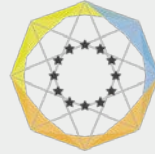


NSCG workshop – Clean Energy Week



ETIP SNET

EUROPEAN
TECHNOLOGY AND
INNOVATION
PLATFORM

SMART
NETWORKS FOR
ENERGY
TRANSITION

PLAN.
INNOVATE.
ENGAGE.

ETIP SNET WG4 Digital Energy POV

Elena Boskov Kovacs

ETIP SNET WG4 Digital Energy – Task Force 2 leader
– Disruptive Use Cases and New Markets

Managing Partner, Blueprint Energy Solutions

elena@blueprintenergy.at



etip-snet.eu



info@etip-snet.eu

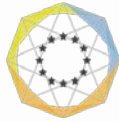


[@etipsnet](https://twitter.com/etipsnet)



linkedin.com/groups/8208338

Zagreb, 20 September 2018



ETIP SNET's organisation



WG1
Reliable, economic and efficient smart grid system



WG2
Storage technologies and sector interfaces



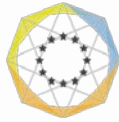
WG3
Flexible Generation



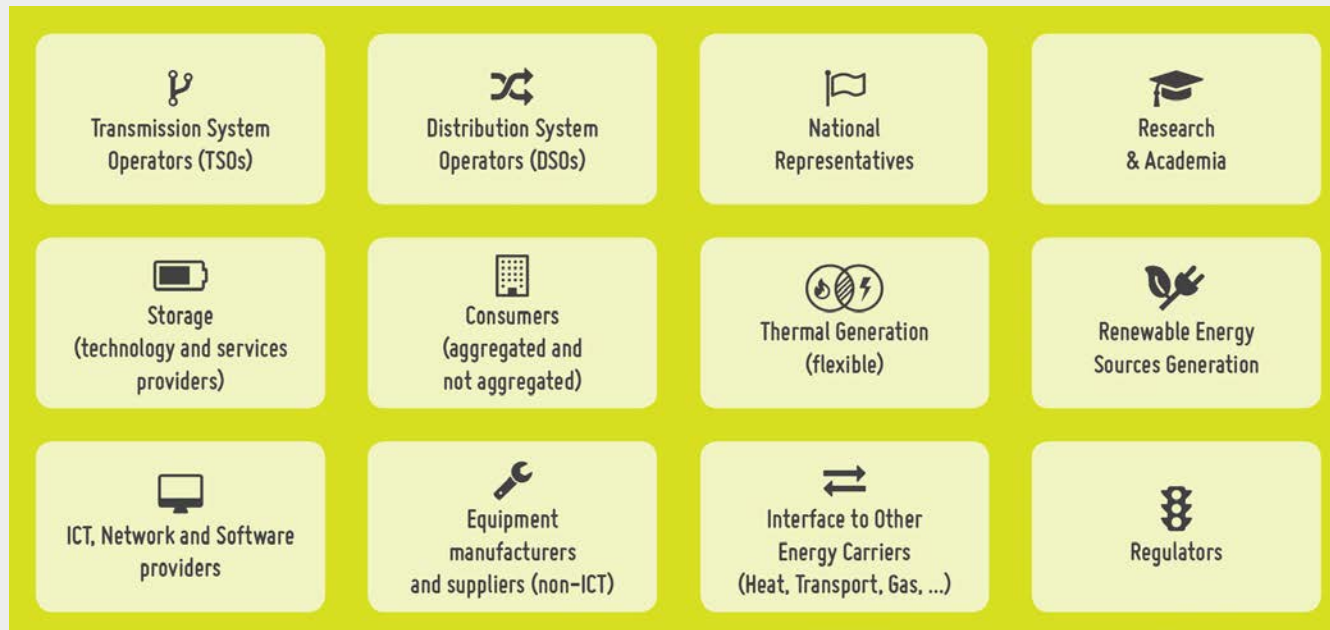
WG4
Digitisation of the electricity system and customer participation



WG5
Innovation implementation in the business environment

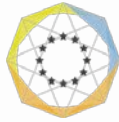


ETIP SNET Stakeholders




WG4 Digital Energy Stakeholders

- Consumers
- DSO/TSO
- Equipment suppliers
- ICT Technology providers
- Telecom operators
- Renewable Energy Sources providers
- Research and Academia
- Others



ETIP SNET WG4 : Digital Energy



WG4
Digitisation of the
electricity system
and customer
participation

Maher Chebbo (Chair)
Esther Hardi (Co-Chair)
Miguel A. Sánchez Fornié (Co-Chair)

Task Force 1

Antonello Monti
George Huitema

**Digital
Technologies
(enablers)**

Task Force 2

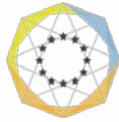
Elena Boskov-Kovacs

**Digital
Use Cases
(services)**

Task Force 3

Marcus Meisel

**Digital
Cyber Security
(Robust)**

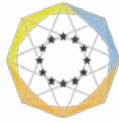


ETIP SNET WG4 : Members of the TF1

Task Force 1

**Digital
Technologies
(enablers)**

D1: Name	D2: Surname	D3: Email address	D4: Stakeholder group
Rolf	Apel	rolf.apel@siemens.com	Equipment supplier (NON ICT)
Liam	Beard	liam.beard@vodafone.com	Telecom service providers
Theo	Borst	theo.borst@dnvgl.com	ICT technology provider
Elena	Boskov-Kovacs	elena@blueprintenergy.at	ICT technology provider
Miguel	Carvalho	mcarvalho@watt-is.com	ICT technology provider
Norela	Constantinescu	norela.constantinescu@entsoe.eu	Transmission system operator
john	dalton	john.dalton@dit.ie	ICT technology provider
philippe	DESBATS	philippe.desbats@cea.fr	
Aris	Dimeas	adimeas@power.ece.ntua.gr	Research and academia
Jesus	Fraile-Ardanuy	jesus.fraile.ardanuy@upm.es	Research and academia
Guillaume	GIRAUD	Guillaume-np.giraud@rte-france.com	Transmission system operator
HENGXU	HA	hengxu.ha@gmail.com	Equipment supplier (NON ICT)
Ludwig	Karg	L.Karg@baumgroup.de	Research and academia
Georges	Kariniotakis	georges.kariniotakis@mines-paristech.fr	Research and academia
Henric	Larsson	Henric.larsson@vattenfall.com	Distribution System Operator
Yannis	Mantzaris	I.mantzaris@deddie.gr	Distribution System Operator
Antonello	Monti	amonti@eonerc.rwth-aachen.de	Research and academia
Antonio	Moreno-Munoz	amoreno@uco.es	Research and academia
Daniel	Mugnier	daniel.mugnier@tecsol.fr	ICT technology provider
SANTIAGO	OTERO PEÑA	santiagojose.otero@enel.com	Distribution System Operator
Sandra	Riaño	sandra.riano@tecnalia.com	Research and academia
Moamar	SAYED MOUCHAWEH	moamar.sayed-mouchaweh@mines-douai.fr	Research and academia
Bruno Miguel	Soares	brunomiguel.soares@rdnester.com	Research and academia
Eric	Suignard	eric.suignard@edf.fr	Research and academia
J.-Christian	Toebermann	christian.toebermann@iwes.fraunhofer.de	Research and academia
Manolis	Vavalis	m.vavalis@gmail.com	Research and academia
Arjan	Wargers	arjan.wargers@elaad.nl	Distribution System Operator
Malcolm	Yadack	malcolm.yadack@swtue.de	Distribution System Operator



ETIP SNET

PLAN.
INNOVATE.
ENGAGE.

ETIP SNET WG4 : Members of the TF2

Task Force 2

Digital
Use Cases
(services)

D1: Name	D2: Surname	D3: Email address	D4: Stakeholder group
Peter	Fröhlich	peter.froehlich@ait.ac.at	Research and academia
Aimee	Betts-Charalambous	aimee.betts-charalambous@techuk.org	ICT technology provider
Yvonne	Boerakker	yvonne@tki-urbanenergy.nl	
Elena	Boskov-Kovacs	elena@blueprintenergy.at	ICT technology provider
Miguel	Carvalho	mcarvalho@watt-is.com	ICT technology provider
Norela	Constantinescu	norela.constantinescu@entsoe.eu	Transmission system operator
philippe	DESBATS	philippe.desbats@cea.fr	
Aris	Dimeas	adimeas@power.ece.ntua.gr	Research and academia
Jesus	Fraile-Ardanuy	jesus.fraile.ardanuy@upm.es	Research and academia
Peter	Fröhlich	peter.froehlich@ait.ac.at	Research and academia
Guillaume	GIRAUD	Guillaume-np.giraud@rte-france.com	Transmission system operator
HENGXU	HA	hengxu.ha@gmail.com	Equipment supplier (NON ICT)
Esther	Hardi	ESTHER.HARDI@ALLIANDER.COM	
Risto	Kosonen	risto.kosonen@aalto.fi	Research and academia
Henric	Larsson	Henric.larsson@vattenfall.com	Distribution System Operator
Christian	Lechner	Christian.Lechner@EVN.at	Renewable energy sources
Yannis	Mantzaris	I.mantzaris@deddie.gr	Distribution System Operator
ASIER	MOLTÓ	asier.molto@ree.es	Transmission system operator
Ana Carina	Morais	anacarina.morais@edp.pt	Distribution System Operator
Daniel	Mugnier	daniel.mugnier@tecsol.fr	ICT technology provider
SANTIAGO	OTERO PEÑA	santiagojose.otero@enel.com	Distribution System Operator
Jan	Pedersen	jan.pedersen@ae.no	Distribution System Operator
JAN	PEDERSEN	jan.pedersen@ae.no	Distribution System Operator
Sandra	Riaño	sandra.riano@tecnalia.com	Research and academia
Liliana	Ribeiro	liliana.ribeiro.pt@ieee.org	Distribution System Operator
Rémy	Rousset	remy.rousset@wivaldy.com	ICT technology provider
Arshad	Saleem	arshad.saleem@innoenergy.com	Research and academia
Moamar	SAYED MOUCHAWEH	moamar.sayed-mouchaweh@mines-douai.fr	Research and academia
Marco-Robert	Schulz	marco-robert.schulz@siemens.com	Equipment supplier (NON ICT)
Pierre	Serkine	Pierre.serkine@innoenergy.com	Research and academia
Pieter	Vingerhoets	pieter.vingerhoets@energyville.be	Research and academia
Malcolm	Yadack	malcolm.yadack@swtue.de	Distribution System Operator

ETIP SNET WG4 : Members of the TF3

Task Force 3

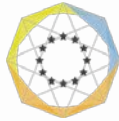


**Digital
Cyber Security
(Robust)**

D1: Name	D2: Surname	D3: Email address	D4: Stakeholder group
Rolf	Apel	rolf.apel@siemens.com	Equipment supplier (NON ICT)
philippe	DESBATS	philippe.desbats@cea.fr	
Marcus	Meisel	marcus.meisel@tuwien.ac.at	Research and academia
Jean-François	MONTAGNE	jeff.montagne@enedis.fr	Distribution System Operator
Antonello	Monti	amonti@eonec.rwth-aachen.de	Research and academia
Liliana	Ribeiro	liliana.ribeiro.pt@ieee.org	Distribution System Operator
Moamar	SAYED MOUCHAWEH	moamar.sayed-mouchaweh@mines-douai.fr	Research and academia
Bruno Miguel	Soares	brunomiguel.soares@rdnester.com	Research and academia
Manolis	Vavalis	m.vavalis@gmail.com	Research and academia
Arjan	Wargers	arjan.wargers@elaad.nl	Distribution System Operator

**DIGITALIZATION OF THE ELECTRICITY SYSTEM
AND CUSTOMER PARTICIPATION**
Technical Position Paper WG4
COMPLETED





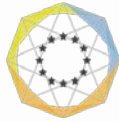
Contents

SUMMARY	8
1. DIGITALIZATION OF THE ENERGY SYSTEM – TECHNOLOGY (TF1)	11
1.1 EXECUTIVE SUMMARY	11
1.2 PREMISES	13
1.3 DIGITALIZATION OF THE ENERGY SYSTEM	13
1.4 ENABLING DIGITALIZATION – RELEVANT TECHNOLOGIES AND STANDARDS	17
1.4.1 DC GRIDS	17
1.4.2 SMART TRANSFORMERS	18
1.4.3 SECTOR COUPLING	18
1.5 TECHNOLOGIES AT THE INFRASTRUCTURE LAYER	20
1.5.1 MODERN COMMUNICATION NETWORKS	20
1.5.2 POWER GRID OPERATION	38
1.5.3 DIGITAL TWINS	40
1.6 TECHNOLOGIES AT THE BUSINESS LAYER	44
1.6.1 VISUALIZATION TOOLS	44
1.6.2 FLEXIBILITY AGGREGATION PLATFORMS	46
1.6.3 DATA ANALYTICS AS A SERVICE (SAAS)	47
1.7 STANDARDS IN SUPPORT OF DIGITALIZATION	51
1.8 ENABLING DIGITALIZATION – TRENDS	52
1.8.1 ADAPTIVE & HOLISTIC EVOLVEMENT	53
1.8.2 USER CENTERED EXPERIENCE	53
1.8.3 FUTURE ROLE OF AGGREGATION PLATFORMS	53
1.8.4 DISRUPTIVE ENABLING TECHNOLOGIES	54
1.9 ENABLING DIGITALIZATION – RECOMMENDATIONS	59
1.9.1 PHYSICAL LAYER	59
1.9.2 INFRASTRUCTURE LAYER	60
1.9.3 BUSINESS LAYER	60
2. DIGITAL ENERGY DISRUPTIVE USE CASES AND NEW MARKET, BUSINESS MODEL AND CUSTOMER PARTICIPATION (TF2)	81
2.1 EXECUTIVE SUMMARY	81
2.2 INTRODUCTION	82
2.3 IMPORTANT QUESTIONS TO ANSWER	82
2.4 EXPECTED IMPACT OF ETIP SNET AND WORKING GROUP 4 TASKFORCE 2	83
2.5 ROLES AND DEFINITION	83
2.6 STATE OF THE ART	84
2.7 USE CASES – MAIN OUTCOME	85
2.8 INFRASTRUCTURE LAYER	87
2.8.1 MONITORING, VISUALISATION, AND ANALYTICS FOR EVERY STAKEHOLDER GROUP	87
2.8.2 USE CASES BETWEEN DSO AND TSO	70
2.8.3 EBAY FOR ENERGY - ENSQUARE: A TRANSPARENT, ACCESSIBLE MARKET FOR LABELED ENERGY	75
2.8.4 LOCAL ENERGY COMMUNITY	77
2.9 PHYSICAL LAYER	79
2.9.1 DELIVER FLEXIBILITY TO THE MARKET	79
2.9.2 TRANSPARENT FLEXIBILITY MARKET WITH LV MONITORING - AGDER ENERGI	80
2.9.3 PREVENTIVE MAINTENANCE – SMART METERING USE CASE	82
2.9.4 EV / MOBILITY USE CASE	83
2.10 BUSINESS LAYER	85
2.10.1 INCREASING PHOTOVOLTAIC SELF CONSUMPTION WITH DIGITALIZATION USING BLOCKCHAIN	85
OVERVIEW	85
2.10.2 JOULIETTE - BLOCKCHAIN-BASED ENERGY TOKEN	86
2.10.3 CONSUMER EMPOWERMENT, CUSTOMER RELATIONSHIP AND BEHAVIOURAL CHANGE	88
2.10.4 DEMOCRACY BY DESIGN	91
2.10.5 DIGITAL TWIN	93
2.11 EMERGING TRENDS	95
2.12 RECOMMENDATIONS	96
2.13 FURTHER RECOMMENDATIONS	98
2.13.1 CONGESTION MANAGEMENT	98
2.13.2 BALANCING	98
2.13.3 FLEXIBILITY	99
2.13.4 COORDINATION OF FLEXIBILITY OPTIONS	99
2.13.5 REAL-TIME CONTROL AND SUPERVISION	100

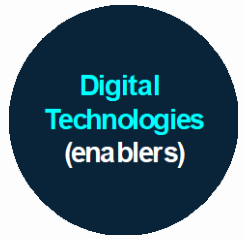
3.1 EXECUTIVE SUMMARY	101
3.2 INTRODUCTION TO CYBERSECURITY AND RESILIENCE	103
3.2.1 BACKGROUND	104
3.2.2 DIFFERENTIATION TO PARALLEL ACTIVITIES	105
3.2.3 INCREASING CYBER-ATTACKS	106
3.3 MOTIVATION FOR FURTHER CYBERSECURITY RESEARCH	108
3.3.1 EXAMPLE EXCERPT OF EUROPEAN CYBERSECURITY PROJECTS	108
3.3.2 OPERATIONAL TECHNOLOGY CYBERSECURITY VS. INFORMATION TECHNOLOGY CYBERSECURITY	112
3.3.3 CYBERATTACKS IN INDUSTRIAL CONTROL SYSTEMS	113
3.3.4 RISK ASSESSMENT	114
3.3.5 IDENTIFYING CLUSTERS, TOPICS, AND SCENARIOS	115
3.4 FUTURE CYBERSECURITY AND RESILIENCE CHALLENGES	115
3.4.1 CLUSTER: TECHNOLOGY	115
3.4.2 CLUSTER: POLICY	126
3.4.3 CLUSTER: FUTURE	135
3.5 CONCLUSION	146
3.5.1 CYBERSECURITY RESEARCH TOPICS RECOMMENDATIONS	146
3.6 OUTLOOK – ETIP SNET – IMPLEMENTATION PLANS	149
4. DIRECTORIES	161
4.1 REFERENCES	161
4.2 ABBREVIATIONS	168
4.3 APPENDIX CYBERSECURITY	160
4.3.1 RECOMMENDATIONS AND GUIDELINES	160
4.3.2 CONTACTS AND ORGANIZATIONS	161
4.3.3 RELEVANT STANDARDS	162
4.3.4 CYBER-ATTACKS REPORTS LIST	164
4.3.5 FURTHER READING	165
5. ABOUT THE AUTHOR	168

INDEX OF IMAGES, TABLES AND FIGURES

TABLE 1: RELEASES OF THE 3GPP	22
TABLE 2: CHARACTERISTICS OF COMMUNICATION TECHNOLOGIES	23
TABLE 3: STATUS OF COMMUNICATION TECHNOLOGIES	23
TABLE 4: PHYSICAL LAYER MODULATION TECHNIQUES (WITHIN 200KHZ CHANNEL)	24
TABLE 5: LATEST WIFI STANDARDS	25
TABLE 6: LATEST BLUETOOTH STANDARDS	26
TABLE 7: LATEST BROADBAND PLC STANDARDS	27
TABLE 8: LATEST NARROWBAND (NB) PLC STANDARDS	29
TABLE 9: ITU-T ACTIVE STANDARDS	30
TABLE 10: SONET/SDH DESIGNATIONS AND BANDWIDTHS	30
TABLE 11: EXAMPLE OF SDH/SONET STANDARDS STATUS	31
TABLE 12: WDM STANDARDS STATUS	31
TABLE 13: OTN STANDARDS STATUS	32
TABLE 14: OPTICAL ETHERNET STANDARDS (ACTIVE)	33
TABLE 15: OPTICAL ETHERNET STANDARDS (DEVELOPMENT)	33
TABLE 16: EFFECTIVE TERMINAL ACCESS CAPACITY AT PRESENT	35
TABLE 17: EXAMPLES SATELLITE STANDARDS	36
TABLE 18: OVERVIEW OF USE CASES PRESENTED IN THIS POSITION PAPER	65
TABLE 19: BENEFITS AND ATTENTION POINTS OF SMARTNET TSO-DSO COORDINATION (SOURCE: [24])	71
TABLE 20: SELECTED EUROPEAN RESEARCH PROJECTS AND THEIR TIMING	108
TABLE 21: COMPARISON BETWEEN IT AND OT (SOURCE: T&D EUROPE)	112
TABLE 22: CORRELATION OF IMPACT LEVELS AND MEASUREMENT CRITERIA IN AN ANALYSIS SCENARIO	113



WG4 Task Force 1 : Highlights



Digitalization of the energy system

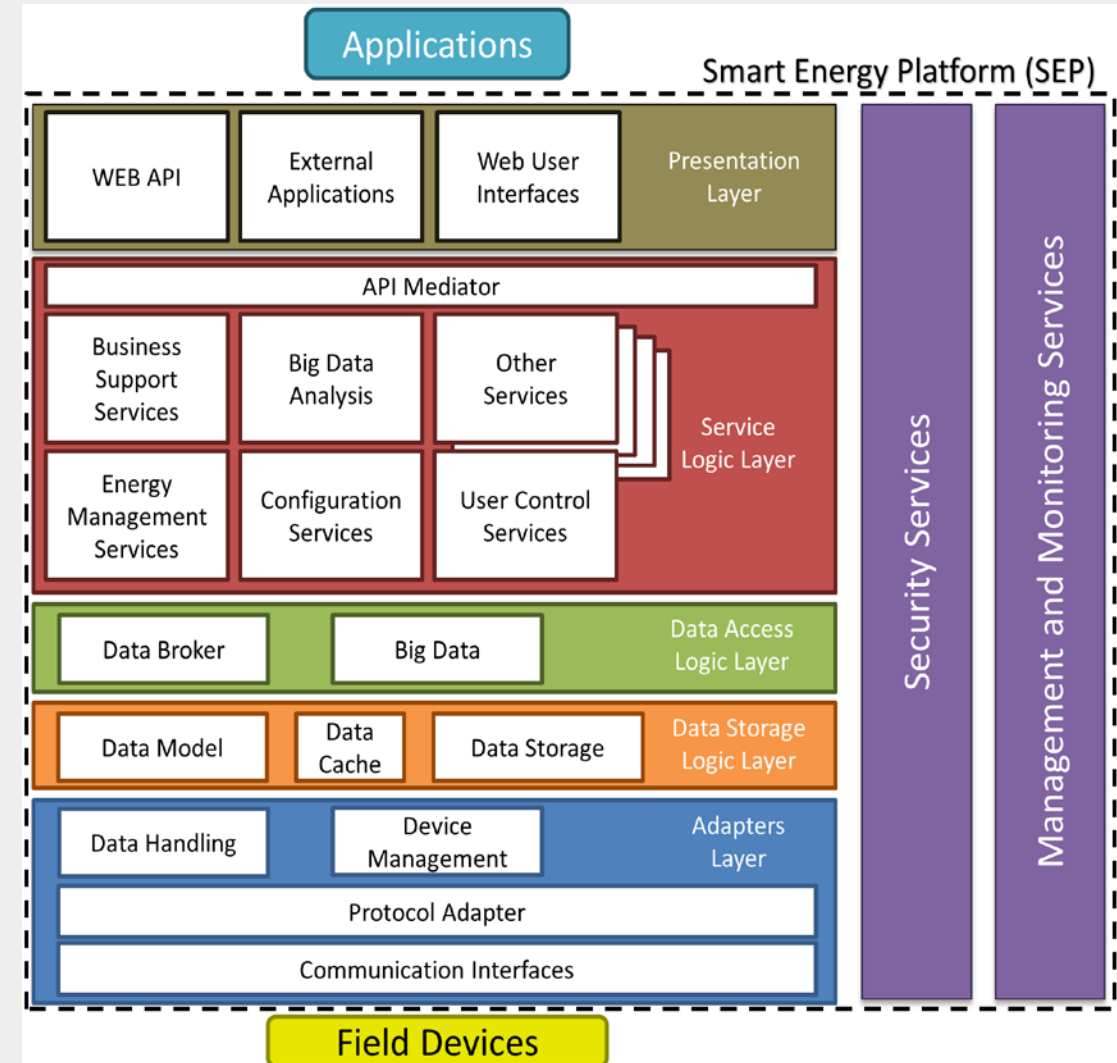
Enabling Digitalization – Relevant Technologies & Standards

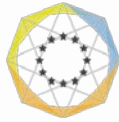
- Technologies at the Physical Layer
- Power grid operation
- Technologies at the Business Layer

Standards in support of Digitalization

Enabling Digitalization – Trends

- Adaptive & Holistic Evolvement
- User centered Experience
- Future role of aggregation platforms
- Disruptive Enabling Technologies





Physical Layer

- Need for new principles of operation
- Using AC versus DC

Infrastructure Layer

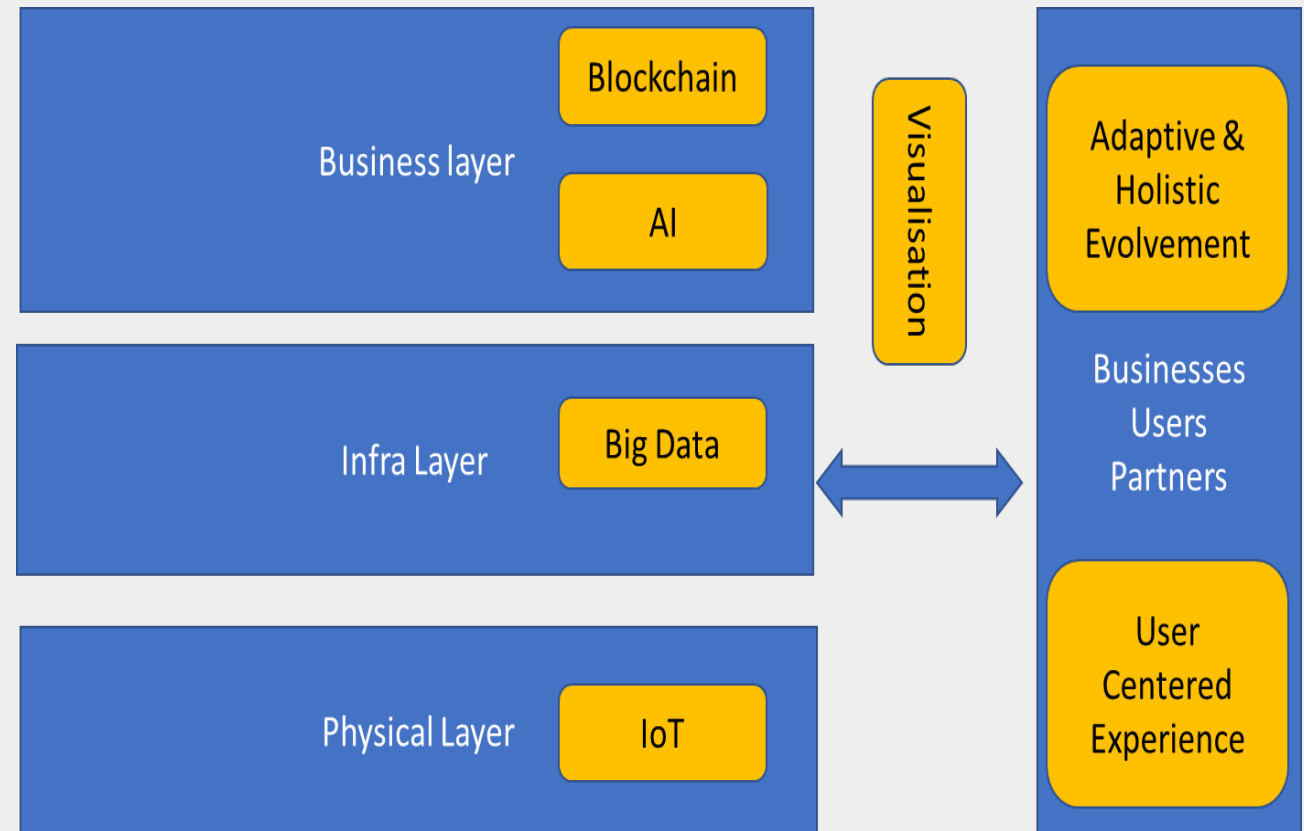
- Sharing infrastructure investments
- Need for overall covering architectures

Business Layer

- Need for trust raising technologies
- Need for adequate Service Management &Ops

General recommendations

- Need for adequate education
- Adaptation of legislation



Use Cases (UC) – Main Outcome

Infrastructure Layer

- Monitoring, visualisation, and analytics per stakeholder
- Use Cases between DSO and TSO
- Democracy by Design use case (+ social networks)

Physical layer

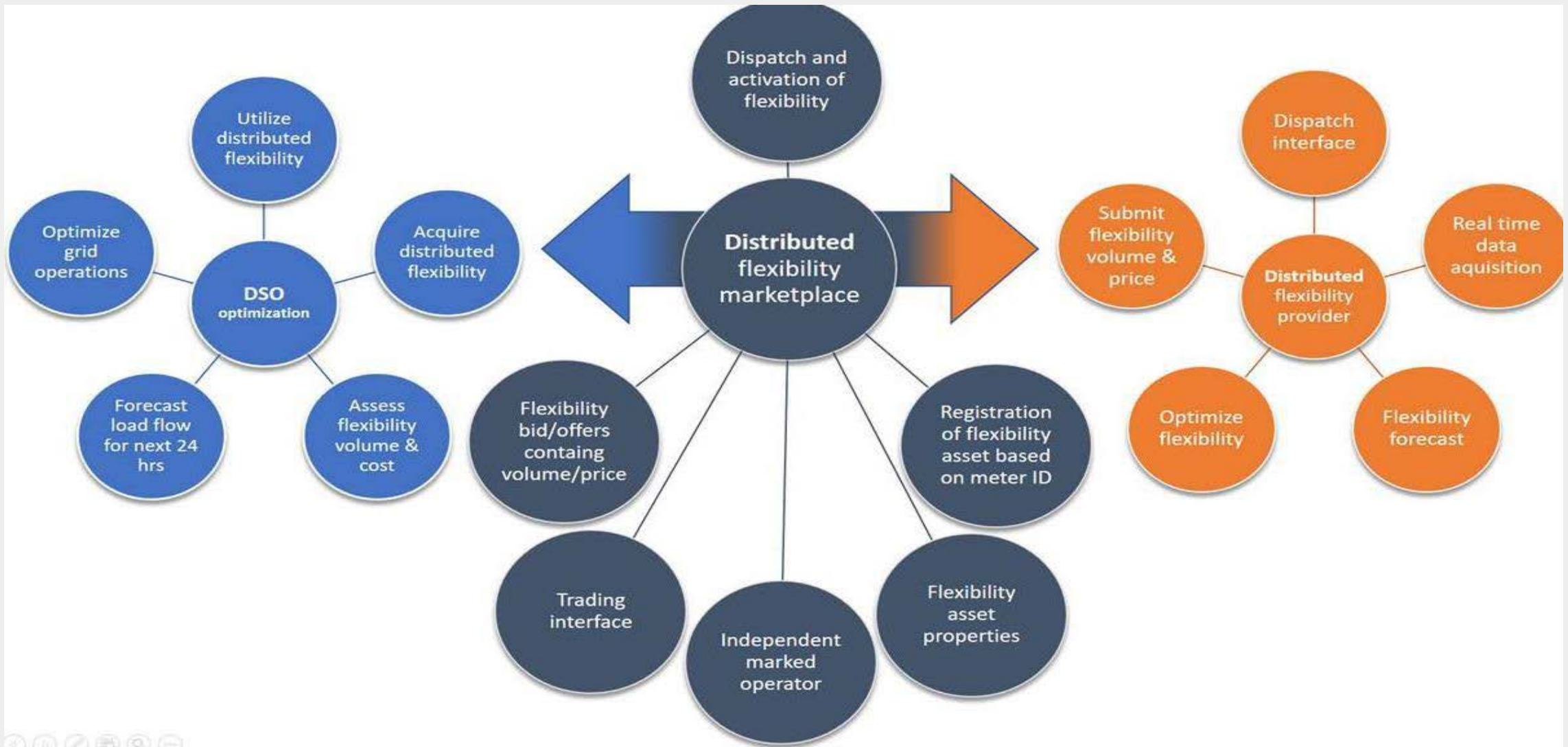
- Deliver Flexibility to the market
- Use Case from Agder Energi – Norway
- Preventive Maintenance – smart metering use case
- EV / mobility use case

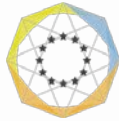
Business Layer

- Increasing self consumption – BLOCKCHAIN Use Case 1
- BLOCKCHAIN Use Case 2
- Local Energy Community
- Democracy by design
- Digital twin

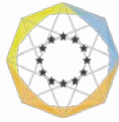


WG4 Task Force 2 : Illustration of the Distributed Flexibility Marketplace





- Enabling monitoring, visualization, and analytics for every stakeholder group
- Building data hubs
- Cross-sector coupling – needed to offer complete service to customer
- Local energy communities – offer benefits but need further work on regulation and ownership structure
- strong collaboration between industry leaders and utilities is needed
- Existing infrastructure such as smart metering should be further exploited and utilized
- Establishing Innovation/Expert centers – case in point for EV penetration
- Data transformation – case of digital twin
- Decomposing blockchain challenges through research
- Customer empowerment – needs not only technology but behavioural change
- TSO-DSO cooperation and coordination



Technology

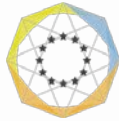
- Artificial Intelligence
- Authentication
- Vision Cybersecurity
Centralized vs. Distributed
- Huge Sensor Databases
- Cloud Computing
- Safety intersecting Security
- Blockchain
- Predictive Analytics
- System Integrity

Policy

- Metrics
- Existing Related/Background
Efforts
- GDPR
- Naming Risk Cost Benefit
- Anonymisation Aggregation
- Privacy Layer
- NIS Directive
- Sharing of Vulnerabilities
- Training and Policy Amendments

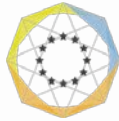
Future Challenges

- Progress Considerations
- Societal Impact
- Quantum Processing
- Quantifying Impacts
- New Crypto Environments
- Data Stream Challenges
- Bio-Nano Challenges
- Robotics Safety Impact
- Autonomous Vehicles Regulation



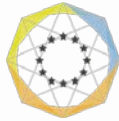
Technology

1. AI will help cybersecurity industry to efficiently monitor sophisticated threats
2. Blockchain is considered as a promising technology to address authentication
3. Blockchain offers a secure decentralized way to guarantee the veracity of various transactions
4. Digitalization enables and relies on the massive deployment of sensors that improve analysis
5. IoT enabled devices will make the energy system more transparent and efficient with Analytics
6. For highly networked components, safety is not reachable without cybersecurity
7. Machine Learning enables predictive analytics which helps detecting specific cyber attacks
8. OT/IT Cybersecurity architecture raises the question of on-premise vs cloud based calculation
9. Grid optimization application are suitable to be deployed in a cloud environment; however safety or security relevant grid control requires still a decentralized grid asset deployment



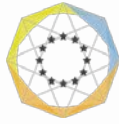
Policy

1. Metrics and frameworks should be developed for decision making of cybersecurity risks
2. Stakeholders living in isolated silos need a communication platform (IT, TSOs, DSOs, Policy).
3. Cybersecurity research at a meta level should be stimulated among the Member States
4. Transparency of data flows and standardized data models are required comply with GDPR
5. Cost benefit analyses shall be considered (e.g., black out simulators).
6. Research on regulation securing Cybersecurity investments is recommended
7. The NIS directive boosts cooperation between (US) MS for cybersecurity. Same should be for EU
8. Obscurity is not equal to security
9. Knowledge databases are used to share and access known vulnerabilities
10. Regular trainings are key to make our critical infrastructure resilient against cyber-attacks



Future challenges

1. Society and energy users need awareness about cybersecurity in the energy use
2. Involvement of energy users is necessary to achieve the desired level of risk protection
3. Quantum cryptography is a promising disruptive computing technology (US)
4. Simulation is promising to quantify cyber-attack impacts on energy systems
5. Research should include field demonstrations with cryptographic open protocol solutions
6. New communication technologies, like 5G need to guarantee SLAs for critical infrastructures
7. Bio- and nano-technologies will raise the number of cyber threats which require research
8. Programming tools need to offer new testing and simulation frameworks
9. Security protocols for life forms need to guide customers at home with DIY CRISPR Kits
10. Robotics brings new threats which requires research like Physical Unclonable Functions (PUF)
11. Investigate Autonomous vehicles, like drones and cars, bringing new threats for energy grids

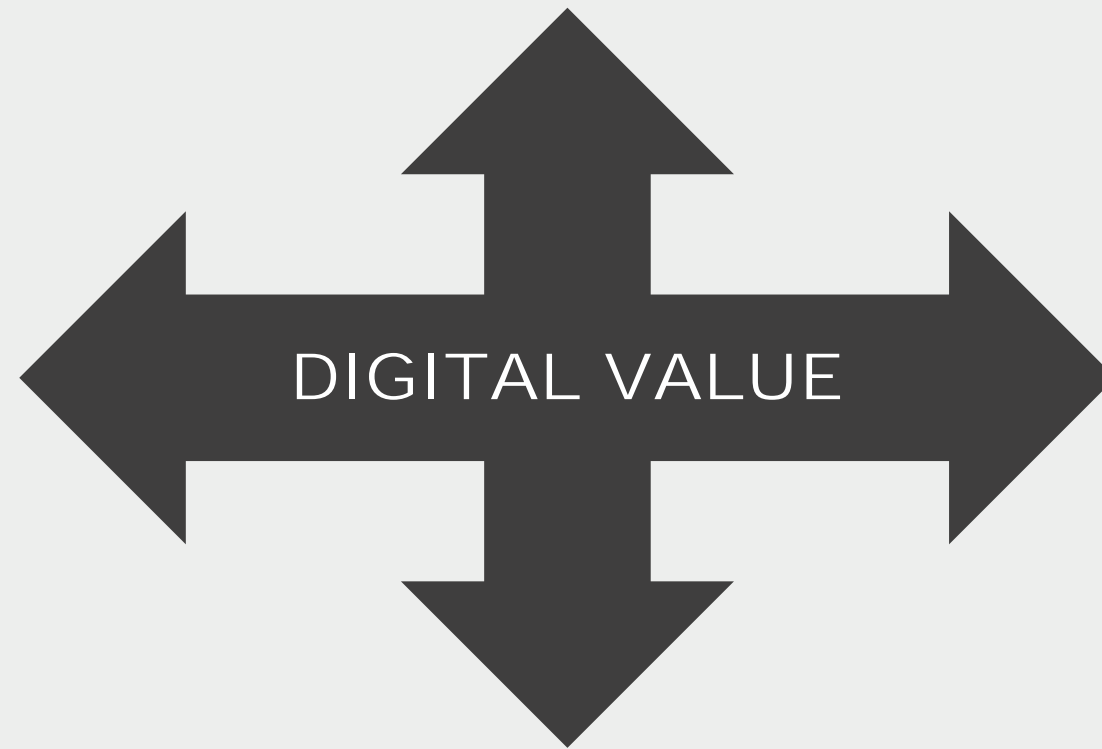


ETIP SNET PLAN.
INNOVATE.
ENGAGE.

The Winning Digital Energy Equation

POLICY & REGULATION

ENERGY
VALUE
CHAIN



SOCIO-
ECONOMICS

TECHNOLOGY

Digital Opportunity



\$387B
Eliminate
Downtime



\$191B
Match Supply
& Demand



\$59B
Integrate
Storage



\$60B
Digitalize
Maintenance



\$68B
Aggregate
Supply



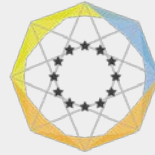
\$69B
Energy
Management

\$1.3T
Economy

\$2.0T
Society



Source: World Economic Forum 2016



ETIP SNET

EUROPEAN
TECHNOLOGY AND
INNOVATION
PLATFORM

SMART
NETWORKS FOR
ENERGY
TRANSITION

**PLAN.
INNOVATE.
ENGAGE.**

**Thanks for your
attention**

More information:



etip-snet.eu



[@etipsnet](https://twitter.com/etipsnet)



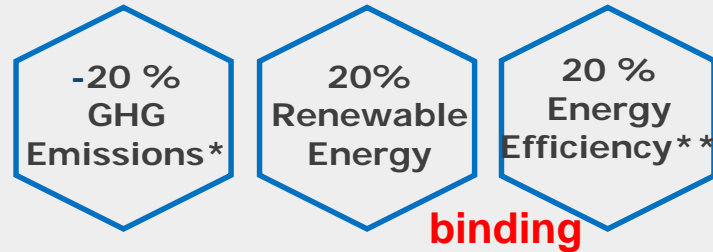
info@etip-snet.eu



[linkedin.com/groups/8208338](https://www.linkedin.com/groups/8208338)

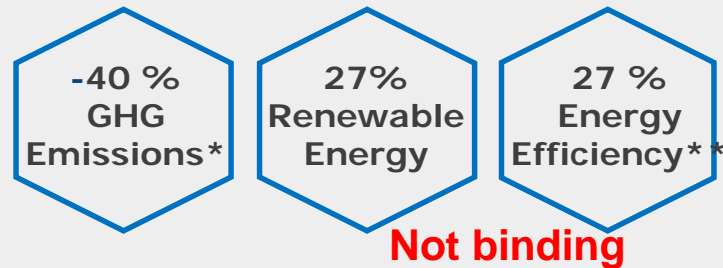
European R&I energy policies

▶ 2008: The SET Plan



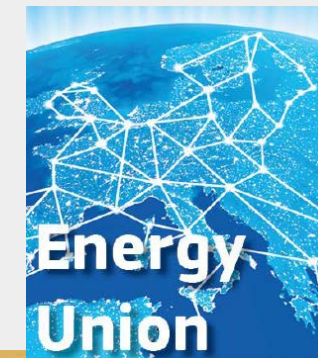
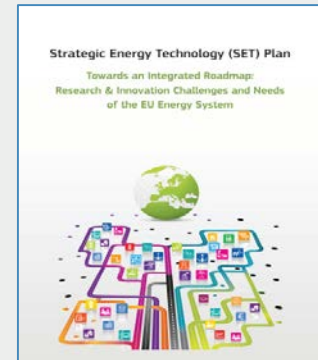
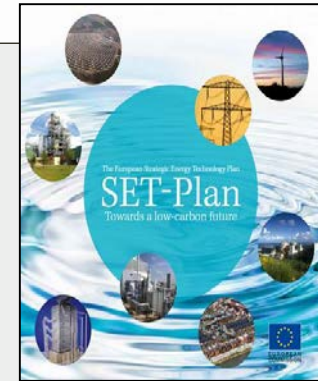
▶ 2014: Towards an Integrated Roadmap

- Individual Technologies → Energy system
- Policy challenges
 - Consumer at the centre
 - Energy efficiency (demand)
 - System optimisation
 - Technologies (supply)



▶ 2015: Energy Union – Priorities

- Energy security, solidarity and trust
- A fully integrated European energy market
- Energy Efficiency (EE) first: moderation of demand
- Transition to a low-carbon society: decarbonising the economy,
- **Research, Innovation and Competitiveness**



From a fragmented EU advisory to an integrated framework



« EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM
SMART NETWORKS FOR ENERGY TRANSITION »...

... addresses the innovation challenges in energy system and market evolution necessary for achieving climate protection and renewables integration with affordability and security of supply

... **beyond smart electricity grids**