and web applications relating to the energy sector
- Software tools for the energy sector
- Open source software for the energy sector

The most interesting field is undoubtedly the field of mobile and web applications insofar as these applications, supported by our smartphones, have become a privileged mode of interaction with our environment. To consume less and better, applications already exist to inform users about their consumption, to benchmark themselves with homes or buildings of similar characteristics or to select energy efficient household appliances. These applications could be improved if they were interoperating with more low-cost smart sensors and if they were embedding more (artificial) intelligence to help the users to more clearly understand the relationship between their consumption, their CO2 emissions and the actions they take.

Apps are also a pillar of the sharing economy. A good example is car sharing that, under various business models, allow a person to use a car he/she does not own. Car sharing may contribute to reduce fuel costs and parking fees, to reduce traffic pollution while improving air quality and lowering carbon emissions, to reduce traffic congestion and to increase the probability to find a parking space.

As previously mentioned, applications based on the blockchain technology could contribute certifying peer-to-peer transactions between local producers and consumers, to certify the origin of renewable energy or to manage billing for electrical vehicle parking and charging.

Monumentenmeter, an example of energy smart control model using connectivity and monitoring.

The National Bank in Antwerp is a monument dating from the nineteenth century and needs renovation. A consortium (Onnergy, Itho Daalderop, Zero Friction, Option, Ingenium, Lync Lexington) was therefore formed around a number of partners with the aim of reducing the building's CO2 footprint. An important starting point is that the cost of the renovation and the return on the savings must at least be in balance. The findings from this renovation will be incorporated into a reusable model to stimulate interest among owners of other historic multi-zone office buildings in reducing their own footprint.

https://www.monumentenmeter.be/

Contribution to the 5 core energy challenges

Not surprisingly, Applications and Tools have been found more particularly interesting for the energy challenge [30] “Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability”.

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 12: Sample of consortium members in the field Applications and Tools

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
E01 - Business-oriented applications on PC			StatikAEProximusSDM_projects	Applilogik	

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
E02 - Mobile and Web Applications		orbyta ermes cws enerbrain	HEMS_systems	Applilogik Codeffekt Kalkin Sogilis	
E03 - Open Source Software	BME University	Aethia	EnergieID	Oslandia VATES	
E04 - Software Tools	BerényiSoft_Ltd. Tandofer_Informatics _Ltd.	emisfera edilclima eurix capetti ors group comai torino teoresi	VITO IRC.be Statik Itineris Smart_Building _Software_Solutions	Cosinus	

Optics & Photonics

General introduction

Photonic technologies provide innovative solutions, particularly for the production and consumption of energy. More particularly, photovoltaic technologies are adapted to current societal challenges: depletion of fossil resources and the fight against climate change. This market shows strong growth in Europe, with an average increase of 12% per year. In addition, the use of nanotechnologies in photovoltaic solar panels, in particular to structure matter at the nanometre scale, should be able to increase the efficiency of energy yield.

Building-integrated photovoltaics (BIPV) are dual-purpose: they offer the classical functions of building materials such as thermal insulation, protection against wind and weather and generate electricity at the same time for on-site use or export to the grid. Building-integrated elements can replace façade, rooftop or glazing elements. Main challenges of BIPV elements are to offer diverse and aesthetically attractive integration thanks to flexible formats, shapes, colours and component forms, while remaining economically affordable, and lasting for a time compatible with a classical building lifetime. New technologies currently evaluated by organisms like CEA-Liten are for example printed glasses, glasses having a thin filtering layer on the surface and encapsulating resin films printed by screen-printing. Heterojunction solar cells integrated into the modules and a wire interconnect allows eliminating the visual impact of copper ribbons.

Beyond Building Integrated Photovoltaics that has been selected as a possible core focus of the consortium, the report "Europe's age of light : How Photonics will power growth and innovation" [12] published by the association of European photonics actors Photonics 21 enumerates other possible contributions of green photonics to Europe's sustainability goals:

- Development of the next generation of organic photovoltaic (OPV) devices. OPV devices are cheaper to produce, and can easily be applied to virtually any surface. Even indoor photovoltaics (to recapture the energy of artificial lighting) may become feasible. These advantages are so profound that OPV devices could replace conventional photovoltaics for many applications, giving European companies an opportunity to win back market share from Asian producers.

- New generation of intelligently networked optical pollution sensors improving the real-time detection of toxic substances. Ultraviolet LEDs and other photonics technologies play an increasingly important role in purifying air, water and food.
- Efficiency gains from additive manufacturing bringing the possibility of designing entire products from a single material, greatly boosting both production efficiency and ease of recycling after disposal.
- Use of laser tools for the production of lightweight cars, batteries and fuel cells. These products, too, will become greener as laser-based manufacturing reduces downtime, defects, attrition, chemical waste and energy consumption.
- Use of fiber optics and optical technologies to shrink the carbon footprint of the internet. Data centres already produce as many greenhouse gas emissions as the entire world's air travel. Greening the global IT infrastructure is therefore an imperative in our fight to reduce emissions.
- Adaptive lighting systems that use sensors to automatically switch off lights in buildings and on streets and would significantly reduce energy consumption and light pollution. These sensors could be coupled with artificial intelligence at the edge (see A – Data Sciences and Artificial Intelligence) and would of course control inorganic and organic LED-based lights to scale-down the global power consumption.

CLEDIA, an example of project at the crossing between Energy, Photonics and Artificial Intelligence

Developed by Pollen Metrology, ALEDIA and the University of Grenoble-Alps, CLEDIA (French acronym standing for Growth of MicroLeds assisted by Artificial Intelligence) is a software project aiming at developing a complete process improvement and acceleration protocol (process optimization, yield enhancement) based on an appropriate use of deep learning.

Contribution to the 5 core energy challenges

Optics and Photonics have been found more particularly interesting the energy challenge [14] "Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)"

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 13: Sample of consortium members in the field Optics and Photonics

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
F01 - Solar technologies (PV materials, BIPV, …)	3COM_Line_Ltd. Asianet		IMEC	CEA Dracula_Technologies	Issol CRMAGC
F02 - Low consumption Lighting (LED, …)	Villometric GET_LTD. SolvElectric_Ltd	capetti	IMEC	Eco-Innov Witti	

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
F03 - Optic & Photonic Sensors (infrared, …)			IMEC	Lynred Isorg Pyxalis	
F04 - Imaging & Machine Vision		digisky		Expertise_Vision NT2I Prophesee Senssight	
F05 - Low consumption Displays				Aledia MicroOLED	

Micro / Nano / Electronics

General introduction

As explained in the previous chapter, the multiplication of connected objects requires paying attention to their consumption. In this race for energy sobriety, different approaches may be used independently or in conjunction. A first one is to work on materials. Technologies like the FD-SOI (Fully Depleted Silicon on Insulator) improves the architecture of the transistor itself, which is the fundamental component of integrated electronic chips and circuits. The objective of FD-SOI is to reduce or even cancel parasitic leakage currents, the importance of which increases as the miniaturization of transistors progresses: electrons are "lost" on the way between the source and the drain of the transistor. However, these leakage currents degrade the efficiency and cause random behaviour. A second one is to work on microprocessors and microcontroller architectures. Conventional processors consume a large amount of power for memory access, in registers, and for the control of the processor itself rather than for computation. Improvements in the architecture allow reducing useless losses.

The new energy system is also interspersed with direct current (DC) to alternating current (AC) and vice-versa conversion systems. Solar modules generate direct current, but this direct current is not constant and depends on the solar irradiation. The voltage at the output of solar modules varies also widely with the temperature. Injecting this power onto the grid requires converting the DC power in AC power having characteristics compatible with the grid. Along the grid, AC power may need to be converted again in DC power to be stored in large-scale batteries. On the consumption side, computers, sensors, LED-based lighting, electric vehicles require DC power. Although losses in conversion systems are already quite low (a good quality photovoltaic inverter reaches an efficiency generally greater than 98%), some improvement remains possible using new materials like Silicon Carbide (SiC) or Gallium Nitride (GaN).

MEMS, acronym for Micro Electro Mechanical Systems, are miniaturized devices combining several physical principles. They generally integrate mechanical elements coupled with electronics and are made by manufacturing processes derived from microelectronics. MEMS exploit, among other things, effects related to electromagnetism, thermal and fluidics. MEMS sensors directly link a mechanical deformation with an electric variation. For example, they can be used as pressure sensors (resistive type) for monitoring water heaters or liquid natural gas tanks.

An example of project at the crossing between Energy and Micro- / nano- / electronics

The demand for silicon carbide chips is accelerating, especially in automotive with electric vehicles, in telecommunications and in industrial applications; their adoption has however remained limited for reasons of access to silicon carbide substrates, cost and low yield of their production. The French substrate manufacturer Soitec, member of Minalogic, works currently with Applied Materials to develop substrates that will meet these challenges and bring value to all industry players. The co-development program combines the leadership of Soitec in the manufacture of innovative substrates and that of Applied Materials in the engineering of solutions for materials. Soitec relies on its proprietary Smart Cut technology, currently used for the production of silicon-on-insulator (SOI) products adopted by a large number of chipmakers, while Applied Materials will provide its expertise in equipment and manufacturing process. As part of this co-development program, the two companies will install a pilot line dedicated to innovative silicon carbide substrates within the Substrate Innovation Centre located on the CEA-Leti site.

Contribution to the 5 core energy challenges

Micro- and nano-electronics as well as electronics have been found particularly interesting for the energy challenges [5] “Develop Innovative solutions for local renewable generation of thermal energy (heating, cooling)”, [14] “Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)” and [30] “Applications for car sharing service billing, software to implement Vehicle-to-Grid, protocols for interoperability”

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 14: Sample of consortium members in the field Micro- and nano- electronics

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
G01 - Low-loss electronic components (SiC, GaN, InP, crystals …)			IMEC	DiamFab Exagan (STMicro) Wise-Integration Kalray	
G02 - IoT / AI oriented processors		capetti comai torino	IMEC Research_centers	Hawaii.Tech	
G03 - MEMS			IMEC	Morphosense Tronics Microsystems	

Interactivity & Immersivity

General introduction

Interactivity comprises the various technologies allowing humans to interact with machines and machines to emulate human senses as well as the data processing linked to that. It can be for example seeing, recognizing shapes or objects, hearing, recognizing noises, understanding natural language, smelling, recognizing odours and chemicals, tasting, touching or providing feedback to reproduce in remote operation or computer simulation the sensations that would be felt by a user interacting directly with physical objects (haptic). Correlatively, immersivity (or immersiveness) refers to all the technologies that make it possible to provide a user with a feeling of immersion in an environment, like for example virtual reality.

Contribution to the core energy challenges

Interactivity and Immersivity have not been found very relevant for the 5 core challenges. The best rating is 1.5 on 3 for the challenge [29] "Develop battery second life use and recycling at their end of life".

The table hereafter gives a sample of possible contributors to these challenges on the digital side:

Table 15: Sample of consortium members in the field Interactivity and Immersivity

Technology	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
H01 - Augmented and Virtual Reality		cws emagine kairos3D		Speedernet Hyperfiction Ino-VR Miscible	
H02 - Audio & Sound diffusion				Digigram	
H03 - Vocal Assistants, Speech Recognition				Taiwa	
H04 - Social Robots, Cobots				Hoomano Meanwhile	
H05 - UX-UI		experientia		Ark_Innovation HAP2U KIDS	

05

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Appendix 1 - Results of the assessment View by Energy Challenge

Strengthening the European economy through collaboration

Appendix 1: Complete results of the questionnaire – View by Energy Challenge

The table below presents the complete results of the assessment of the 37 energy challenges by the consortium members
In the column "Importance score", X-Y-Z means that X participants placed the said energy challenge in its top 10 priorities, Y rated it as a secondary priority and Z as not important.

Table 16: Complete assessment of energy challenge importance for the consortium members

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
37	F - Smart Communities	3 - Adapt grids	Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities.	4-1-0	2,25	2,25	2,50	2,67	2,00	1,50	1,50	1,00
5	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop Innovative solutions for local renewable generation of thermal energy (heating, cooling)	3-2-0	2,00	2,50	2,50	2,33	1,67	1,50	2,00	1,00
9	B - Smart Grids	3 - Adapt grids	Store energy along the grid	3-2-0	3,00	1,50	3,00	2,00	1,50	2,00	1,50	1,00

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
14	C - Smart Buildings	1 - Production carbon-footprint reduction	Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)	3-2-0	1,50	1,00	1,67	1,50	1,50	2,50	2,00	1,00
30	E - Smart Mobility	2 - Consume less and better	Applications for car sharing service billing, software to implement V2G, protocols for interoperability	3-2-0	2,00	2,50	2,00	2,50	2,75	2,00	2,00	0,00
19	C - Smart Buildings	3 - Adapt grids	Develop self-consumption management associated with storage systems in buildings	3-1-1	3,00	1,50	1,67	2,50	2,00	3,00	2,00	1,00
29	E - Smart Mobility	2 - Consume less and better	Develop battery second life use and recycling at their end of life	3-1-1	2,00	1,50	1,50	1,67	2,00	1,33	2,00	1,50
3	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop new renewable production process (including CO2 capture)	2-3-0	2,00	1,00	2,50	1,33	2,33	2,50	1,50	1,00

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
8	B - Smart Grids	3 - Adapt grids	Address technical issues resulting from renewable intermittency	2-3-0	2,00	2,00	2,50	3,00	1,75	1,50	1,50	1,00
10	B - Smart Grids	3 - Adapt grids	Explore the coupling of STEPs with renewables	2-3-0	3,00	1,50	2,00	2,00	2,50	1,00	1,00	2,00
16	C - Smart Buildings	2 - Consume less and better	Develop more efficient appliances (lighting, heating, ventilation, air conditioning)	2-3-0	3,00	1,00	3,00	2,50	3,00	2,00	1,00	1,50
17	C - Smart Buildings	2 - Consume less and better	Optimize building consumption with respects to external (temperature, solar irradiance) and internal (occupancy) parameters	2-3-0	2,00	0,00	2,00	2,67	2,50	1,50	1,67	0,00
18	C - Smart Buildings	2 - Consume less and better	Develop smart building envelope components (sun blinds, windows with low-emission coatings, etc.)	2-3-0	2,50	1,00	3,00	2,00	3,00	2,00	1,50	2,50

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
24	E - Smart Mobility	1 - Production carbon-footprint reduction	Develop regional hydrogen sectors of excellence	2-3-0	1,00	0,00	2,00	2,00	3,00	0,00	0,00	0,00
1	A - Decarbonized Production	1 - Production carbon-footprint reduction	Deploy massively renewable energies	1-4-0	3,00	3,00	0,00	2,00	1,00	2,00	2,00	2,00
2	A - Decarbonized Production	1 - Production carbon-footprint reduction	Improve the carbon balance of renewables	1-4-0	2,00	0,00	2,00	0,00	2,00	3,00	0,00	0,00
7	B - Smart Grids	3 - Adapt grids	Develop more accurate production forecasts	1-4-0	2,00	2,00	3,00	1,00	1,50	2,00	2,00	0,00
11	B - Smart Grids	3 - Adapt grids	Secure the energy supply with regards to external attacks, cybersecurity	1-4-0	1,00	2,67	0,00	1,50	2,00	0,00	1,00	0,00
12	B - Smart Grids	3 - Adapt grids	Develop technologies and systems for thermal transformation, transport and storage	1-4-0	2,00	2,00	2,50	2,50	2,33	2,00	2,00	1,00
13	B - Smart Grids	3 - Adapt grids	Make electricity, gas, hydrogen, etc. infrastructures interoperable	1-4-0	1,00	0,00	2,00	2,00	2,00	0,00	3,00	0,00

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
15	C - Smart Buildings	2 - Consume less and better	Lower the carbon footprint of building construction processes	1-4-0	0,00	0,00	1,50	3,00	2,00	2,00	1,50	0,00
20	D - Smart Processes	2 - Consume less and better	Develop the measurement of consumption at the finest possible scale	1-4-0	3,00	1,00	3,00	2,00	2,00	0,00	3,00	0,00
21	D - Smart Processes	2 - Consume less and better	Reduce energy losses in processes	1-4-0	2,00	0,00	2,00	2,00	0,00	1,00	2,00	0,00
23	D - Smart Processes	3 - Adapt grids	Develop self-consumption management associated with storage systems in buildings	1-4-0	2,50	2,00	3,00	3,00	2,00	1,50	1,50	1,00
36	F - Smart Communities	2 - Consume less and better	Raise awareness among regional actors (in particular, communities) of good practices for the territorial deployment of electric mobility	1-4-0	2,00	0,00	2,00	0,00	3,00	0,00	0,00	3,00

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
4	A - Decarbonized Production	1 - Production carbon-footprint reduction	Explore Power-to-X technologies	1-3-1	1,50	3,00	3,00	1,00	2,50	2,50	1,50	0,00
27	E - Smart Mobility	2 - Consume less and better	Develop energetic optimization of vehicles (energy recovering, ...)	1-3-1	2,00	0,00	2,00	2,00	2,00	0,00	2,00	0,00
6	A - Decarbonized Production	1 - Production carbon-footprint reduction	Integrate large-scale renewable generation parks in specific contexts (for example harbours, airports, etc.)	1-2-2	2,00	3,00	3,00	2,50	1,50	2,00	1,00	1,00
22	D - Smart Processes	2 - Consume less and better	Recover the heat of processes to use it for other applications	1-2-2	2,00	1,00	2,50	2,50	3,00	1,00	2,00	0,00
25	E - Smart Mobility	1 - Production carbon-footprint reduction	Support the development of Bio-NGV	0-5-0	2,00	0,00	2,00	2,00	2,00	0,00	0,00	0,00
28	E - Smart Mobility	2 - Consume less and better	Develop new generations of electric motors limiting the use of rare materials	0-5-0	0,00	0,00	0,00	3,00	2,00	0,00	2,00	0,00

N°	Energy System Component	Main challenge	Energy Challenge	Importance Score	A - Data Sciences & Artificial Intelligence	B - Digital Trust & Security	C - Digital Engineering	D - Digital Infrastructure & IoT	E - Applications & Tools	F - Optics & Photonics	G - Microelectronics	H - Interactivity & Immersivity
31	E - Smart Mobility	2 - Consume less and better	Know better the operating and filling status of stations	0-5-0	2,00	0,00	2,00	0,00	2,00	0,00	2,00	0,00
33	E - Smart Mobility	3 - Adapt grids	Develop new generations of energy storage means for mobility	0-5-0	1,00	0,00	3,00	0,00	0,00	0,00	1,00	0,00
32	E - Smart Mobility	3 - Adapt grids	Develop technologies limiting the impact of high power refueling stations on grid infrastructures	0-4-1	0,00	0,00	1,00	2,00	1,00	2,00	3,00	0,00
34	E - Smart Mobility	3 - Adapt grids	Explore interactions between vehicles and networks ("Vehicle-to-Grid")	0-4-1	0,00	0,00	1,00	2,00	0,00	2,00	1,50	0,00
35	F - Smart Communities	2 - Consume less and better	Reduce the consumption of public lighting with smart adaptive or traffic adaptive systems	0-3-2	3,00	0,00	2,00	2,00	2,00	3,00	2,00	3,00
26	E - Smart Mobility	2 - Consume less and better	Reduce losses in mobility (frictions)	0-2-3	0,00	0,00	3,00	3,00	2,00	0,00	0,00	0,00

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Appendix 2 - Results of the assessment View by Digital Sub-sector

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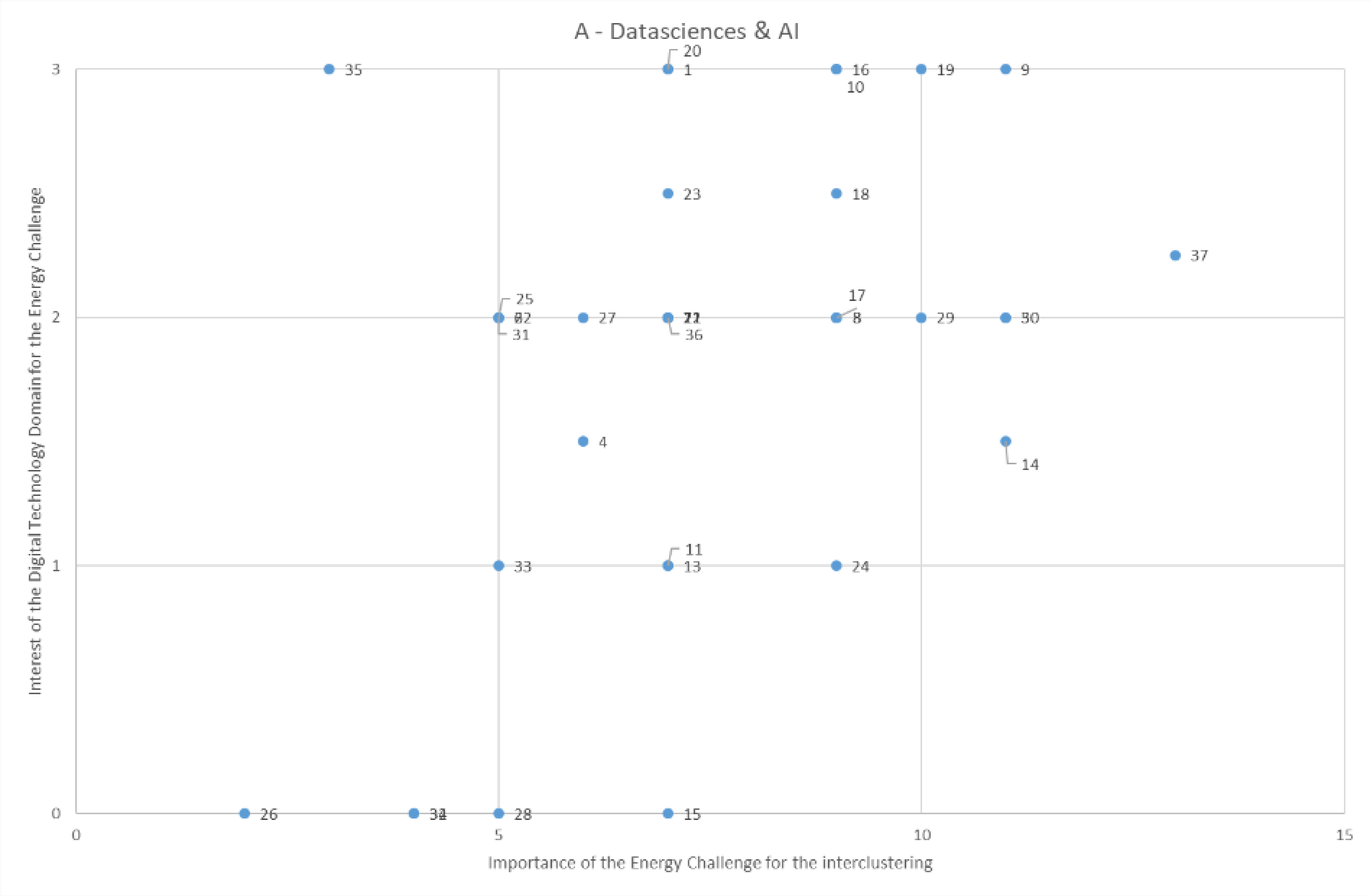
Appendix 2 : Complete results of the assessment – View by Digital sub-sector

Note: Graphics display for each Digital Technology sector how the contribution of the sector has been rated to help solving each energy challenge (Y-axis). The rating may vary from 0 (no contribution) to 3 (very important contribution).

Energy challenges are disposed along the X-axis according to their importance score (see Annex 1). For the purpose of the representation, the importance score X-Y-Z has been converted in a number as follow : Score = (3*X) + (1*Y) + (0*Z) where X is the number of participants that placed the said energy challenge in their top 10 priorities, Y the number of participants that rated it as a secondary priority and Z as not important.


A - Datasciences & AI
Interest of the Digital Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
35
20
1
16
10
19
9
23
18
37
25
32
31
27
36
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8
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30
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14
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11
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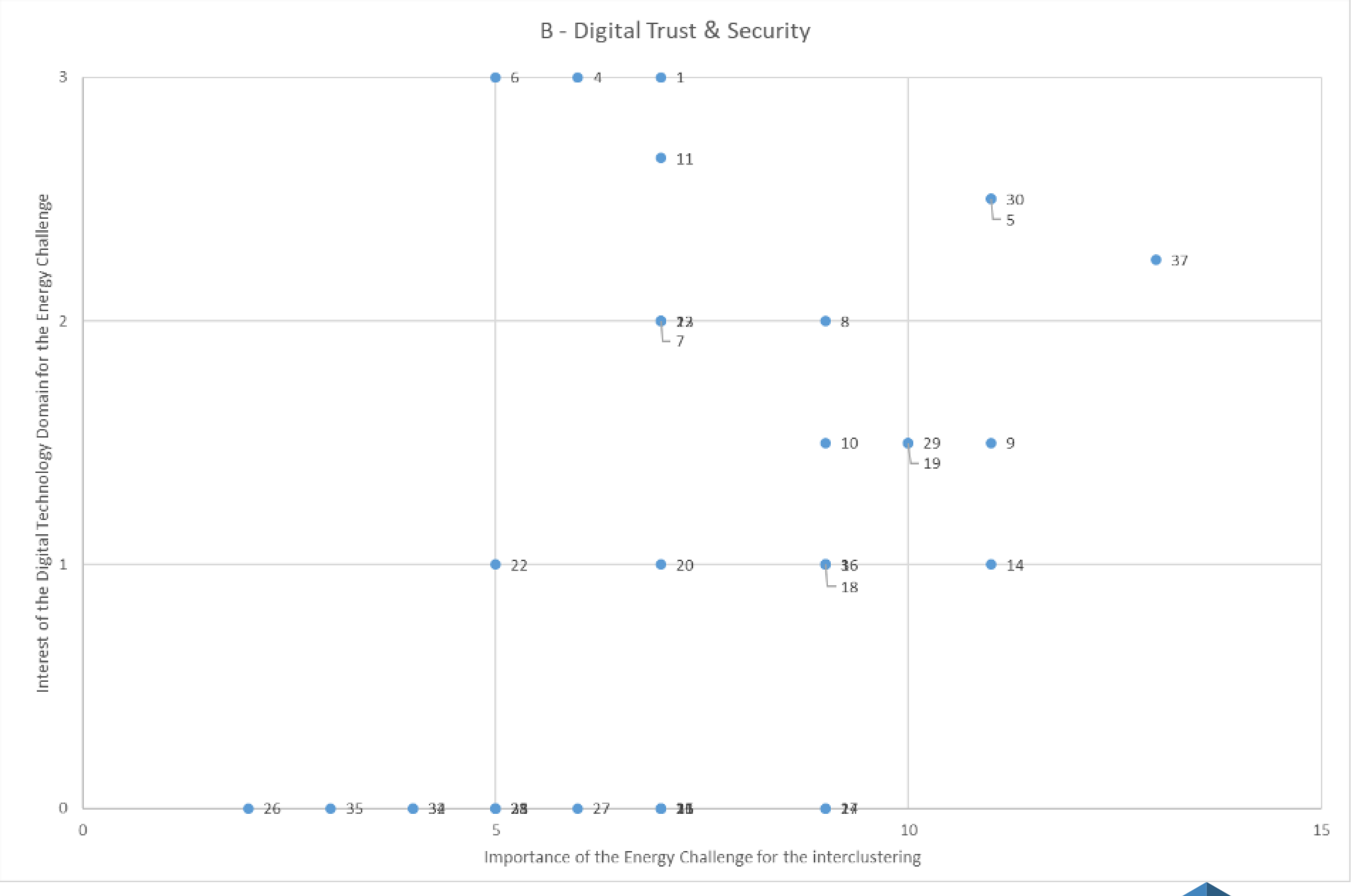
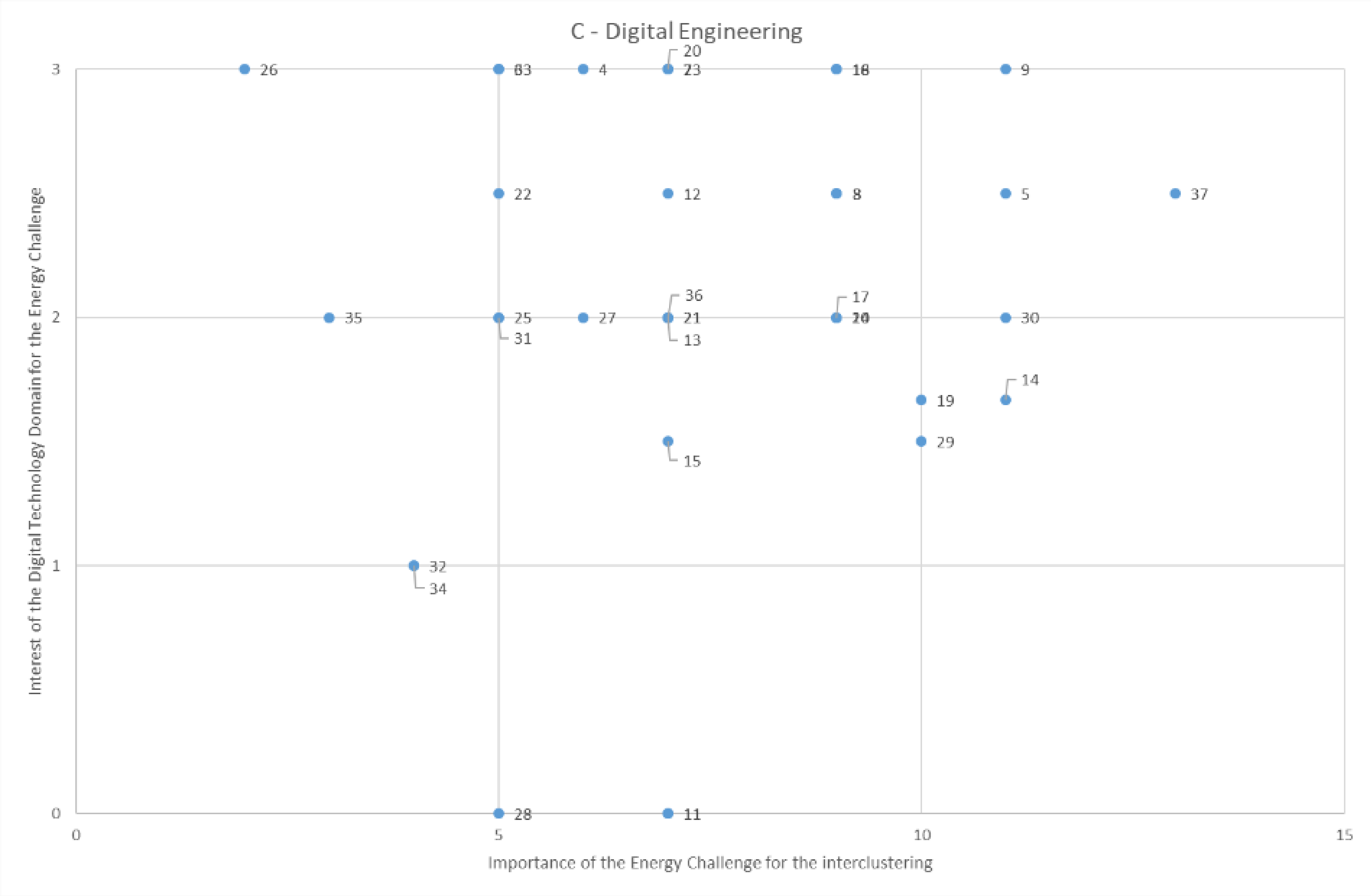
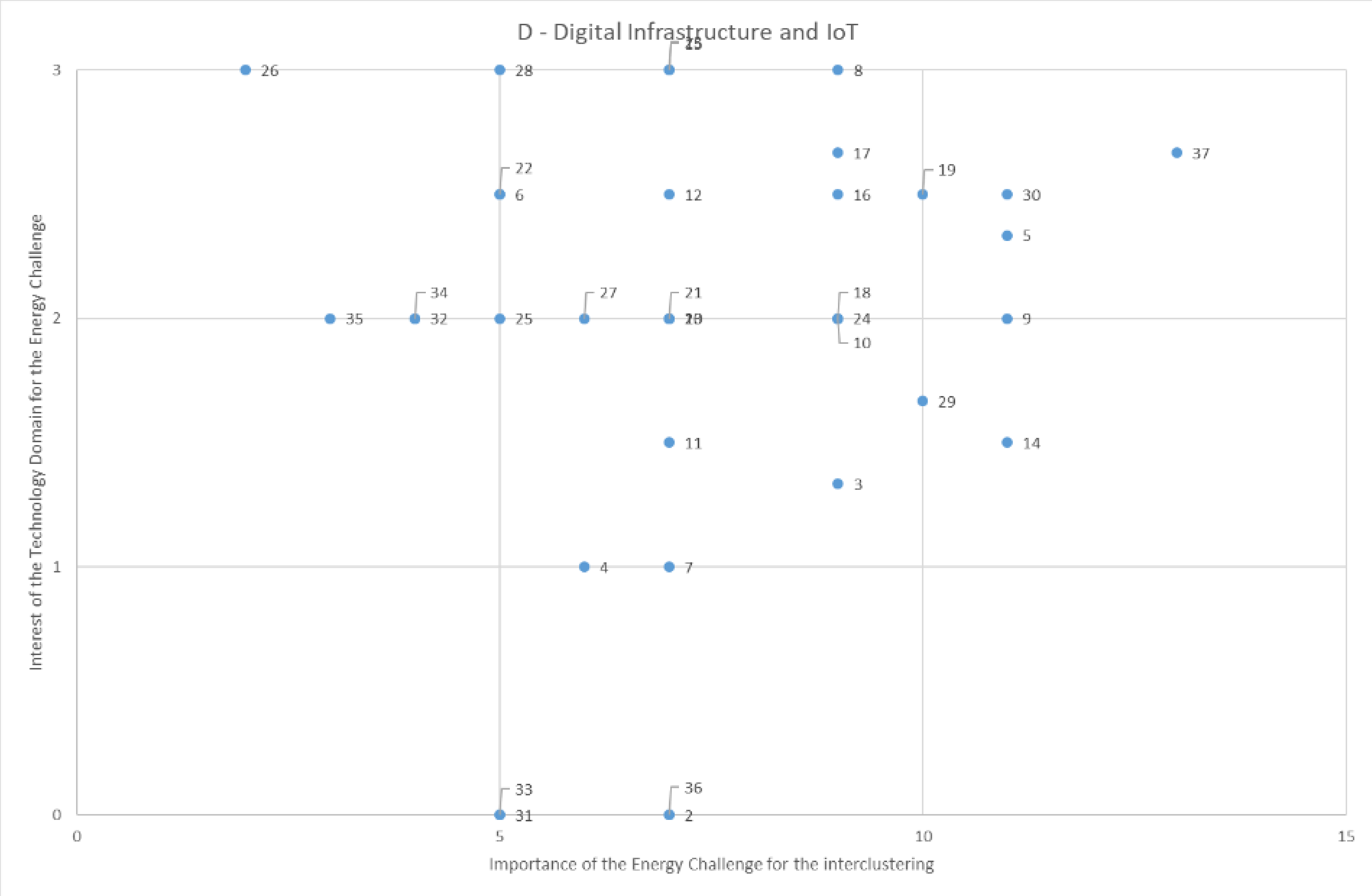
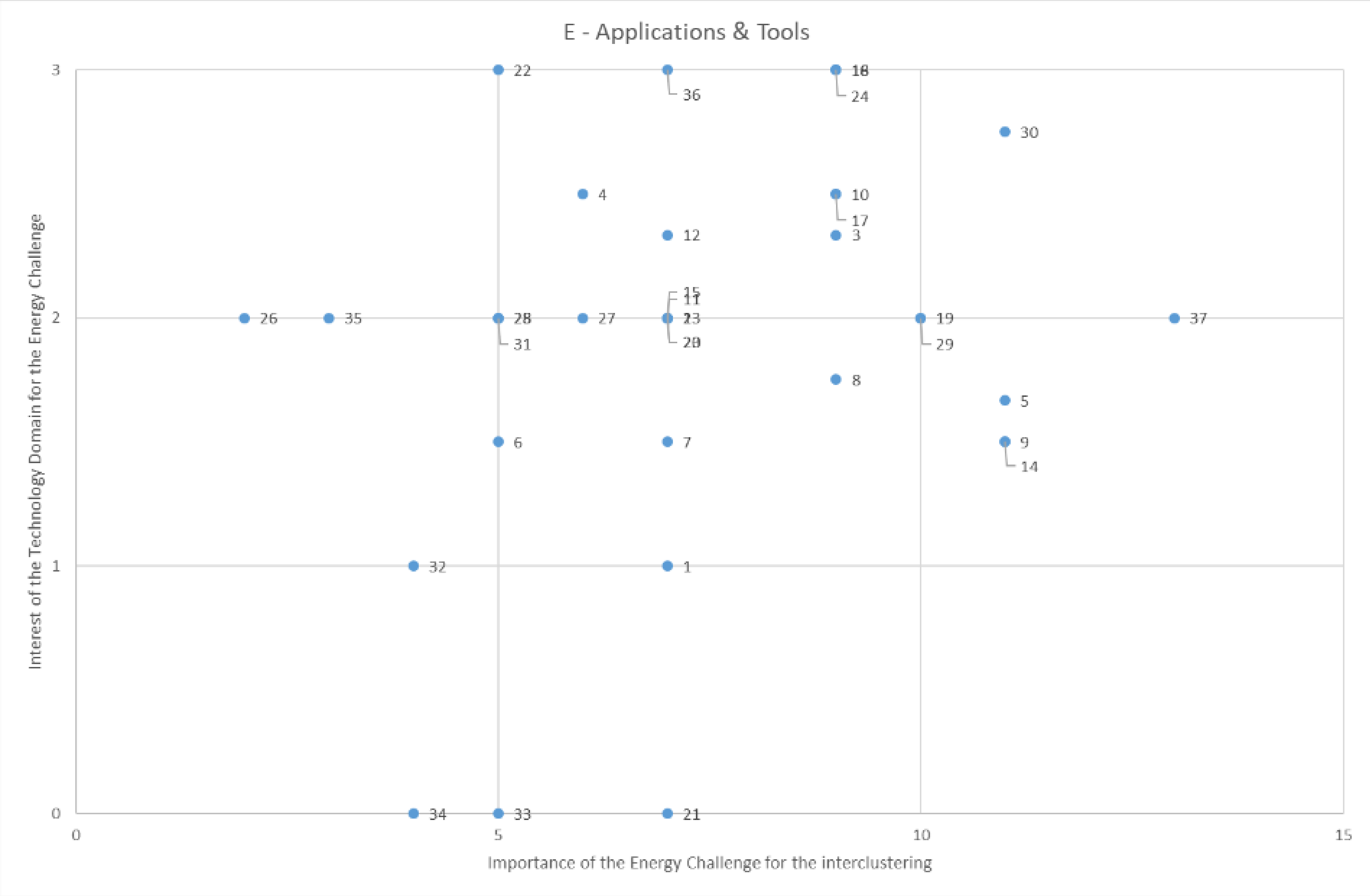
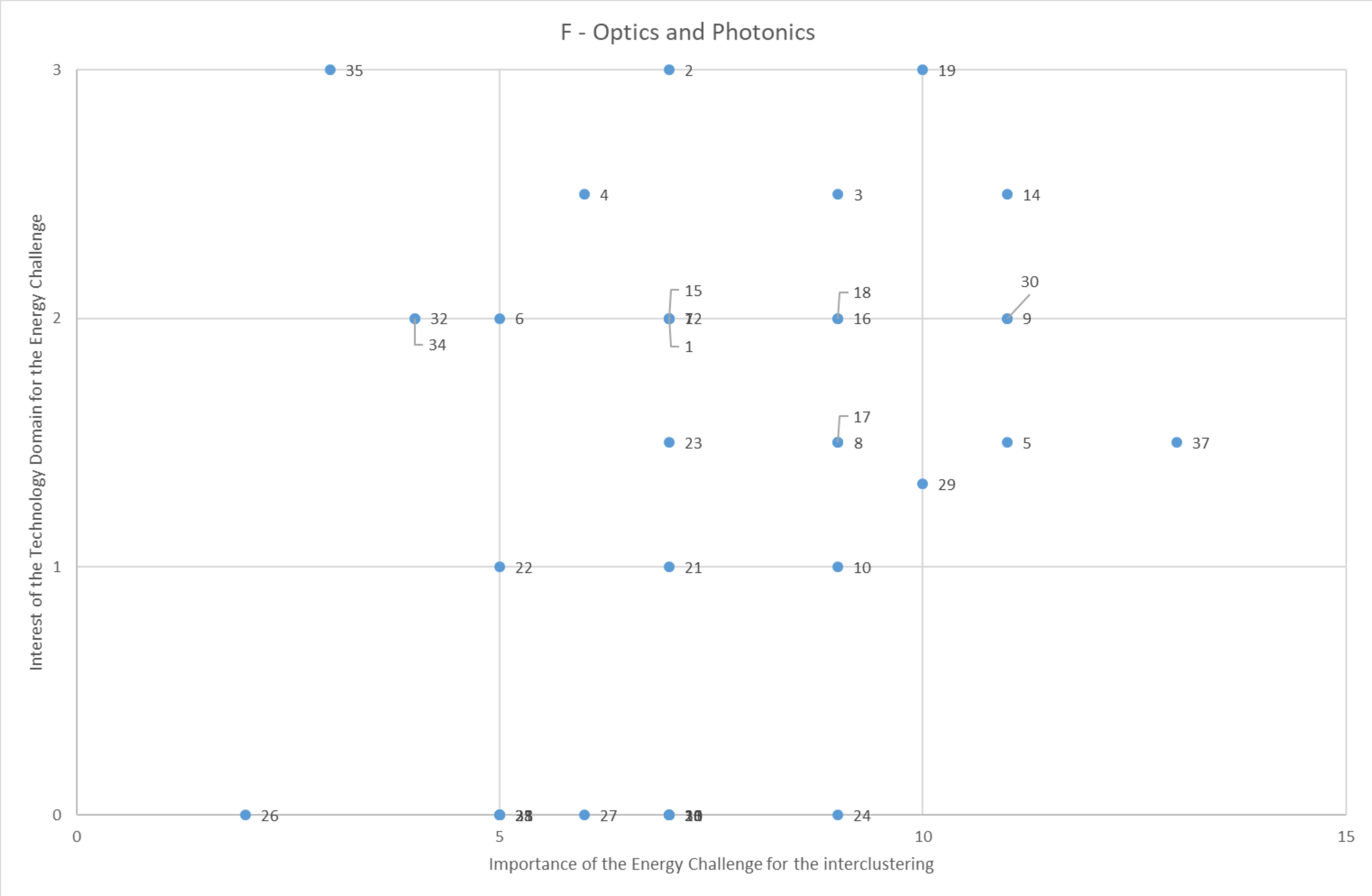
24
26
28
15

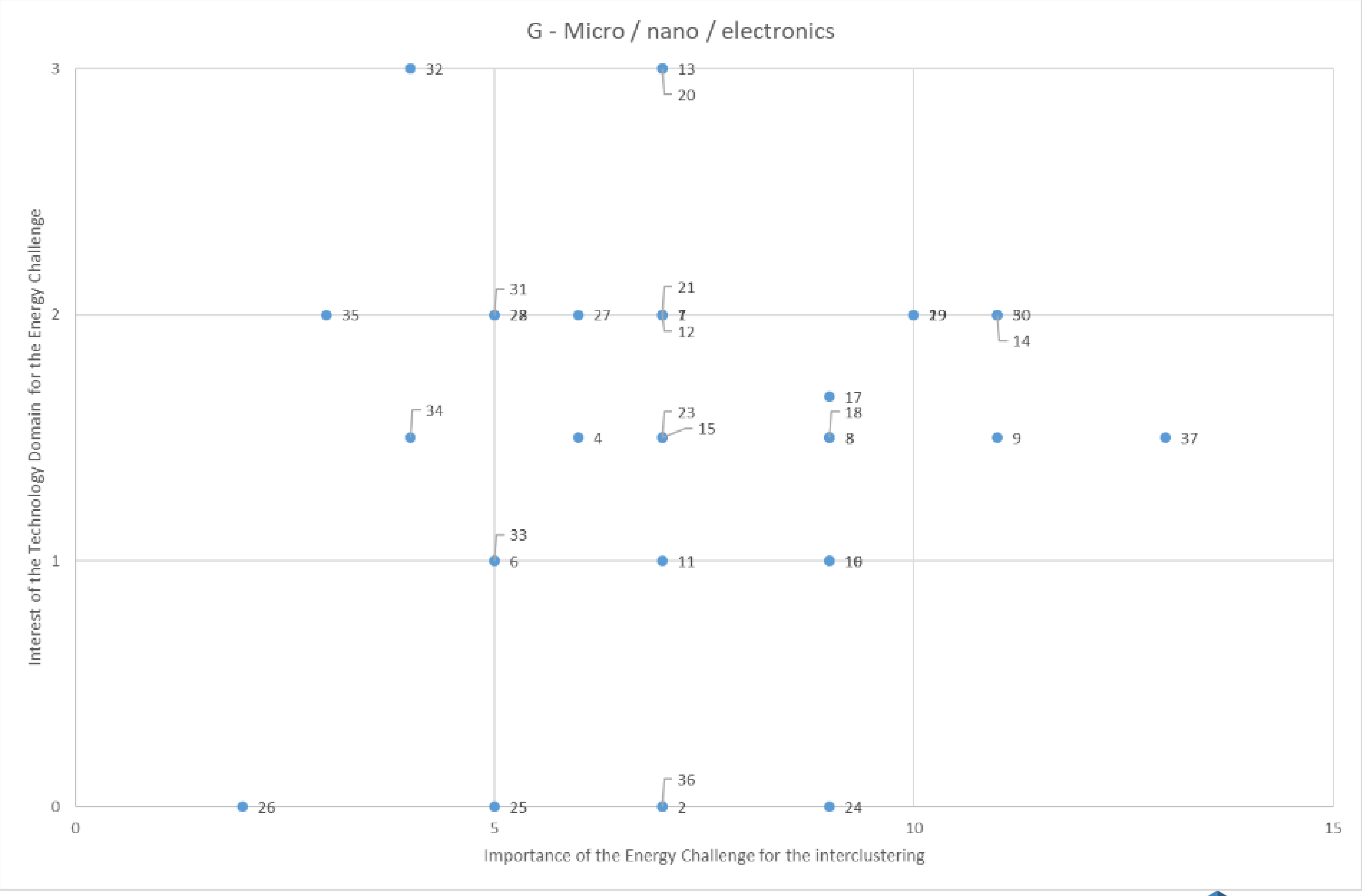

B - Digital Trust & Security
Interest of the Digital Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
5
10
15
1
2
3
6
4
1
11
30
5
37
8
7
10
29
19
9
22
20
18
14
26
35
27

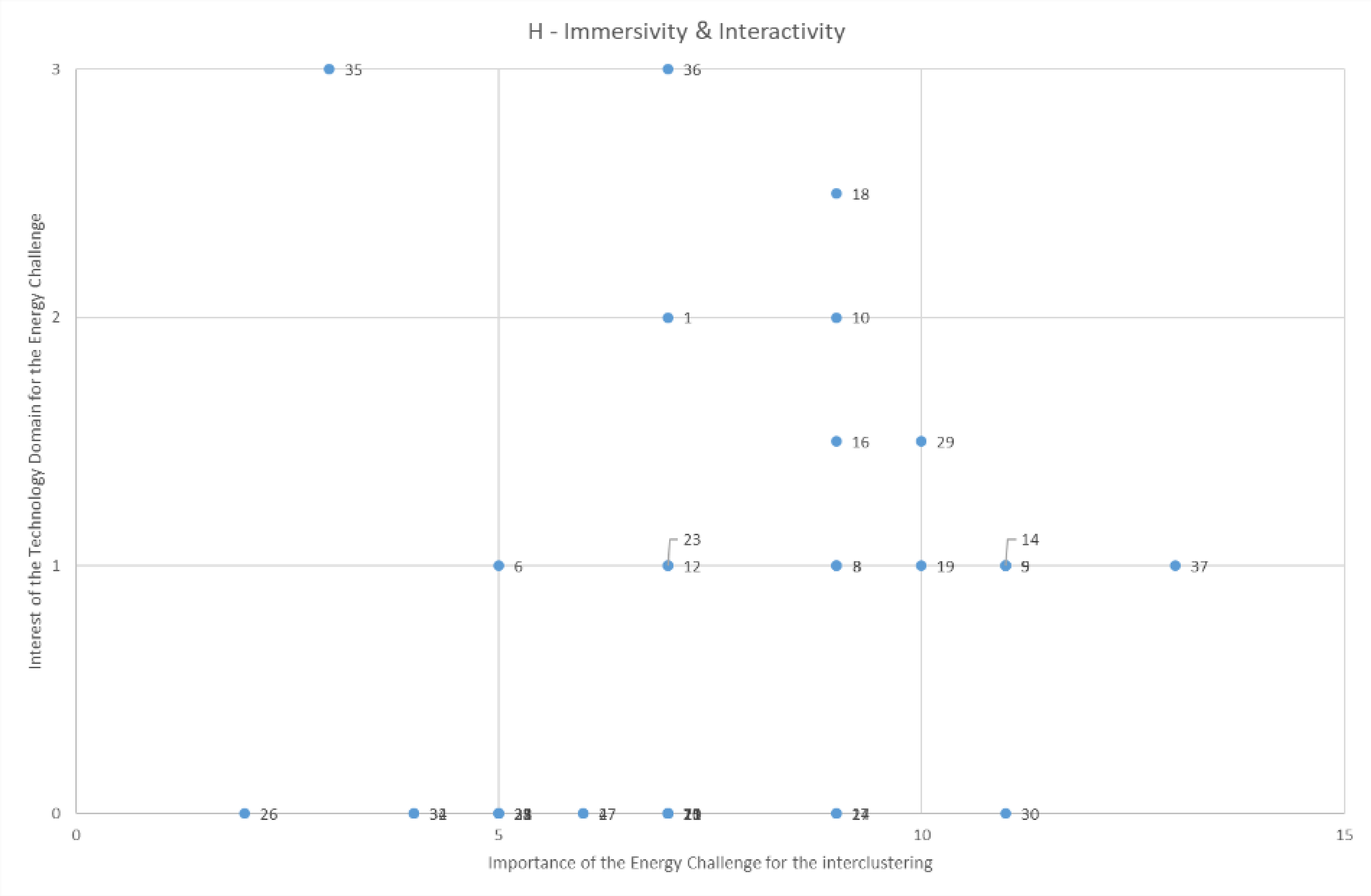

C - Digital Engineering
Interest of the Digital Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
26
33
4
20
23
18
9
22
12
8
5
37
35
25
31
27
36
21
13
17
30
19
14
29
15
32
34
28
11


D - Digital Infrastructure and IoT
Interest of the Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
26
28
8
17
37
22
6
12
16
19
30
5
34
35
32
25
27
21
18
24
10
9
29
11
14
3
4
7
33
31
36
2


E - Applications & Tools
Interest of the Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
22
36
18
24
30
4
10
17
12
3
15
11
26
35
28
31
27
23
20
19
29
37
8
5
6
7
9
14
32
1
34
33
21


F - Optics and Photonics
Interest of the Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
35
2
19
4
3
14
15
18
30
32
6
12
16
9
34
1
17
23
8
5
37
29
22
21
10
26
27
24


G - Micro / nano / electronics
Interest of the Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
32
13
20
31
28
35
27
21
7
12
19
30
14
34
23
15
17
18
4
8
9
37
33
6
11
16
36
26
25
2
24


H - Immersivity & Interactivity
Interest of the Technology Domain for the Energy Challenge
Importance of the Energy Challenge for the interclustering
0
1
2
3
0
5
10
15
35
36
18
1
10
16
29
23
14
6
12
8
19
37
26
30

08

Appendix 3 : Examples of players for each Energy Challenge

Appendix 3: Examples of players for each Energy Challenge

Table 17: Examples of players working on each energy challenge among consortium members

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
37	F - Smart Communities	3 - Adapt grids	Develop grid-connected and off-grid micro-grids technologies to enable smart energy communities.	Vilometric, 3ComLIne, Vilometric		SDM Group, YouPower, Enervalis, I.Leco, Think-E, ABB, ….	Schneider Electric, Ausar Energy, Enogrid	CE+T Energrid
5	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop Innovative solutions for local renewable generation of thermal energy (heating, cooling)	Energotest, Kiss Ltd. Thermoszerviz Ltd. Cozero Ltd.	Ago Renewables Asja Ambiente Italia E++		Inddigo, Cylergie, Caeli Energy	Haulogy
9	B - Smart Grids	3 - Adapt grids	Store energy along the grid	3Com Line, Vilometric, Asianet	Electro Power System		GE, Artelia, McPhy, Storengy, Wattmen, RTE, Atos	Tractebel, Restore
14	C - Smart Buildings	1 - Production carbon-footprint reduction	Develop renewable energy production systems adapted to Buildings (BIPV, adapted wind turbines, etc.)	3 Com Line, Vilometric, Asianet, AeroEnergi, Pannonsolar Ltd.	Enecom		Schneider Electric, Vesta System	Issol, CRM

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
30	E - Smart Mobility	2 - Consume less and better	Applications for car sharing service billing, software to implement V2G, protocols for interoperability	Tandofer informatikai Ltd. BerényiSoft Ltd.	Metatronix	VUB, Leasing companies, Enervalis, Powerdale	Enedis	Enersol, Powerdale
19	C - Smart Buildings	3 - Adapt grids	Develop self-consumption management associated with storage systems in buildings		Electro Power System	Besix, Youpower, ….	Lancey, Schneider Electric	
29	E - Smart Mobility	2 - Consume less and better	Develop battery second life use and recycling at their end of life		Hensel Recycling	VUB, Agoria, Umicore,	SNAM, Lancey Energy Storage, CEA	Comet
3	A - Decarbonized Production	1 - Production carbon-footprint reduction	Develop new renewable production process (including CO2 capture)	Bodai Ltd., Bodrogi Bau Ltd. Ax	IIT	Port of Ghent and Antwerp		
8	B - Smart Grids	3 - Adapt grids	Address technical issues resulting from renewable intermittency		Electro Power System IREM Sasso srl		G2ELab, Atos Worldgrid	N-Side

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
10	B - Smart Grids	3 - Adapt grids	Explore the coupling of STEPs with renewables		Electro Power System	https://snowball.eu/; https://www.greenenergypark.be/?lang=en	GE	
16	C - Smart Buildings	2 - Consume less and better	Develop more efficient appliances (lighting, heating, ventilation, air conditioning)	GET Ltd., Energotest, , Labaro Ltd, Wagner Solar Ltd.	Giacomini Neodelis		Verelec,	
17	C - Smart Buildings	2 - Consume less and better	Optimize building consumption with respects to external (temperature, solar irradiance) and internal (occupancy) parameters	Rolló Ltd. Szeplast Ltd, Villometric Ltd. Metal Hungaria	Ardea Energia		Schneider Electric	

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
18	C - Smart Buildings	2 - Consume less and better	Develop smart building envelope components (sun blinds, windows with low-emission coatings, etc.)	Rolló Ltd. Szeplast Ltd, Villometric Ltd. Horizont Global Ltd.	Enerpaper	Niko, BAM group, Loxone, Ahrend group, Priva, Smappee, Smart Building Solutions, Darwin ….		
24	E - Smart Mobility	1 - Production carbon-footprint reduction	Develop regional hydrogen sectors of excellence	Tibor Kellessy Exitium Ltd	SAPIO, Tecnodelta, Dolomitech			
1	A - Decarbonized Production	1 - Production carbon-footprint reduction	Deploy massively renewable energies	Snell Tel Ltd. Asia Net Ltd. 3 Com Line	Asja Ambiente Italia E++ IREN		H2 McPhy,	
2	A - Decarbonized Production	1 - Production carbon-footprint reduction	Improve the carbon balance of renewables	Szeplast Ltd.	IREN		PhotoWatt, Rosi	

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
7	B - Smart Grids	3 - Adapt grids	Develop more accurate production forecasts	Mix R Ltd, Debreceni University			Steadysun	
11	B - Smart Grids	3 - Adapt grids	Secure the energy supply with regards to external attacks, cybersecurity	Székely CO.				
12	B - Smart Grids	3 - Adapt grids	Develop technologies and systems for thermal transformation, transport and storage			Powerdale, Imtech, HocoSto, I.Leco, DCInergy	CEA,	
13	B - Smart Grids	3 - Adapt grids	Make electricity, gas, hydrogen, etc. infrastructures interoperable	Erno Bezeczki (Exitium Ltd)	IREN		CEA, GRTGaz,	
15	C - Smart Buildings	2 - Consume less and better	Lower the carbon footprint of building construction processes	Kardinalis Ltd.			Vicat,	

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
20	D - Smart Processes	2 - Consume less and better	Develop the measurement of consumption at the finest possible scale	Mix R Ltd. Energotest, 3com Line			A&I, Probayes,	
21	D - Smart Processes	2 - Consume less and better	Reduce energy losses in processes	Mix R Ltd. Energotest, 3com Line	EURIX, Trigenia Srl (ESCO), TEA Sistemi Srl		A&I	
23	D - Smart Processes	3 - Adapt grids	Develop self-consumption management associated with storage systems in buildings	Energotest	Electro Power System			AGC, De Simone, ACIT
36	F - Smart Communities	2 - Consume less and better	Raise awareness among regional actors (in particular, communities) of good practices for the territorial deployment of electric mobility	SZTE, SolarT Investment Ltd.				
4	A - Decarbonized Production	1 - Production carbon-footprint reduction	Explore Power-to-X technologies		IREN	Moonshot projects		

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
27	E - Smart Mobility	2 - Consume less and better	Develop energetic optimization of vehicles (energy recovering, …)	Energotest	Cold Car Spa, Ecomotive Solution Srl (Gruppo Holdim), Testing Technologies Srl			
6	A - Decarbonized Production	1 - Production carbon-footprint reduction	Integrate large-scale renewable generation parks in specific contexts (for example harbours, airports, etc.)					Klinkenberg
22	D - Smart Processes	2 - Consume less and better	Recover the heat of processes to use it for other applications	Pirze-Nagy Ltd.		Ducoop, Condugo, Kelvin Solutions, Qpinch, Sweco		
25	E - Smart Mobility	1 - Production carbon-footprint reduction	Support the development of Bio-NGV	Pirze-Nagy Ltd.	Barricalla ACEA Pinerolese			

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
28	E - Smart Mobility	2 - Consume less and better	Develop new generations of electric motors limiting the use of rare materials	Zoltan Sidó				
31	E - Smart Mobility	2 - Consume less and better	Know better the operating and filling status of stations	SZTE, BME	Gruppo Holdim			
33	E - Smart Mobility	3 - Adapt grids	Develop new generations of energy storage means for mobility	Exitium Ltd. BME	Azimut Benetti Tecnodelta, Gruppo Holdim, Punch Torino			
32	E - Smart Mobility	3 - Adapt grids	Develop technologies limiting the impact of high power refueling stations on grid infrastructures		SNAM			
34	E - Smart Mobility	3 - Adapt grids	Explore interactions between vehicles and networks (“Vehicle-to-Grid”)					

N°	Energy System Component	Main challenge	Energy Challenge	ARCHENERG	ENVIPARK	FLUX50	TENERRDIS MINALOGIC	TWEED
35	F - Smart Communities	2 - Consume less and better	Reduce the consumption of public lighting with smart adaptive or traffic adaptive systems	GET, Vilometric				
26	E - Smart Mobility	2 - Consume less and better	Reduce losses in mobility (frictions)					

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