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TWINERGY

Business analysis / Exploitation plans

D10.1

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Deliverable

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TWINERGY	**957736**	**Intelligent interconnection of prosumers in positive energy communities with twins of things for digital energy markets**

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Business analysis / Exploitation plans

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Statement of Originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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Executive Summary

The purpose of this document is to provide an innovative business plan which maximizes the exploitation potential and results from multiple Work Packages (WP 2, 3, 4, 6, 7, 11) and Deliverables (D2.2, D2.3, D2.4, D2.5, D4.2, D4.3, D11.2), within the TwinERGY project. This deliverable provides valuable insights to enhance existing business models and introduces new, high-value models that drive increased success.

The deliverable unlocks a competitive edge, starting with the sectorial analysis. This powerful tool delivers a comprehensive overview to optimally position TwinERGY's market strategy. Our analysis connects and assesses the impact of various market factors such as Socio-Economic, Technical, and Regulatory conditions across EU countries where TwinERGY pilots are active (Greece, UK, Germany, Italy). This insight is crucial as it lays the foundation for creating stronger business models, both for the TwinERGY project and beyond.

Main Exploitable Results

This leads us to the identification and evaluation of the main exploitable results. These results have the potential to revolutionize the energy market and bring new value to the table. As a trailblazer in this space, the TwinERGY project generates numerous game-changing outcomes, and this report highlights the most impactful results with the greatest business exploitation potential, such as:

- TwinERGY Platform
- TwinERGY Modules
- TwinERGY Products / Services

Strategic Advantages from Exploitable Results

From the point of identification of the exploitable results, one can clearly notice the huge potential hovering over the fields of the Digital Twin Platform, as a centrepiece and backbone for creating improved value in the current and future flexibility markets, and, the Transactive Energy Marketplace as a novel solution which enables decentralized energy trading.

The TwinERGY platform is leveraging the capabilities of Digital Twins (DTs) at three different granularities, namely the Consumer DT, the Building DT and the Community DT. The intent is that each involved stakeholder within the community ecosystem is twinned

to facilitate the detailed analysis of data and prediction of energy use and behaviour at any energy level within this community.

TwinERGY's Transactive Energy Marketplace, build for the 21st century grid, characterized by active "prosumer" (both producer and consumer of energy) participation in energy markets, bidirectional power flows (e.g., net metering of Behind-The-Meter (BTM) resources), and sophisticated financial transactions between prosumers, utilities, and third-party service providers, is something that can create this positive improvement of value and is a business model worthy of a future. TE transactions BTM and In Front of the Meter (IFOM) are already on a hockey-stick shape of growth as they are now merging with the increased adoption of smart Internet of Things (IoT) devices, such as connected thermostats and other newly networked Distributed Energy Resources (DERs) such as renewable energy sources, electric vehicles (EV), and Electric Storage Resources at the edge of the grid.

Improving the Business Models

Having in mind the exploitable results, their key advantages, and synchronised with the findings from D2.3, it is now possible to evaluate the potential for improving the models, by improving the value propositions and create additional value, engaging factors which were not evaluated before. Moreover, the exploitable results are enabling the formation of the main TwinERGY Business Model, which will serve as a backbone for the commercialization strategy of the project product/solutions on the energy market. In line with this and with the wider availability of contemporary software platforms, technology innovation, digitization and decentralization, increased adoption of DERs and IoT devices, the possibility of creating and improving Transactive Energy (TE) and dynamic Virtual Power Plants (VPP) business models in line with D2.3, has also been provided.

At the end, the report touches upon the classic elements of the business plans in terms of target market, product/service mix, marketing and especially the financial projections in order to give a positive push of TwinERGY towards real market commercialization.

The potential of TwinERGY is tremendous, enhanced by its strategic exploitable advantages, novel solutions and innovative business models. It lays the ground for a successful launch to the market, in order to be able to share all values that have been created in this project. World famous corporations (Google, Ford, GM) have already announced that they will be creating alliance in order to tackle novel solutions (VPPs and TE) in the energy market. TwinERGY project, already ripping the benefits of having the exploitable business results, first hand, has a huge first mover advantage. This is extremely highly regarded, not only as opportunity for value creation and delivery, but also from investors perspective, as a lighthouse for what the future on the energy market will bring. This deliverable report, backed up by the information from previous WPs and deliverables, is creating the foundation for the next deliverables to build upon and bring the project to a successful commercialization and new frontiers.

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Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

Abbreviations

Acronym	Full Name
BRP	Balance Responsible Parties
BMC	Business Model Canvas
BTM	Behind the Meter
CHP	Combined heat and power
CPP	Critical-Peak-Pricing
CRM	Capacity Remuneration Mechanism
DER	Distributed Energy Resources
DR	Demand Response
DSF	Demand Side Flexibility
DSO	Distribution System Operator
DSR	Demand Side Response
DT	Digital Twin
EE	Energy Efficiency
EES	Energy Efficiency Service
ESCO	Energy Service Company
EV	Electric Vehicles
GA	Grant Agreement
G2V	Grid-to-Vehicle
HLUC	High Level Use Cases
ICT	Information Communication Technologies
IFOM	In Front of the Meter
IoT	Internet of Things
IPR	Intellectual Property Rights
JV	Joint Venture
PUC	Primary Use Cases
PV	Photovoltaics
P2P	Peer-to-Peer
RES	Renewable Energy Sources
RTP	Real-Time-Pricing
SAGM	Smart Grid Architecture Model
SUC	Secondary Use Cases
TE	Transactive Energy
TEP	Transactive Energy Platform
TOU	Time-of-use
TSO	Transmission System Operator
VPP	Virtual Power Plant
V2G	Vehicle-to-Grid

1/ Introduction and structure

1.1 Deliverable scope and methodology

This Deliverable is part of WP10 - Exploitation and Business Plans listed under Task 10.1 – Business Plan development, which peaks with Deliverable 10.1 (D10.1), Business analysis / Exploitation potential. As indicated in the TwinERGY Project Document (2020), this task mainly focuses on the role of the industrial partners when exploiting the results of the TwinERGY project. Hence, industrial partners are exploiting the results and implementing what has been learnt in this project into their products and services when launching them to the market. For this reason, this task integrates, on one hand, the results of several previous WPs and, on the other, it includes the analysis of market opportunities in relevant sectors considering the reality of each organization. The elaboration of a business analysis in the fields of customer focuses on demand response mechanisms and LEMs. During this task work was carried out in order to identify industrial partners' needs and challenges. For this reason, visits to cities where industrial partners are based took place to establish a close collaboration with industrial partners. A joint work with industrial partners resulted in the creation of an innovative and attractive business plan.

This report gravitates around several topics, in relation with other WPs and Deliverables, which are

- Understanding and performing an evaluation of the power markets, in order to provide proper market analysis
- Evaluating exploitable results and using them to create improved value
- Evaluating improved business models and creating an innovative business plan for TwinERGY

1.2 Relation to other WPs and Tasks

This document is the final outcome of the Task 10.1 – Business Plan Development as part of WP10 – Exploitation and Business Plans. The objective of the WP10 is to elaborate sectorial business analysis, in order to provide industrial partners who are participating in the pilots an overview of business opportunities, based on the market assessment methods. This work package is oriented to industrial partners that will have to exploit the results providing a sectorial business analysis and a description of future business opportunities. Moreover, this deliverable will provide a business plan by combining the results of several previous WPs and incorporating analysis of market opportunities in those most relevant sectors for the project considering how each organization is positioned (TwinERGY Project, 2020).

The reader might notice that much of the work elaborated in this report has already been researched or at least noted in other WPs, Tasks and Deliverables throughout the project. Therefore, we must acknowledge the relationship between this deliverable and the other connected part of the project. In that respect, it is closely connected to tasks, T2.2 - Stakeholders Requirements, T2.3 - Business models analysis, and their respected deliverables D2.2 and D2.3. Additional relationship exists with the rest of WP2 - Stakeholder Requirements, Obstacles to innovation and Business Models, as well as, WP4 - Methodological framework and Architecture Design, WP6 - Development of Digital Twin Platform & System dynamics, WP7 - Development of TwinERGY system Modules and their respective Tasks and Deliverables, of course (TwinERGY Project, 2020).

2/ Power markets and Regulatory framework

In order to deep dive into the subject matter of this deliverable, one needs to understand the forces that tailor the conditions of markets. This is possible by reviewing academic literature, performing interviews, taking part in workshops with stakeholders and consortium partners as well as from revisiting the findings from the previous work packages of the TwinERGY project.

2.1 Key Performance Indicators, Use Cases and Pilot sites

With the elaboration of the KPI's from the TwinERGY project proposal and the connection to the use cases specified in the project, D2.2 is able to provide a direct correlation and relative ranking that will guide the project and act as a roadmap to assist stakeholders to be involved, satisfied, and informed in the pursuit of the applicable KPIs (Pinto et al, 2021). Figure 1 summarises the main KPI's from D2.2 and provides a short description of them.

Key Performance Indicators	Description
RES share in energy consumption	Measures the RES share: the total energy delivered to end-users as well as DSO's and TSO's losses for electricity and heat. It should be noted that exports/imports of electricity are not considered renewable energy (Eurostat, 2020).
Reduction of peak loads	Measures the reduction of the largest daily power consumption value.
Self-consumption ratio	Measures the amount of energy produced and consumed locally relative to the total production that is locally available from on-site generation units (most of the time the self-generated energy comes from PV). It is calculated as the ratio of self-consumption divided by the self-generated energy.
Penetration of dynamic energy tariffs	Measures the increase of residential consumers exposed to dynamic electricity tariff schemes (any such tariff, e.g., ToU, RTP, etc.) in TwinERGY pilot sites, hence quantifying the improvement

	in the penetration of DR mechanisms among these end-use consumers.
Active participation rate through user engagement and acceptance	Measures the sum of the number of users actively participating in the pilots in relation to the total that accepted participation.
Customer responsiveness	Measures how many customers have responded to a DR program following a DR signal sent to them, like a price change, as the total number of signals sent back by the customers as an absolute number or a percentage.
Total energy reduction against discomfort level constraint	Measures the reduction of energy consumption without exceeding a specific discomfort level/threshold. i.e., Given a Discomfort level X.
Customer satisfaction	Measures the user's satisfaction of overall participation in the pilot and the services that have been tested.
Demand flexibility	Measures the increase of the amount of load capacity participating in demand-side management at each pilot.

Figure 1 - Main KPI's (Source: TwinERGY D2.2)

Concerning the Use Cases, the project identifies 9 different ones. A short description of, as specified in the TwinERGY GA document, are shown in Figure 2.

Use Cases
UC01 - Home Energy Management
UC02 - RES Generation in domestic and tertiary buildings
UC03 - Grid capacity enhancement utilizing e mobility
UC04 - Prosumers empowerment in local energy trading markets
UC05 - Enhance grid's flexibility through DER Management
UC06 - Consumers engagement in Demand Side Management Programs utilizing feedback mechanisms
UC07 - Consumer's engagement in demand response programs utilizing a socio-economic context
UC08 - Consumer's engagement in demand response programs utilizing personalized comfort/health-oriented services
UC09 - Consumer's engagement in demand response programs utilizing digital twins' prediction capabilities for dynamic VPPs

Figure 2 - Use Cases of the TwinERGY Project

The four places chosen as demonstration sites of the project (City of Athens - Greece, Benetutti smart Community -Italy, Hagedorn village - Germany, Bristol City - United Kingdom) have different levels of readiness, but all of them are working towards becoming smart cities and deploy their Smart City plans. Targeting at different types of loads (including heating and mobility sector), while enforcing the increase of RES penetration rate, the proposed system will be based on carefully designed business models, in order to provide the costumers with novel sources of income or opportunities for financial exploitation (TwinERGY GA, 2020).

Furthermore, Figure 3 provides a summary of the KPI's, Use Cases and pilot sites.

KPIs	Use Cases	Pilot Demonstration
1. RES share in energy consumption	**UC02, UC05**	**Athens, Hagedorn, Benetutti**
1.1 Increase RES share	UC05	Hagedorn, Benetutti
1.2 Increase RES share in energy consumption of domestic and tertiary buildings	UC02	Athens, Benetutti
2. Reduction of peak loads	**UC03, UC04, UC05**	**Athens, Benetutti, Hagedorn**
2.1 Reduced congestion	UC03	Athens
2.2 Balance the grid	UC04	Athens, Benetutti
2.3 Improve grid quality and reliability	UC04	Benetutti, Hagedorn
2.4 Optimize VPP through services offered to DSOs	UC05	Athens
3. Self-consumption ratio	**UC01, UC04**	**Hagedorn**
3.1 Improve self-consumption from PV	UC01,	Hagedorn
3.2 Establishment of microgrids	UC04	Hagedorn
4. Penetration of dynamic energy tariffs	**UC04**	**Bristol, Hagedorn**
4.1 Prosumer engagement in local energy trading markets	UC04	Hagedorn
4.2 Increase investments of prosumers in energy system, data generation and contribution to community schemes		Bristol
5. Active participation rate through user engagement and acceptance	**UC06, UC07, UC08, UC09**	**Athens, Benetutti Bristol, Hagedorn**
5.1 Increase awareness of residential customers in demand-side management programs	UC06	Hagedorn

5.2 Increase engagement of residential customers in demand side management programs	UC06, UC07, UC08	Athens, Benetutti, Bristol.
5.3 Employment of community-based social marketing	UC07	Benetutti
5.4 Engage members of Digital Twin communities to use interactive dashboards	UC09	Bristol
6. Customer Responsiveness	**UC01, UC08, UC09**	**Athens, Benetutti, Hagedorn**
6.1 Increase consumer participation in demand response programs	UC01	Hagedorn, Benetutti
6.2 Provide consumers with personalized feedback notifications	UC08	Benetutti, Athens
6.3 Automation of explicit demand response processes	UC09	Athens
7. Total energy reduction against discomfort level constraint	**UC03, UC06**	**Athens**
7.1 Reduce CO2 emissions	UC03	Athens
7.2 Decrease residential energy use	UC06	Athens
7.3 Preserve comfort of consumers		Athens
7.4 Comply to Energy Efficiency obligations by EC		Athens
8. Customer satisfaction	**UC01, UC03, UC08**	**Athens, Benetutti, Bristol, Hagedorn**
8.1 Minimize energy costs for the end user	UC01, UC03	Bristol, Benetutti
8.2 Obtain consumers' realistic comfort/well-being level	UC08	Athens
8.3 Increase satisfaction and social benefits		Hagedorn
9. Demand Flexibility	**UC04, UC05, UC06, UC09**	**Athens, Benetutti, Hagedorn**
9.1 Launch decentralized energy transaction platform	UC04	Benetutti
9.2 Improve demand flexibility and stability	UC05	Hagedorn, Benetutti
9.3 Increase residential demand flexibility	UC06	Athens
9.4 Optimize demand flexibility considering weather and energy system constraints	UC09	Athens
9.5 Deliver clusters of flexibility profiles of consumers		Athens

Figure 3 - KPIs of Use Cases and Pilot sites (Source: TwinERGY D2.2)

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2.2 Power Market - UK Pilot

As argued by Forouli et al (2021), the UK energy market is a fully liberalized and privatized electricity system that can be considered highly reliable. Energy from renewable resources accounted 12% of gross final energy consumption in 2019. Currently the electricity system of UK is interconnected with Ireland, France, Belgium and the Netherlands. The British TSO is National Grid (NG). There are, at the moment, fourteen licensed Distribution Network Operators (DNOs), having under their responsibilities distinct local zones. The main companies owning the distribution network are UK Power Networks, Western Power Distribution (WPD), Scottish Power Energy Networks (SPEN), Scottish and Southern Energy (SSNE), Northern Powergrid (NP) and Electricity North-West. Additionally, there are plenty of independent network operators (IDNOs) owning and operating a number of smaller networks. The day-ahead (DA) and intra-day (ID) markets are operated by two spot platforms EPEX SPOT and Nord Pool, while a separate entity, Elexon, is in charge of balancing and settlements services. The UK has many regulative authorities. An influent non-ministerial government department also with the role of an independent National Regulatory Authority is Ofgem (Office of Gas and Electricity Markets). As UK is leading the charge in integration of energy flexibility, where demand side flexibility (DSF) is already well established, either directly or, via aggregation in the electricity markets, as a revenue generating stream, which also allows network charges avoidance. The participation in the market is possible for commercial and industrial customers, SMEs, and aggregators, utilizing several aspect of technology, such as, battery storage, EVs, generators etc (Ahunbay et al., 2021; Chondrogiannis at al., 2022).

Figure 4, provided by Forouli et al. (2021), summarises the UK's electricity market services and demand side flexibility (DSF) participation.

Service	Product	Open to DSF	Remuneration Type	Value Stacking Available	Market Participation
Adequacy	Capacity Market	Yes	Capacity based	Yes	T-4 2016 auction: 1367 MW of unproven DSF and 44 MW of proven DSF for £22.50 per kW T-4 2017 auction: 110 MW of unproven DSF and 46 MW of proven DSF with a record low contract price £8.40 per kW/year for delivery in 2020/21 T-1 2017 auction: contracts of 521 MW of unproven DSF and 93 MW of proven DSF, record low clearing price of £6.00 per kW
Wholesale	DA	Yes, through suppliers	Energy based	N/A	N/A
Balancing	ID	Yes, through suppliers	Energy based	N/A	N/A
Constraint management	Firm frequency response (or Frequency Containment Reserve—FCR)	Yes	Capacity based and Energy based	Yes across different windows. Yes across same availability windows, but subject to the product and further agreements	2341 MW (in 2018) and 773 MW (in 2017) across all tenders
	Fast Reserve (or FRR)	Yes	Energy and Capacity based	Yes (excluding Response products)	Limited participation (3 DSF providers) due to the 50 MW threshold to participate)—date from 2018
	STOR (Replacement Reserve)	Yes	Energy and Capacity based	Yes (excluding Response products)	10,192 MW (accepted tenders)—data for 2018. This number reflects all the tenders for STOR during 2018, across 3 tenders. The average DSF accepted capacity pre tender is around 3GW.
	Balancing Mechanism (Replacement Reserve)	Yes (recently open for DSF and aggregators acting as Virtual Lead Parties—VLPs)	Energy-based, according to the contracted volumes during Bids and Offers processes	Yes	Not on operation yet for DSF
	Demand Turn Up (DTU—replacement reserve, currently discontinued by NG)	Yes	Energy and Capacity based	Yes (excluding Response products)	114 MW
Constraint management	TSO level	Not open	N/A	N/A	N/A

Figure 4 - UK's electricity market services and demand side flexibility (Forouli et al.,2021)

2.2.1 Market Regulation - UK

As Chondrogiannis at al., (2022) highlights, there are several challenges that aggregators face in the UK capacity market. One such challenge is the inability to secure long-term contracts, which hampers their ability to secure the necessary financial resources to run their operations effectively. This can put them at a disadvantage compared to generators who have a more opportunistic approach and lower costs. Another challenge is that the market rewards capacity over reliability, which can affect the stability of the overall system.

The supplier's energy imbalance charges are another obstacle for aggregators, as they can be exposed to delivery or imbalance risks created by the actions of independent aggregators. However, the relevant modifications to the Balancing and Settlement Code, made by Ofgem in response to these concerns, have helped mitigate this issue. Despite market uncertainties that limit the participation of demand-side flexibility sources, policies are actively pushing for wider access to these sources, and funding for innovation projects is playing a critical role in driving new technologies and market mechanisms (Forouli et al., 2021).

2.2.2 Technical Market Conditions - UK

The UK demand aggregation market can be quite challenging, as Forouli et al. (2021) notes. With the abundance of balancing services available, the market can be complex, making it difficult for participants to fully understand the details and benefits of each service. The yearly or seasonally tendering period is also a major barrier, as a daily resolution would be a more advantageous trade-off for enabling DR involvement. The lack of automatic consumption reading is another technical issue that hinders the development of new energy markets, as full implementation of the UK's plans for this won't occur until 2024. Additionally, some ancillary services have prequalification requirements that can be tough for aggregators to meet, such as a high minimum capacity or a long run duration. Despite these barriers, the policy is actively pushing for wider access to these sources. Fundamentally, these challenges provide an opportunity for innovation and progress (Chondrogiannis at al., 2022).

2.2.3 Economic Market Conditions - UK

Although UK is leader in adoption and offering of many flexibility products and services, the liquidity that is floating in the market at this very moment, is still not sufficient to serve as an incentive mechanism which will encourage investment in new technology, thus creating new value propositions, products and services is limited. The Ofgem already is addressing this situation and providing inputs which will improve it, by including clear price signals towards the providers. What is also worth mentioning here, is that high competition already exists on the market, among players from different service areas, but also among payers from the same service area, as well, which makes new market entrants sceptical, especially in the area of aggregators services (Chondrogiannis at al., 2022; Forouli et al.,2021).

2.2.4 Recommendations - UK

As Forouli et al. (2021) indicates, to support the transition to a smarter and more flexible energy system, actions in UK should focus on removing policy and regulatory barriers to smart energy solutions, as electricity storage, and enabling them to enter the market and compete fairly alongside other new or established energy technologies. The use of smart solutions, including DR, in homes and businesses should be further incentivized and enabled by the roll-out of smart meters, the move towards market-wide half-hourly settlement, and the provision of a framework for smart tariffs.

2.3 Power Market – Italian Pilot

According to Forouli et al. (2021), in Italy 18% of energy consumption (electrical, thermal and transportation) was covered by renewables in 2019. With its prime location, Italy is interconnected with several European countries, including France, Switzerland, Austria, Slovenia, Greece, and Malta. The country's electricity market is expertly managed by GME (Gestore del Mercato Elettrico), TSO Terna, and the Electricity MO. The market is split into two main categories: the short-term market and the forward electricity market. The short-term electricity market is a hub of activity with the day-ahead market (MGP), the intraday market (MI), and the daily products market (MPEG) all expertly managed by GME. The ancillary services market (MSD) is operated by TSO Terna. Meanwhile, the forward electricity market is constantly thriving on a trading platform run by GME. With 126 DSOs overseeing the electricity distribution network, Italy's energy landscape is well taken care of. ARERA (Regulation Authority for Energy, Network and Environment) serves as the regulatory authority in Italy, ensuring the country's energy market operates with the utmost efficiency.

On the basis of flexibility, as a market force, what is important for Italy's development, is to be able to fully open the market for DER's as qualified services, since the progress of the market is mainly concerned with the aggregation of generation, consumption points and storage systems. Still, participation of demand in energy markets is not supported, unlike traditional dispatching points, that also participate in energy markets (e.g., large conventional power stations) (Ahunbay et al. 2021; Forouli et al.,2021). As further argued, Italy has started progressive inclusion of distributed resources into the ancillary services market, which will allow organic reform of the market, led by the Italian TSO (Terna), together with ARERA, through several pilot projects. The opening projects characteristics of the market can be better illustrated on Figure 5.

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Pilot Project	Characteristics	Minimum Power Threshold	Services	Mode	Remuneration
UVAC	Consumption points	1–10 MW	mFRR (upward) Balancing service (upward)	Reduction of consumption of at least 1 MW within 15 min from Terna's request	= to ancillary services remuneration/ Penalties + long-term contracts *
UVAP	Non-relevant generation points	1–5 MW	Congestion management mFRR (spinning and replacement) Balancing service	Increase or decrease generation of at least 1 MW within 15 min from Terna's request	= to ancillary services remuneration/ Penalties
UVAM	Consumption points Non-relevant generation points Relevant generation points Storage installations	1 MW	Congestion management mFRR (spinning and replacement) Balancing service	Increase or decrease generation of at least 1 MW within 15 min from Terna's request	= to ancillary services remuneration/ Penalties + long-term contracts *

Figure 4 - Italian Market Opening Projects. (Forouli et al.,2021)

Since the starting results from the opening of the Italian market has yield satisfactory results in terms of liquidity and aggregated capacity, the officials are continuing with the proposed next steps, which include: residential loads, encourage competition, participation of distributed resources in all services, and general system overhaul (Forouli et al.,2021).

2.3.1 Market Regulation - Italy

As Forouli et al. (2021) describes in the paper, the regulatory obstacles in Italy can be summarized in one short sentence, implicating that disagreements in the cooperation scheme between the TSO and DSOs are the main deterrent factor for the slow evolution of Local Flexibility Markets.

2.3.2 Technical Market Conditions - Italy

The minimum size selected for the UVAM project is 1MW. This decision permits small loads to be included as participants in the market and will involve residential consumers in the long run. Nevertheless, it represents a drawback when it comes to technology, as this level of capacity is more difficult to control and manage (Forouli et al.,2021).

2.3.3 Economic Market Conditions - Italy

Remuneration for availability is necessary to recover the high up-front investment the demand side must face, in order to become an active participant in the ancillary service market, especially due to the cost of the installation for monitoring and control of flexible loads. Moreover, these stakeholders have to stop or vary the productive cycle, facing economic losses of an activity that is not part of their core-business. Thus, to encourage demand-side flexibility, the capacity is highly remunerated. On the other hand, the energy price cap that UVAM can bid in the ancillary markets are high and not restricting at all. Therefore, the consumption units risk becoming passive elements of the system, offering availability (thus profiting on the capacity), while bidding with a high energy price, in order to avoid being selected as flexibility providers. The imbalance between the offers for availability and the offers for energy is observable also in the cashflow figures. During 2018, the ancillary service market spent 4.8 million euros to pay UVAs for capacity availability and only 0.29 million euros for the energy activation (Ahunbay et al., 2021; Forouli et al.,2021).

2.3.4 Recommendations - Italy

As Forouli et al. (2021) research suggests, Italy should enact a regulation to further open the market to reorganize the flexibility element and the imbalances rules, involving all available resources for participation. Additionally, the development of a large storage capacities, has been recommended, in order to provide support for the flexibility market and flexibility activities. Moreover, it is important to enhance and upgrade the electrical transmission and distribution network, partly with a view towards smart grids, and install apparatus designed to optimally manage energy flows. In parallel to distributed generation, the encouragement of more pro-active and flexible electricity DR resources is important. For example, as regards electric vehicle recharging, it is vital to establish suitable market and technological measures and instruments so as to foster the convergence of supply and demand peaks for non-dispatchable renewable sources (Forouli et al.,2021).

2.4 Power Market - Greek Pilot

During the last decade, the Greek energy sector has experienced reforms which include among others the liberalization of electricity wholesale and retail markets. In addition, the electricity fuel mix has been substantially diversified, with an increase in the share of variable renewable sources in the total final energy consumption, to almost 20% in 2019. Another major recent development concerns the electricity market operation and relates to the transition to the new European Union target model market, with forward, DA, ID markets (operated by the Hellenic Energy Exchange) and the balancing market operated by the Independent Power Transmission Operator (IPTO-ADMIE). There is one DSO, the Hellenic Electricity Distribution Network Operator (HEDNO) and the energy market is supervised by the Regulatory Authority for Energy (RAE) (Forouli et al., 2021).

From the flexibility side of the market, as indicated by Forouli et al. (2021), there is an institutional framework in place which promotes DR. The Hellenic Distribution Network Code [104] foresees the activation of distributed DR by the DSO by establishing "Demand Control Contracts" with individual electricity consumers located in congested network areas. These contracts shall allow the Greek DSO to set limits or even to interrupt, at its own initiative, the supply to the facilities of the contracted consumers, subsequent to their notification, in the periods specified in the contracts (Forouli et al., 2021).

Moreover, Greece, as part of its market policy, is trying to encourage demand side participation with several compensation schemes, which they have put in place.

Consumers connected to the electricity transmission and medium voltage network of the interconnected system can offer to the TSO the interruptible load service by participating in auctions. The TSO has then the right to temporarily decrease, up to a pre agreed value, the active power of interruptible counterparties, who are financially compensated for their services. Moreover, customers connected to the medium and low voltage network of the interconnected system and in the non-interconnected islands (NIIES) can also opt for demand control contracts, provided the existence of the necessary telemetering equipment in their premises. Additionally, residential customers can sign contracts offering lower tariffs for night consumption and interruptible load contracts for "agricultural customers". The latter motives are included in the commercial packages/tariff schemes of the supplies to the customers (implicit DR) and they do not concern participation in the wholesale electricity market (explicit DR) (Forouli et al., 2021)

In parallel, the option of establishing aggregators and energy communities is institutionally foreseen, giving electricity consumers the possibility to operate in the electricity market, either as consumers or as producers. To restrict the costs for consumers involved in these bodies, but also for the System, dynamic electricity tariffs are also instituted. However, the participation of all electricity consumers in the electricity market will not be possible until the completion of the smart meters installation project, which is expected in the following decade. To date, smart meters have been placed at medium-voltage customer sites and in few low-voltage customer locations, at a pilot phase. HEDNO has also installed two telemetering centres for the remote collection of meter readings from all medium voltage customers and RES producers, as well as from all major low voltage customers (>55 kVA) including photovoltaics (Forouli et al., 2021).

2.4.1 Market Regulation – Greece

In Greece, both the IPTO's Balancing Market Rulebook and the regulatory framework introduce some obstacles regarding the consumer size in balancing services provision, and the energy storage licensing and operation, respectively. In particular, the recent update of the IPTO Balancing Market Rulebook includes dispatchable load portfolios as assets to offer Balancing Services and highlights that those can be represented either by a DR aggregator or, if the portfolios include only one load, they can be represented by a consumer. However, demand management and response schemes are not yet implemented for all consumers and in principle concern only large industrial consumers. This excludes consumers' participation whether individually or through aggregators (Forouli et al., 2021).

The regulatory framework for the development and operation of electromobility and energy storage is incomplete, and the procedures for their integration in electricity market are too complicated. In order to tackle energy storage licensing and operation issues, a special committee assembled by the energy ministry (FEK B' 5619/21 December 2020) to deliver a plan, by May 2021, on revising an existing framework to facilitate, and make financially beneficial, battery system installations at homes, businesses and industrial facilities. The existing framework is particularly restrictive and, as a result, subduing related investments, limits energy storage system installations to 30 KW and permits usage to roof-mounted photovoltaic (PV) panels for self-production (Forouli et al., 2021).

2.4.2 Technical Market Conditions - Greece

The majority of the technical limitations within the Greek case may be attributed to the shortage of the suitable infrastructure, both technical and/or virtual, from the concerned parties. The absence of technical infrastructure, like smart metering device, which remains within the initial rollout section, is one of the reasons DR schemes are spreading at a sluggish pace. Moreover, there's whole loss of the suitable infrastructure from the TSO's aspect to send dispatch Instructions in real-time to dispatchable portfolios of RES aggregators and DR aggregators and/or storage operators, on the way to balance the system in real-time. Delays withinside the virtual transformation of the Greek DSO, HEDNO, prevent it from being capable of reply efficaciously to the demanding situations of accelerated RES penetration, control decentralised structures for energy production and storage, and power transactions. Finally, to assess the extent of market concentration, and to detect anti-competitive practices, mechanisms and indicators to monitor the market, and the analysis of bidding behaviour through cooperation between competent bodies, where relevant, are needed, that are currently absent (Forouli et al., 2021).

2.4.3 Economic Market Conditions - Greece

According to Forouli et al. (2021), new financial instruments being compatible with the new market environment will contribute to the implementation of the required investments. Such instruments may concern incentives for the penetration of electromobility, the use of electricity storage systems, tax incentives and dynamic electricity tariffs to support local energy communities and consumers, the efficient implementation of research or pilot projects by all market players, with the ultimate goal of creating benefits for final consumers etc.

2.4.4 Recommendations - Greece

Greece requires a more cost-effective and sustainable functioning of the system, which can be achieved through complementary functions of various energy operators and sources supported by an appropriate regulatory framework. Policy priorities for the next decade should include regulatory change and sectoral energy coupling measures, penetration of renewable energy into new sectors and applications, and development of relevant pilot and pioneering applications. Proposing incentives for the implementation of such projects requires changes to the regulatory framework. At a technical level, a proposition to facilitate participation in the electricity market using simplified procedures for integration into existing or new-build RES power plants, without impacting the fees applicable to such power plants, will be considered a desired outcome. It is important to develop relevant institutional frameworks for an addition to the plan to gradually expand the net metering system to achieve a higher growth rate. This will reshape the electricity market by digitizing the grid and meter management, and boost competition through measures such as installing digital “smart” meters and centralized systems on operator assets for optimal management and control. It may be facilitated by promoting it with full support of the stakeholders (Forouli et al., 2021).

2.5 Power Market - German Pilot

Unbundling of the traditional, vertically integrated power supply system, i.e. unbundling of generation, transmission and distribution system operation, and supply to final customers, establishes a fundamentally positive environment for new market entrants and is thus essential for the development of most VPP business models. In Germany, un-bundling is regulated by the Energy Industry Act (Ener-giewirtschaftsgesetz, EnWG). All energy companies with not less than 100,000 grid customers (§7 EnWG) are required to legally unbundle their grid operation business from the competitive business of generation or supply. This means, transmission system operators (TSO) but also larger distribution system operators (DSO) operate independently from other electricity market players, such as generating companies, traders, suppliers. Smaller companies have to have strictly separate accounts for the competitive and the grid functions. Consequently, a large share of power is traded on the wholesale market (Xia-Bauer et al. 2021).

2.5.1 Market Regulation – Germany

As described in Xia-Bauer et al. (2021), trading on the German power market exchange consists of its three commodities with different durations from purchase to actual delivery. Long-term trading takes place in the futures market and may begin several years in advance of actual delivery, based on long-term forecasts and estimates. Therefore, buyers can protect themselves from the risk of price increases. The majority of power trading occurs suddenly on the EPEX spot market. Short-term trades are initially made on the day-ahead market, where bids can be made until 12:00 pm at the latest. This allows for more accurate forecasts of power generation and consumption than the futures market. After arbitration, the electricity supplier plans the connection of the power plant and sends the plan in the form of a timetable to the TSO in charge, by 14:30 o'clock the previous day. Forecast deviations from the previous day's results are balanced in the intraday market, and 15-minute and 1-hour products can be traded up to 5 minutes before the delivery (shortened compared to the previous 45 minutes) (Xia-Bauer et al. 2021). Intraday consecutive bids are accepted according to the order book principle. Each successful completion will be priced individually instead of unit price. Cross-border intraday trading (XBID) was launched in 2018, with the aim of creating a single cross-zone intraday market across Europe. The XBID solution is based on a common IT system with a common Purchase Order (SOB), Capacity Management Module (CMM) and Shipment Module (SM). The intraday market is gaining importance as intermittent renewables penetration increases, as it reacts to deviations from load and the updated BRP forecast of renewables production. In Germany, VPPs are active in both day-ahead and intra-day markets. Moreover, shorter lead times in the intraday market create additional demand for the short-term, rapidly controllable flexibility, that VPPs can offer from pools (Xia-Bauer et al. 2021).

As Xia-Bauer et al. (2021) continues, the TSO will introduce balancing power in the balancing power market after the close of intraday market trading, to compensate for the real-time imbalance between supply and demand at the system level and the resulting frequency deviation procured. In 2010, was a unified control reserve market established, where control reserve providers could offer flexibility to the TSOs. Maintaining frequency can be achieved by using different types of balancing reserves i.e., Frequency Containment Reserve (FCR, also known as Primary Control Reserve) and Frequency Restoration Reserve (aFRR, also known as Secondary Reserve; mFRR, also known as Tertiary Reserve). Boot time is 30 seconds to 15 minutes. The minimum bid for FCR is 1 MW. FCR bids must be symmetrical. Bided offers the same capacity in positive and negative directions. Providers of FCR products are rewarded only for the price of performance (the willingness to provide control over a period of time). In contrast, aFRR and mFRR are bided separately for positive and negative reserves with a minimum bid size of 5 MW each. The provision of aFRR and mFRR is rewarded with a capacity price and a balance energy price (the balance energy bill actually consumed and passed to his BRP that initiates the activation) (Xia-Bauer et al. 2021).

In Germany, VPPs are active in the balancing power market, in particular, aFRR and mFRR. A VPP aggregates different DERs in its pool for participating in balancing market, as TSOs in Germany accept pre-qualification at the aggregated pool level. Previously, for delivering balancing energy, the provider had to participate in a capacity auction, in which VPPs aggregating flexible loads often could not participate due to forecasting challenges. Since November 2020, any pre-qualified providers, regardless of their prior participation in a capacity auction, can deliver balancing energy (Xia-Bauer et al. 2021).

2.5.2 Technical Market Conditions - Germany

As participation in DR programs is lower than in EE, it has been argued that Germany lacks a comprehensive strategy to enable greater load aggregation and response for SMEs. Nevertheless, although SMEs (and residential) explicit DR remains untapped, this situation is expected to change. In its Third Electricity Package, the EU committed member states to an (electrical) smart meter roll out target of 80% by 2020. The actual installation and expected installation targets in Europe are unequal, and Germany is among the countries with lower smart meter penetration and targets. Germany started to implement the EU Directives in 2017 after a complex and complicated legislative process and decided to stick to the 80% penetration limit (Valdesa et al.,2019).

According to the Act on the Digitization of the Energy Transition enacted in 2016, Germany implements the EU Directives 2009/72/EG and 2009/73/EG into German law. The Act introduces specific and detailed requirements, both for the design of smart meter devices and for the transmission of data, a subject of great controversy due to the necessity of solving data protection issues. The overall goal of the new law is not only the introduction of dynamic pricing but also gradually achieving a total digital transformation of the German energy market while ensuring a high standard regarding data protection (Valdesa et al.,2019).

2.5.3 Economic Market Conditions Germany

With an announced plan to achieve 35% of renewable electricity supply by 2020 and the phasing out of nuclear power by 2022, the German energy system will integrate more and more de-centralised variable energy generation (wind, solar) as well as de-centralised energy generation by biomass and biogas, and will increase its needs in de-centralised flexibility. Situations where variable generation from wind and solar plants surpasses the general demand in the grid are expected to happen more frequently in the future (Bertoldi et al., 2016).

Today, a significant portion of demand-side flexibility in Germany remains untapped and will remain so, until important barriers are removed. Though Demand Response is legal, aggregation is only enabled for the retailer and these also face significant entry barriers. The wholesale market and re-dispatch (incl. winter grid reserve) are closed for Demand Response. Intra-day markets are open for consumers working through their retailer (assuming the retailer offers this service) (Valdesa et al.,2019).

An aggregator may work as a service provider to a retailer. In this case the aggregator is pooling loads in one retailer's balancing group. Though it is positive to see Demand Response services offered by retailers, this limitation hinders market growth by lowering competition and limiting the range of customers who can participate within the portfolio of a particular retailer. It also does not take into account retailer's business model challenges with Demand Response (Bertoldi et al., 2016).

2.5.4 Recommendations - Germany

As noted in several studies dealing with the German energy market, there are two avenues that need to be exploited in order for the market condition to improve and reach the full potential. From one side it can be easily concluded that the market regulation is very rigid and is creating difficulties for aggregators and DR programs, therefore it needs to improve, in order to harvest the full potential that the country is bringing on the table. On the other side though, Germany, is one of the world leaders in DES and RES as well as smart devices so microgrids, smart grids and p2p platforms, EV-mobility etc, are business models which can be fully applied in this market, but need more stimulation from economic and technical perspective in order to be considered as more attractive and financially viable solutions. (Bertoldi et al., 2016; Stede, 2016; Valdesa et al.,2019).

2.6 Improving the DR Business Models

As stated in D2.3, in the research done by Leutgob et al. (2019), energy markets and especially electricity markets are faced with a strong need for more flexibility, mainly due to the fact that the share of renewable energy sources in energy supply is steadily increasing. The current model of ensuring demand-supply match mainly by investments into supply and transmission infrastructure needs to be complemented by demand-centric solutions, usually summarised under the term demand response (DR) (Lamprinos et al., 2017). Due to digitalisation, the technical possibilities to integrate small- and medium-sized prosumers (residential, tertiary, decentral power and heat storages, micro-grids etc.) into DR activities are continuously expanding. Innovative platforms allow for bundling of small/medium-sized capacities, transaction cost are reduced through automated dispatching, communication with switchable, "smart" appliances is becoming cheaper, new technologies are available to ensure secure data handling for easier forms of "smart contracts", etc. But hand in hand with expansion of DR potentials, there is also a need to adapt and further develop current DR business models to cope with new challenges (Diaz-Diaz et al., 2017).

2.6.1 From Centralized to Decentralized system

There is a noticeable paradigm shift, or change, or one might say, evolvement of the system, from centralized energy generation to a decentralized network of distributed prosumers. Consumers are increasingly being encouraged and empowered to actively participate in the energy network with respect to consumption and generation. The future energy system will be a smart system, where all energy entities are given the opportunity to participate in the marketplace. Moreover, the increase of the renewable energy sources which are one of the main elements of the energy transition, also implies that the system management will be more complex because of its volatility. This is coming from the fact that the supply of the renewable sources is greatly impacted by seasonal factors and fluctuation, thus, the network management will have integrate smaller and more decentralized units in order to guarantee grid stability (Richter, 2012; Leutgob et al., 2019).

The demand side holds the key to overcoming the challenges of increasing flexibility. By aligning demand patterns with the supply patterns of renewables, we can reduce the investment needed on the supply side. This concept, known as demand response (DR), enables consumers to respond to peaks and shortages in electricity supply by adjusting their consumption in real-time. By harnessing the power of DR, we can create a more efficient and sustainable energy system for everyone (Lamprinos et al., 2016).

For many of the large power consuming players and actors on the energy market, the DR concept is already familiar and a concept which they have been using for some time already. However, the challenge still remains for the small and medium-sized consumers, especially from the residential sector. Technical solutions that support the extension of DR towards small and medium sized prosumers are already in place, but there is still a need for the development of appropriate business models (Gharesifard et al., 2016). There is some incentive for all parties involved to make use of DR as it reduces costs for consumers, whereas for suppliers, it can work as a tool to better balance their portfolio and optimise the sourcing costs. DR service providers also may be third parties that act as DR aggregators, who conclude contracts directly with consumers, pooling together their DR capacities and selling them on the flexibility market. Clarifying the roles and responsibilities of all these players needs to be accomplished in order to create a sound DR environment (Leutgob et al., 2019).

2.6.2 Improving the DR through Digitization

The main barrier refraining small and medium-size consumers to valorise their load in DR mechanism is technology constraint. Load-shifting represents a potential high volume but its high transaction and operation costs deter its development (Gao et al., 2017). Therefore, many see the Digitalization element as a game changer, which can bring back the small and medium-sized consumers into the energy "game". Smart devices are one piece of the puzzle, and they are fundamentally important for participation into a DR program. The whole process depends on how easily these smart and switchable devices can be incorporated into a digital platform. Thus, integration of smart devices, building automation systems, storage systems and decentralized electricity production is crucial for facilitation of DR programs (Leutgob et al., 2019).

Another important element for facilitation of DR is a proper software solution for DR aggregation. In recent years, several platforms have been developed in different energy markets, mainly coming from aggregators and paired with hardware which support that specified platform (Hamwi et al., 2020). However, further development is much needed, with additional features and functionalities of the software platforms especially in the fields of:

- Handling small and medium loads; user clustering; grid stability assessment and load forecast (mainly for the case of clustering of small loads) (Gao et al., 2017);
- Improvement of price forecasting tools (Ghavidel et al., 2016);
- Enhancement of interoperability features (Plancke et al., 2015);

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- Virtual Power Plant (VPP) services to enable improved management of energy storage systems in conjunction with RES generation (Leutgob et al., 2019).

Furthermore, recent developments in smart contracts and blockchain is another aspect of the digitization process that positively affects the adoption and facilitation of DR programs in such markets. Conclusion of contract, as well as, monitoring and contract implementation represent a significant part of the transaction cost in DR programs. With the aforementioned smart contracts and blockchain, such actions can be automated with a high degree of immutability, security, traceability and transparency, which in great effect will ease operations in this field (Leutgob et al., 2019).

2.7 Suggestions for improving the Business Models

The future of the energy business models will be increasingly led and dominated by developing technologies, especially by the progress of digitization. It is especially crucial for allowing small and medium sized prosumers to join and participate in the flexibility markets. Therefore, improvement of the current business models is strongly suggested, following the finding of improved business model will prove beneficial in the long run (D2.3 - Papalexopoulos and Sulev, 2021). The suggestions are summarised in Figure 6.

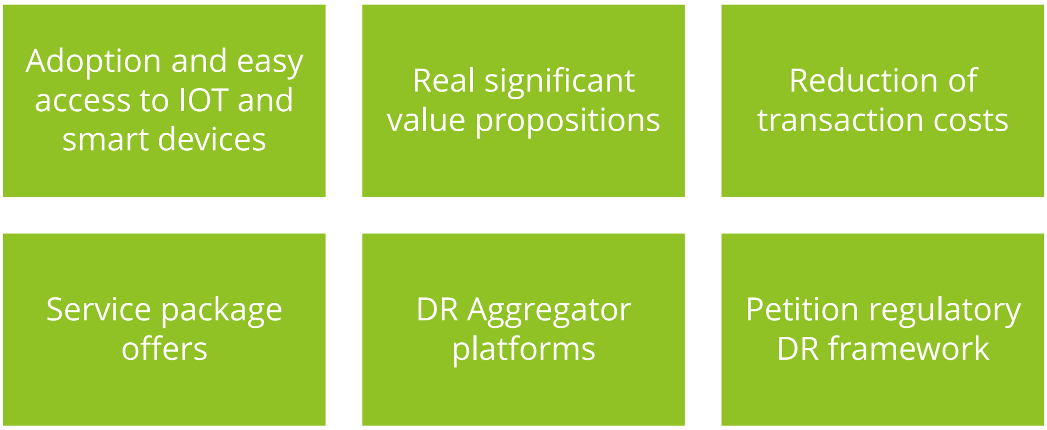

Figure 5 - Suggestions for Improving the Business Models (Source: D2.3)

- Adoption and easy access to IOT and smart devices - Easy access to IoT and smart devices refers to the simplicity and affordability of acquiring these devices, and integrating them into everyday life. With the widespread availability of these devices and their growing popularity, the number of consumers using them continues to grow, making it easier for individuals and businesses to adopt these technologies and gain access to the benefits they offer. In addition to the benefits of convenience and increased efficiency that smart devices offer, IoT and smart devices have the potential to play a significant role in addressing major global challenges, such as energy management and sustainability, by allowing for the creation of smart energy systems and the optimization of energy use. (Diaz-Diaz et al., 2017; Leutgob et al., 2019).

- Real significant value propositions – At the moment what is offered on the market is very rudimentary and not bringing any real value for the participants, thus the DR-participation is limited (Leutgob et al., 2019). The suggestions presented for different kind of incentives can greatly stimulate participants to join the programs as they will have a significant value proposition and, in this way, create benefits and maximise the effect of the DR program (Ghavidel et al., 2016). Although in many EU markets there are regulatory barriers that are making monetary incentives problematic, still there are plenty of non-monetary incentives which can stimulate participation. Such non-monetary incentives can be in the range of: vouchers, environmental benefit, improved data security, transparency and trustworthiness, smart contracts, guarantees of availability etc. (Cazalet et al., 2017)
- Reduction of transaction costs – As the financial earning may be small for a single user, all cost related to distribution and communication with the potential customer need to be very low too. Therefore, it will be decisive to make use of existing distribution and information channels related to the target groups addressed (Leutgob et al., 2019).
- Service package offers – By offering more services at once, economies of scale will be relatively easier to be achieved and consequently the participation of smaller and medium-sized players on the market. It will results in creating greater benefit for them by creating greater value (Alvaro et al., 2016).
- DR Aggregator platforms – this is certainly one field that will need a lot of attention since it holds huge potential and operators should focus their attention on creating innovative platform solutions for better operations. Ranging from better incorporation of loads and automatic dispatching, to keeping updated price signals, information is a crucial factor for success (Alvaro et al., 2016).
- Petition regulatory DR framework – Although in recent years the regulatory conditions have improved, still they are far away from satisfactory level for unobstructed DR program operations. Change is needed, but change can only be inspired by action (Leutgob et al., 2019). Operators should be proactive and push for this change to happen sooner rather than later. For example, a clear definition of the role and responsibility of independent aggregators and their relation to

BRPs/retailers and/or other market participants; reduction of administrative efforts and upfront costs; definition of technical standards (e.g., for data exchange), standardised procedures for prequalification for participation in balancing markets and requirements for measurement and verification, should be further developed (Leutgob et al., 2019).

3/ TwinERGY Exploitable Results

In order to divulge the exploitation potential of the project, one must first start by diving into the broader concepts, and then, step by step, get a sense of the specific concepts, innovative business models, as well as exploitable aspects of the TwinERGY project. To start, as specified in the TwinERGY project documentation and later elaborated in D2.2 and D4.3, the project identified and exploited nine High Level Use Case (HLUC) scenarios, based on TwinERGY objectives, which can be seen in Figure 7, as well as Appendix 1 for more details.

High Level Use Cases (HLUC)
HLUC01 – Home Energy Management
HLUC02- RES generation in domestic and tertiary buildings
HLUC03- Grid capacity enhancement utilizing E-mobility
HLUC04- Prosumer's empowerment in Local Energy Trading Markets
HLUC05- Enhance grid flexibility through DER Management
HLUC06- Consumer's engagement in Demand Side Management Programs utilizing feedback mechanisms
HLUC07- Consumer's engagement in Demand Response programs utilizing a socio-economic context
HLUC08- Consumer's engagement in Demand Response programs utilizing personalized comfort/health-oriented services
HLUC09- Consumer Engagement in Demand Response Programs Utilizing Digital Twin Prediction Capabilities for Dynamic VPPs

Figure 6 - High Level Use Cases TwinERGY Project (D2.2)

As one gets familiar with the use cases, it is also important to make the proper understanding and correlation between them and the project Pilot Sites and how the use cases are distributed among each pilot site.

The four places chosen as demonstration sites of the project (City of Athens - Greece, Benetutti smart Community -Italy, Hagedorn village - Germany, Bristol City - United Kingdom) have different levels of readiness, but all of them are working towards becoming smart cities and deploy their Smart City plans. Targeting at different types of loads (including heating and mobility sector), while enforcing the increase of RES penetration rate, the proposed system will be based on carefully designed business models, in order to provide the costumers with novel sources of income or opportunities

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

for financial exploitation (TwinERGY Project Proposal, 2020). Figure 8 illustrates the correlation distribution between use cases and pilot sites.

Use Cases	Description	City of Athens - Greece	Benetutti Smart Community - Italy	Hagedorn Village - Germany	Bristol City -UK
UC01	Home Energy Management	X	X	X	X
UC02	RES Generation in domestic and tertiary buildings		X	X	X
UC03	Grid capacity enhancement utilizing e-mobility	X		X	
UC04	Prosumers empowerment in local energy trading markets		X		X
UC05	Enhance grid's flexibility through DER management		X	X	
UC06	Consumers engagement in Demand Side Management Programs utilizing feedback mechanisms	X	X		
UC07	Consumer's engagement in demand response utilizing a socio-economic context		X	X	X
UC08	Consumer's engagement in demand response programs utilizing personalized comfort/health-oriented services	X	X	X	
UC09	Consumer's engagement in demand response programs utilizing digital twins prediction capabilities for dynamic VPPs	X	X	X	X

Figure 7 - TwinERGY Use Cases vs. Pilot Sites (D2.2)

This section briefly presents and summarises the main exploitable results of the project. These are results which will be achieved during the lifetime of the project and can be exploited after the end of the project lifetime. It is worth mentioning that during the time of this report the project is still ongoing, therefore a revision near the end of the project may be needed in case of deviation of the results stated in this report. Figure 9, provides overview of the key exploitable results which, according to the TwinERGY project specifications, are:

- TwinERGY Platform
- TwinERGY Modules
- TwinERGY Products / Services

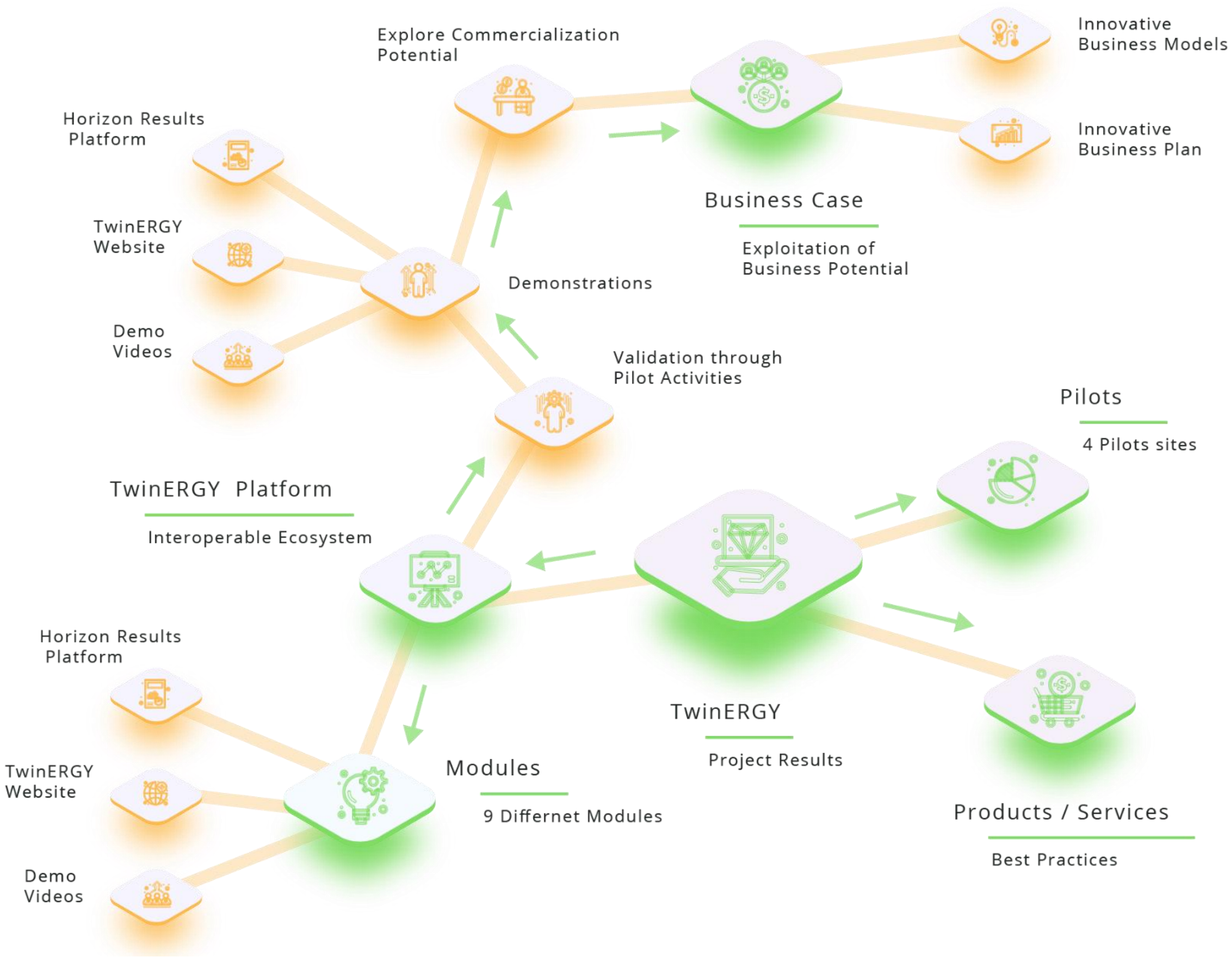

Figure 8 - TwinERGY Exploitable Results

As indicated in the GA, the TwinERGY platform is the backbone of the project and it is providing the necessary support for establishing the potential of the developed solutions. Illustrated in Figure 10, it is based on the SGAM framework, which ensures interoperability of the system and is comprised from several layers including: Component Layer, Communication Layer, Information Layer and Business Layer. To start with the Component Layer, it describes the physical layer of the grid, which includes the system equipment, protection infrastructure and network devices. Next, the Communication Layer, indicates the protocols and mechanisms used for the exchange of information between the model entities. The Information Layer, deals with the information objects and data models exchanged between UC actors/functions, followed by the Function Layer which refers to the UC different functionalities. Finally, the Business Layer models the business logic of the UC scenarios, through the involved market partners, business objectives, goals, and restrictions. (D4.4 - Martinez Garcia and Garcia, 2021)

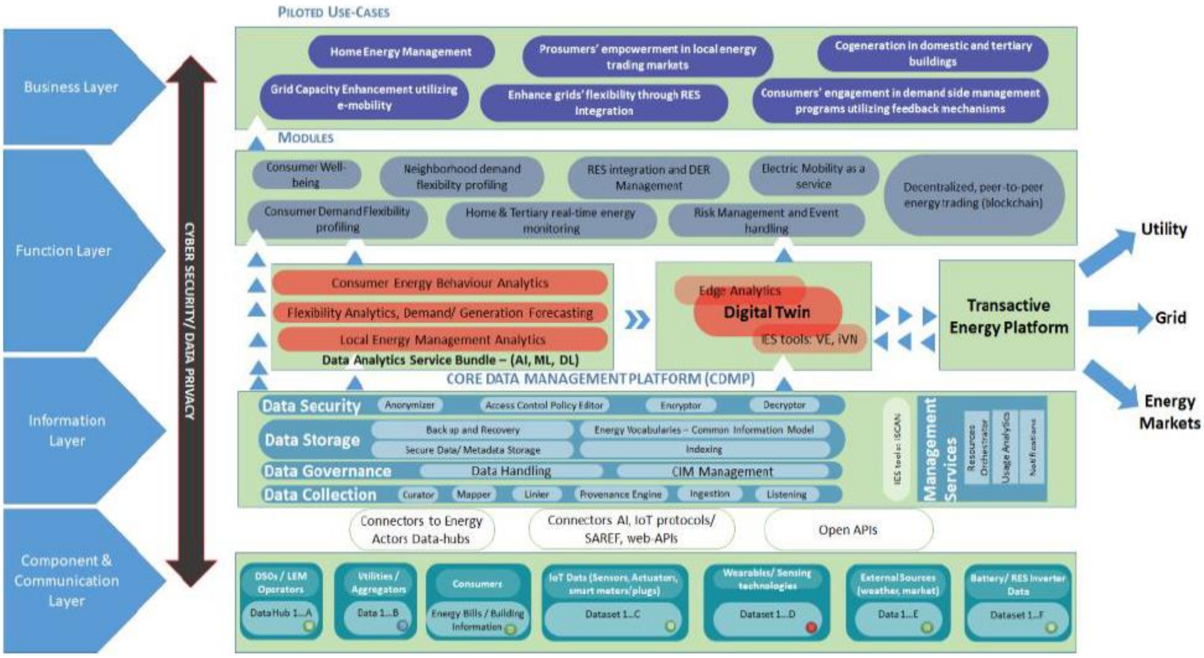

Figure 9 - TwinERGY Interoperable Infrastructure

Next in line from the inputs that provide opportunity for exploitation, are the modules of the TwinERGY project. The project developed different modules which are summarised in Figure 11.

Module	Partner	Description of Module Results	Target TRL	Result Type
Consumer Well-Being	University of Patras	Result is obtaining consumers' comfort / well-being level using low-cost autonomous wearable devices through which data can be unobtrusively obtained and advance unsupervised classification techniques through which the obtained data shall be processed to formulate consumers' respective profiling.	TRL 6-8	Software & Report
Consumer and Neighbourhood demand flexibility profiling	IES R&D	It uses the capabilities of the consumer and communities Digital Twins methodology for calculating and profiling the potential flexibility and micro and macro level. The particular module is based both on physics-driven and data-driven modelling and simulation. Depending on the type of flexibility the appropriate modelling tool was deployed to calculate the amount of flexibility and its controllability aspects.	TRL 7-8	Software & Report
H&T Energy Monitoring	STAM Srl	This module leverages data from buildings and devices to optimize energy consumptions of buildings.	TRL 7-8	Software & Report
DER Management	TH OWL	The DER management module is generating several kinds of signals that are used by other modules for their operation. Also, the signals deliver a possibility to be utilised by local assets like a battery storage to shift the timeframes with higher power demand to daytimes, where more renewable energy is available and thus reducing the overall CO2 emission of a household or a whole community.	TRL 6-8	Report & Algorithm
TwinEV	ETRA	IT accounts for high-value services to EV users, such as minimum charging prices, maximum green electricity supply and different kinds of grid services.	TRL 5-8	Software & Report
Transactive Energy	WEC	It implements organized nodal electricity markets for the distribution grid, which are revolutionizing the relationships among customers, energy companies, and the grid under the new emerging transactive energy paradigm.	TRL 7-8	Software & Report
Social Network	ED	It promotes consumers' participation and engagement through Community-oriented engagement tools: Social comparison, Social competition/ community rewards and Social media	TRL 5-8	Software & Report
Risk Management	STAM Srl	Provides development and implementation of a quantitative risk management application dedicated to the residential buildings.	TRL 5-7	Report & Algorithm

Figure 10 - TwinERGY Modules

As the analysis progress through the potential of the exploitable results, the sublimation of the products/services, as described in the TwinERGY Project (2020), certainly hold potential to be marked as a marketable and independently promotable actions, which can be exploited for future commercialization purposes. Driving on several forces which have been hugely elaborated and researched in other WPs (e.g., WP2,3,4,7), these exploitable results, as products/services, can serve as novel solutions and drivers for future improvement and optimization of the EU Energy market. Figure 12 describes the selected exploitable products/services:

Partner	Main Results-Products/ Services	Products/ Services Description	Relevant Target Groups	Short term (2023)	Medium term (2023-2026)	Long term (2026-2030)
UPat	Consumer Comfort / Well-being Module	The UPat corresponding research team to seize TwinERGY's opportunity and initiate a startup in the road to market to commercialize the specific module.	Retailers	TRL7 – 8	TRL9 – Market **[entering]**	Module updates **[growing]**
STAM SRL	HEM platform	STAM's Home Energy Management platform is an operational service for home energy management. Extending the services with trading, modelling, decision and operation algorithms and the use of blockchain smart contracts will result in an integrated management platform.	Retailers, Energy Communities	TRL 8 development	Commercial application in Europe; 5-25 clients **[entering]**, **[growing]**	Adding Digital Twin optimization components**[enhancing]**
IES R&D	IES Virtual Environment (VE) Intelligent Virtual Network (iVN)	Digital Twin new visualization capabilities will be introduced to enable the interaction with the end-users. New modelling modules will be added for dispatchable RES based generation, storage technologies and VPP optimization	Retailers, Energy Communities	TRL8 development	Commercial application in Europe; 5-25 clients **[entering]**, **[growing]**	Adding Digital Twin optimization components**[enhancing]**
SUITE5	Energy Services Smart Contract Platform	Software extension of current expertise for integration with energy trading platforms, to be licensed.	Retailers, Energy Communities	TRL 8 development	Commercial application in Europe; 1-20 clients **[entering]**, **[growing]**	New services to be in compliance with updated Data protection regulations and cybersecurity issues. **[enhancing]**
ETRA	Smart Charging Tool (SMAC)	Novel, end user friendly, dynamic tariff EVs charging capabilities.	Retailers	TRL 8 development	Commercial application in Europe; 5-50 clients **[entering]**, **[growing]**	New AI optimization components to cover EVs increased market penetration and customers needs. **[enhancing]**
WEC	Transactive Energy Platform	'Near real' time VPPs services into organized wholesale and retail markets.	Retailers, Energy Communities, Energy Market	TRL 8 development	Commercial global rollout **[entering]**, **[growing**	New functionalities to cover novel business models and market needs **[enhancing]** Commercial global rollout **[expanding]**

Figure 11 - Main Results – Product / Services (Source: TwinERGY Project, 2020)

4/ TwinERGY Strategic Advantages from the Exploitable Results

Having briefly elaborated the main exploitable results, one can now dive deeper into more specific parts of those results, parts which hold the most unique, most novel and most bankable idea, in order to lay the grounds for future commercialization and creation of the business case and innovative business plan of the TwinERGY project.

Throughout its project course, TwinERGY, as an innovative concept, has developed some fundamental scenarios through its use cases, objectives, digital twin and modules development, which certainly hold huge potential for the future of the flexibility energy markets and can serve as strategic advantages for implementation in those future energy markets, by providing ultimate value and optimization.

4.1 Digital Twin Platform Exploitable Results

As described in the TwinERGY Proposal (2020) as well as D6.4 and D4.3, the TwinERGY platform is leveraging the capabilities of DTs at three different granularities, namely the Consumer DT, the Building DT and the Community DT. The intent is that each involved stakeholder within the community ecosystem is twinned to facilitate the detailed analysis of data and prediction of energy use and behaviour at any energy level within this community. The DTs that were created for the TwinERGY platform differ from traditional DT assets, as they are based on dynamic simulation models and will leverage actual data regarding the energy consumption and production of the buildings and communities to create fully calibrated DTs. This will support the analytical needs of the TwinERGY platform, particularly those of the modules that will be developed under Work Package 7 of the TwinERGY Description of Action (DoA), those that are requiring the energy forecasting data to function. Figure 13, The TwinERGY Digital Twin Platform has been taken from the TwinERGY DoA and outlines the different DTs as well as the data and IoT devices that will be leveraged during their operation (TwinERGY D6.4, 2022).

The functionality of each level of DT developed for the TwinERGY platform can be described as follows:

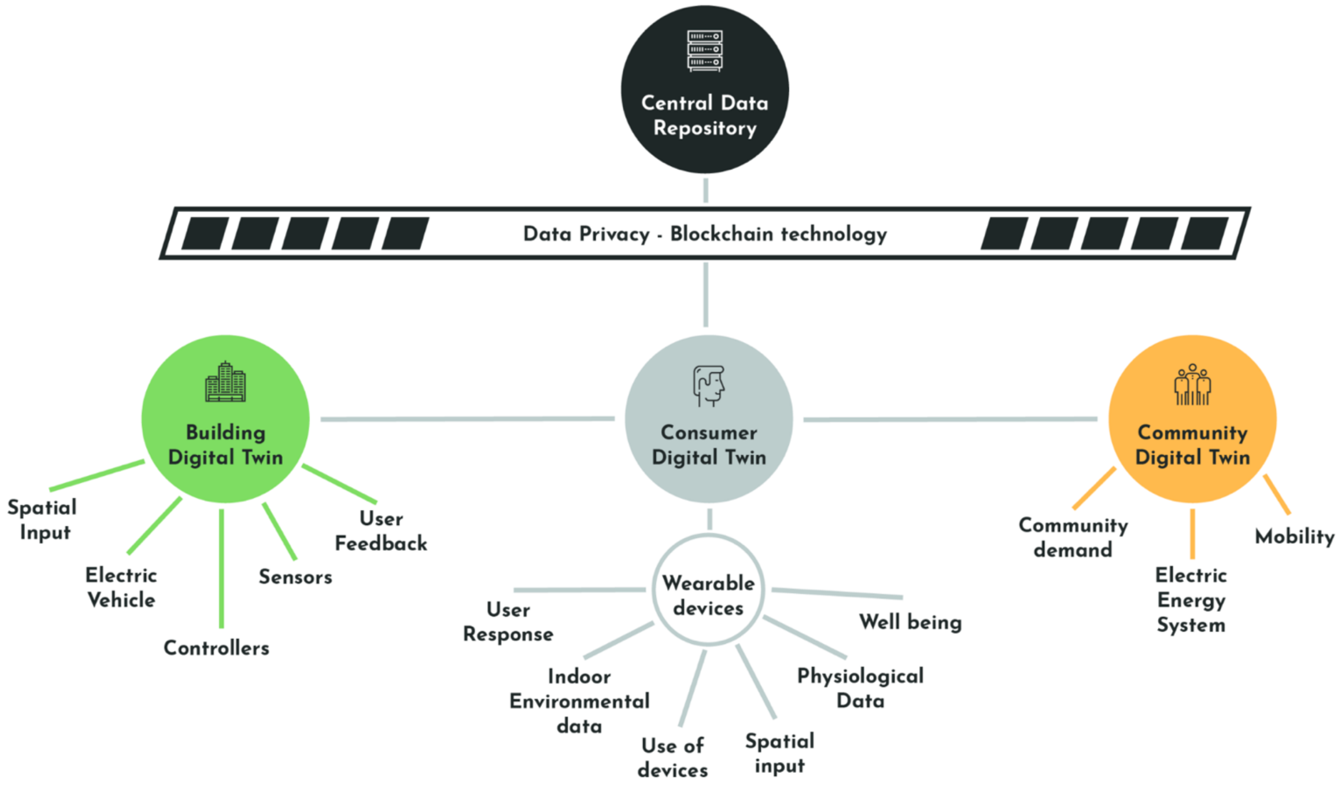

Figure 12 - The TwinERGY Digital Twin Platform

4.1.1 Consumer Digital Twin (CDT)

The CDT is a virtual representation of the building occupant that is leveraging the individual's physiological data, that is collected through the use of an IoT connected wearable device, as well as data collected from other relevant IoT sensors and devices (TwinERGY D6.4, 2022). Through the creation of this level of CDT, the TwinERGY platform is leveraging self-learning algorithms to create dynamic constructs of prosumer energy behaviours, while also identifying consumer preferences with respect to energy usage and openness to engaging in flexibility and demand response actions. With this in mind, the CDT is the central element that will facilitate the employment of human-centric demand response optimization strategies, enabling personalized control functions and automation in a non-intrusive manner and without compromising prosumers' comfort, indoor environment quality or daily operations / schedules for the provision of the required amount of flexibility to aggregators. It also ensures the improvement of demand forecasting at the short and medium term through the utilization of real-life data streams from the consumer assets to enable better predictability of future states of the distribution grid and highly effective VPP configuration at the aggregator side and minimization of DR strategies overrides. A screenshot of the interface of the CDT is presented in Figure 14 (TwinERGY D6.4, 2022).

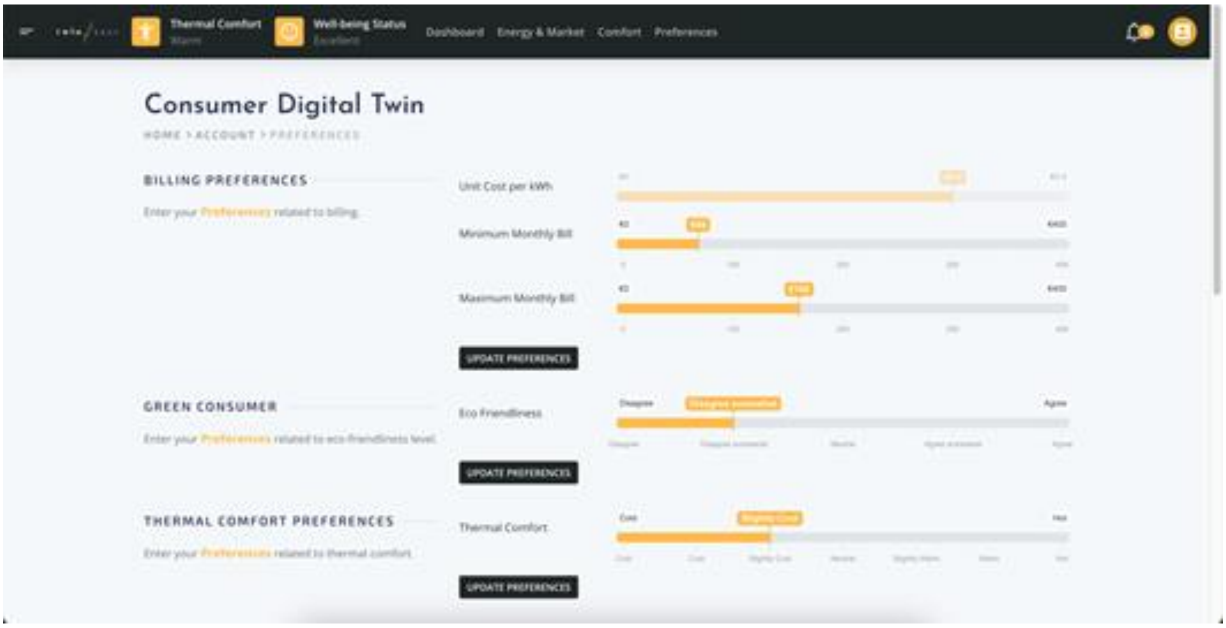

Figure 13 - Mock-up screenshot of the CDT interface

4.1.2 Building Digital Twin (BDT)

The BDT is created using the IES Virtual Environment and iCL tools described above. The development of the BDT was conducted in two phases. Initially, physics-based, DSMs of the pilot buildings were developed based on static information, such as information regarding the components, equipment and systems within each of the buildings. This data was provided by the demonstration sites through the completion of an information intake form (provided in Annex A – Building Data Checklist). At this stage, these DSMs was calibrated using energy bills, during the project development time-series data will be collected from the buildings through the use of IoT sensors and meters or otherwise, will be used once they are installed and the data available on the platform. In addition, actual weather conditions for the site are used to ensure that the model is accurately representing the performance of the actual building (TwinERGY D6.4, 2022).

Once the BDT is calibrated and is accurately predicting the performance of the building, the consumer preferences provided through the CDT, as well as real-time data from the IoT sensors within the building and real time weather forecasting is provided to the BDT to allow for the optimized day-ahead forecasting of energy consumption within the building, as well as production of building level renewables. Flexibility algorithms that have been developed during Task 6.2 (Demand flexibility models) are integrated into the BDT to provide the user with guidance as to the most optimal operation of their building based on their preferences and unique requirements (TwinERGY D6.4, 2022).

4.1.3 Community Digital Twin (CommDT)

The output from the BDT is aggregated to form the CommDT, which will represent the energy behaviour of the entire community (TwinERGY D6.4, 2022).Further to the building level data, community level renewable and storage assets as well as electric vehicles are integrated within the CommDT to accurately represent all energy consuming, producing and storage assets within the community. The CommDT is built on the analytics completed by the BDT to analyse the potential for flexibility and demand response actions at the community scale and the interface will be shown at the community and grid level. Through the use of optimization algorithms, the DT is identifying the most appropriate manner in which the forecasted energy consumption can be satisfied based on the level of generation at the community level. In addition, a link to the Transactive Energy Platform is created to enable the community grid operator to either utilize, import or export energy from or to the grid in the most cost-effective method possible, in the event that this is a point of preference for the community. The outputs from these algorithms are then made available to the relevant modules that will leverage the analysis for their own computational requirements (TwinERGY D6.4, 2022).

4.2 Transactive Energy (TE) Exploitable Results

TwinERGY TE framework is built for the 21stcentury grid, characterized by active "prosumer" (both producer and consumer of energy) participation in energy markets, bidirectional power flows (e.g., net metering of Behind-The-Meter (BTM) resources), and sophisticated financial transactions between prosumers, utilities, and third-party service providers is something that can create this positive improvement of value and is a business model worthy of a future. TE transactions BTM and In Front of the Meter (IFOM) are already on a hockey-stick shape of growth as they are now merging with the increased adoption of smart Internet of Things (IoT) devices, such as connected thermostats and other newly networked Distributed Energy Resources (DERs) such as renewable energy sources, electric vehicles (EV), and Electric Storage Resources at the edge of the grid.

In this project the module creates a TE market, which is likely altering the behaviour and perception of the participants in the electric market as such and is able to improve the business models with the addition of the TE features (Cazalet et al., 2016). The ability to create and hold value is the leading factor in the decision making process, much different from the traditional focus mostly orbiting around revenues. New business models are emerging to serve consumer needs in TE markets and others may change to meet the needs of those markets. Some new market participants will likely be customers or aggregations of customers that supply electric services to the transactive marketplace (Cazalet et al., 2016).

Furthermore, with the TE model in TwinERGY project, we are also bringing to activation the concept of digitalization and how the digitization aspects can improve the current market situation, thus, bring new solutions to life. In a sector which is filled with complex operational models, integration of services and solutions is gaining relevance where digitisation is leading the road to transformation of the energy markets. Many new companies are entering the market with innovative products based on digital solutions. Companies from the information and communication sector and other companies from outside the industry increasingly drive the change. New entrants from other sectors can provide essential skills for the provision of innovative value propositions by entering the energy sector. However, traditional companies in the energy industry can also expand their product portfolio based on their expertise within their value creation network (Giehl et al., 2020).

Blockchain, which involves decentralized transaction verification is potentially empowering individual customers to trade power and make payments in a seamless way. Digitalization can help with better network and congestion management, assisting with the renewable generation intermittency problem, allowing more effective network monitoring and more efficient network operation. It also provides digital platforms for demand response, and Peer-to-Peer (P2P) energy and carbon credit trading (Kufeoglu et al., 2019). The TE module architecture is presented in Figure 15.

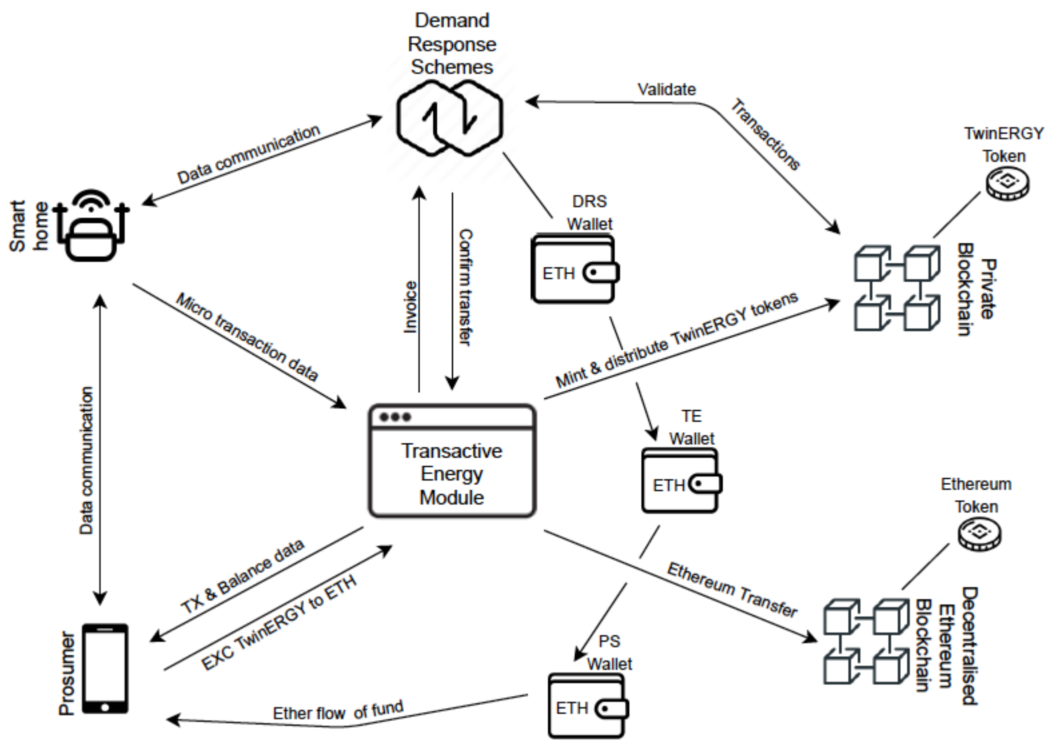

Figure 14. WEC's Transactive Energy Module Architecture

The benefits of the TE model come, firstly, from the fact that there is a direct link between the consumer and the producer, with the scale tilted towards the consumer as he can choose, on its own, from where they will purchase their power. This decentralises the situation dramatically and provides additional value to the consumers because of the increased competition in the market. Secondly, the additional value proposition of this model comes through price-time-shifting as consumers have total visibility when they are purchasing power and from where. All this helps the market to achieve greater matching of demand and generation which can reduce network pressure and creates benefits for the consumers through flexibility markets, and reduced charges and enables generators to sell power at better prices in order to maximise their exposure (Hall et al., 2020).

4.2.1 Scope of TE Results

In TwinERGY project the TE framework is providing solutions to transactive energy uses cases and enables grid decentralization and democratization by connecting the micro-grid operators to the DER managers and their customers. It aims for an integrated energy business model through energy service expansion, customer engagement and financial inclusion. It allows them to balance the grid and provide solutions to a number of grid problems, such as grid power quality and reliability. The core of the TE is a transactional platform that offers its participants to sell their flexible energy loads and excess capacity on an open market to the (micro) grid operators or to each other. Microgrid operators provide balancing and grid services at a local and micro-grid level. A micro-grid could be a collection of a) IoT devices, b) buildings, c) neighbourhoods/substations, and d) regions that operate at a regional level to balance multiple neighbourhoods, districts and/or substations. It could potentially include the high voltage grid. Each component of the system (e.g., device, building, neighbourhood, distribution grid and transmission grid) is a self-contained ecosystem, replicated and nested within the next layer of the system, like in a fractal configuration. All components operate with identical information and control models and each have operational decision-making capabilities. The TE platform offers a path to grid decentralization, energy democratization, and a way to effectively leverage and monetize the emerging DER infrastructure (A.Papalexopoulos, 2021).

The Transactive Energy framework and platform in the project, based on Hybrid Blockchain technologies is developed to solve current intractable optimization problems and create a premiere Transactive Energy (TE) protocol layer settlement process, marketplace, and governance framework to allow energy-related Apps to be written and interoperate with each other.

Through the application and study of TE in three of the TwinERGY project pilot sites (Hagedorn in Germany, Bristol in the United Kingdom and Benetutti in Italy), grid infrastructures are analysed to implement state-of-the-art equipment that can monitor and track energy consumption and distribution. Pilot sites, consisting of apartment buildings and individual houses will be equipped with smart meters, local and public storage facilities and IOT devices such as smart plugs. These are integrated with the Transactive Energy Module giving prosumers a powerful insight of their power consumption and redistribution to the local energy market (LEM).

The TEM is allowing for prosumers to buy and sell energy from the LEM. It is also allowing TE participants to transact in a P2P configuration outside an organized LEM/DSO or an ISO/TSO market. These transactions are stored as an immutable record on the blockchain specifying the actors participating in the transaction and the origin of the energy (A.Papalexopoulos, 2022).

To further support the LEM, the TEM processes and broadcasts price forecasting of the DNO and LEM. Other TwinERGY modules will be able to listen to the broadcast and make energy consumption or discharge decisions on behalf of the prosumer (A.Papalexopoulos, 2022).

For non-ISO/TSO and non LEM/DSO organized energy market transactions one pricing option could be to use a double-sided market in which TE participants pay a unique price based on their preferences and local supply and demand conditions (analogous to the stock market). Another option could be to use a proxy market price using a reference market price of the LEM organized market or the ISO/TSO market, (e.g., the 5-minute real-time auction price (A.Papalexopoulos, 2022). Figure 16 presents the TE platform scheme for the pilot sites.

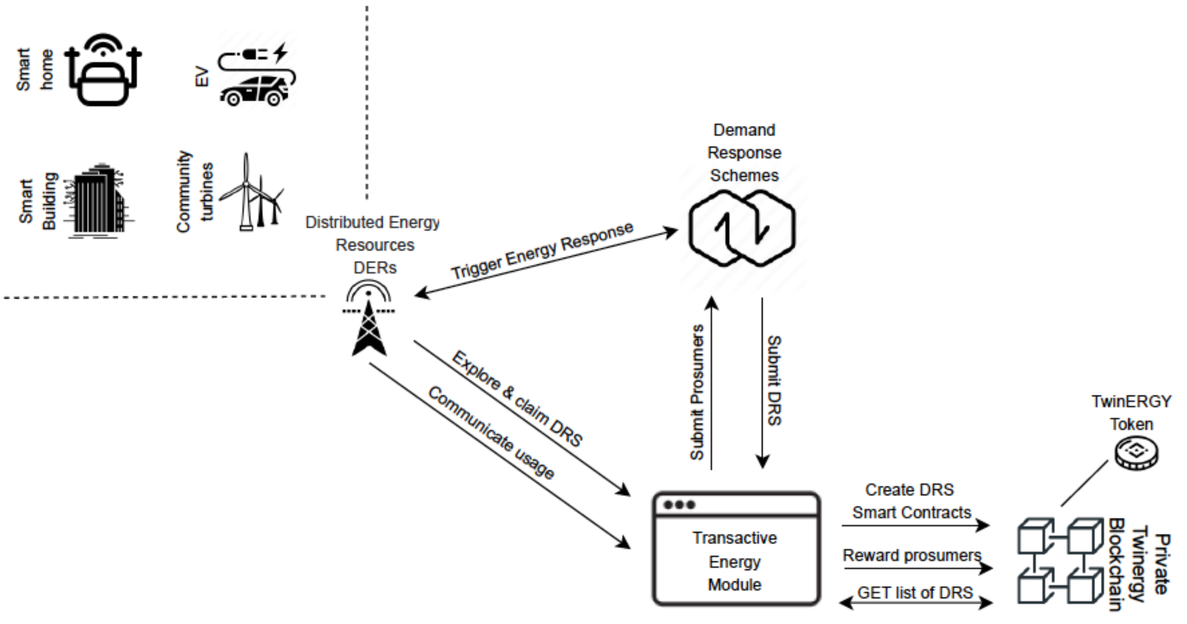

Figure 15 - WEC's Transactive Energy Platform for Pilot Sites

5/ Improving the Business Models based on the Exploitable Results

As described in the deliverable dealing with the business models, D2.3, as well as other supporting inputs from WP2, WP3, WP4 and as indicated by Osterwalder and Pigneur (2010, 2014), for every innovation that wants to make a successful impact on the market and be applicable and accepted as a value creator, it is crucially important to know the working applicable business model that will lead the charge. Deliverable D2.3 uses the business model methodology and the business model canvas as a tool that is capturing that value and being able to deliver that value across different markets. Different business models are evaluated that delivers different value to different stakeholders. Moreover, there is an indication of an improved models for the future, that can lead to creation of new value propositions on the market and create ultimate new value, one which was not perceived before. What is important now, is that with the exploitable results of the project, one can further elaborate on those improved models and be ready to take the first line ahead on the new market field of play. To illustrate everything properly, in this case, we are using the popular tool of the Business Model Canvas (BMC), developed by Osterwalder and Pigneur (2010, 2014), in order to properly describe the innovative improved models, which are delivering improved value creation within the energy market eco-system.

5.1 TwinERGY Platform Business Model Canvas (BMC)

Based on the provisions from the previous sections and other deliverables and WPs, one can already establish that TwinERGY platform constitutes a multi-faceted framework that incorporates multiple technologies and modules in order to provide ultimate value creation for the project framework. Additionally with the use of BMC we can create the general overview using the main elements:

- Customer Segments describe the groups of customers which represent potential beneficiaries of the product/service offered (Osterwalder and Pigneur, 2010, 2014).
- Value Proposition describes the unique product/service that creates value for the customer segment (Osterwalder and Pigneur, 2010, 2014).

- Channels describes how the customers can buy the product/service described by the value proposition (Osterwalder and Pigneur, 2010, 2014).
- Customer Relationships describe how the business interacts with each customer segment (Osterwalder and Pigneur, 2010, 2014).
- Revenue Streams list the sources from which the business generates profit by selling its product/service to the customers (Osterwalder and Pigneur, 2010, 2014).
- Key Activities list all the activities that the business is engaged in for making a profit (Osterwalder and Pigneur, 2010, 2014).
- Key Resources list the key resources or the main inputs to carry out the business (Osterwalder and Pigneur, 2010, 2014).
- Key Partnerships describe external companies or suppliers that help in carrying out the business activities (Osterwalder and Pigneur, 2010, 2014).
- Cost Structure identifies all the costs associated with operating the business (Osterwalder and Pigneur, 2010, 2014).

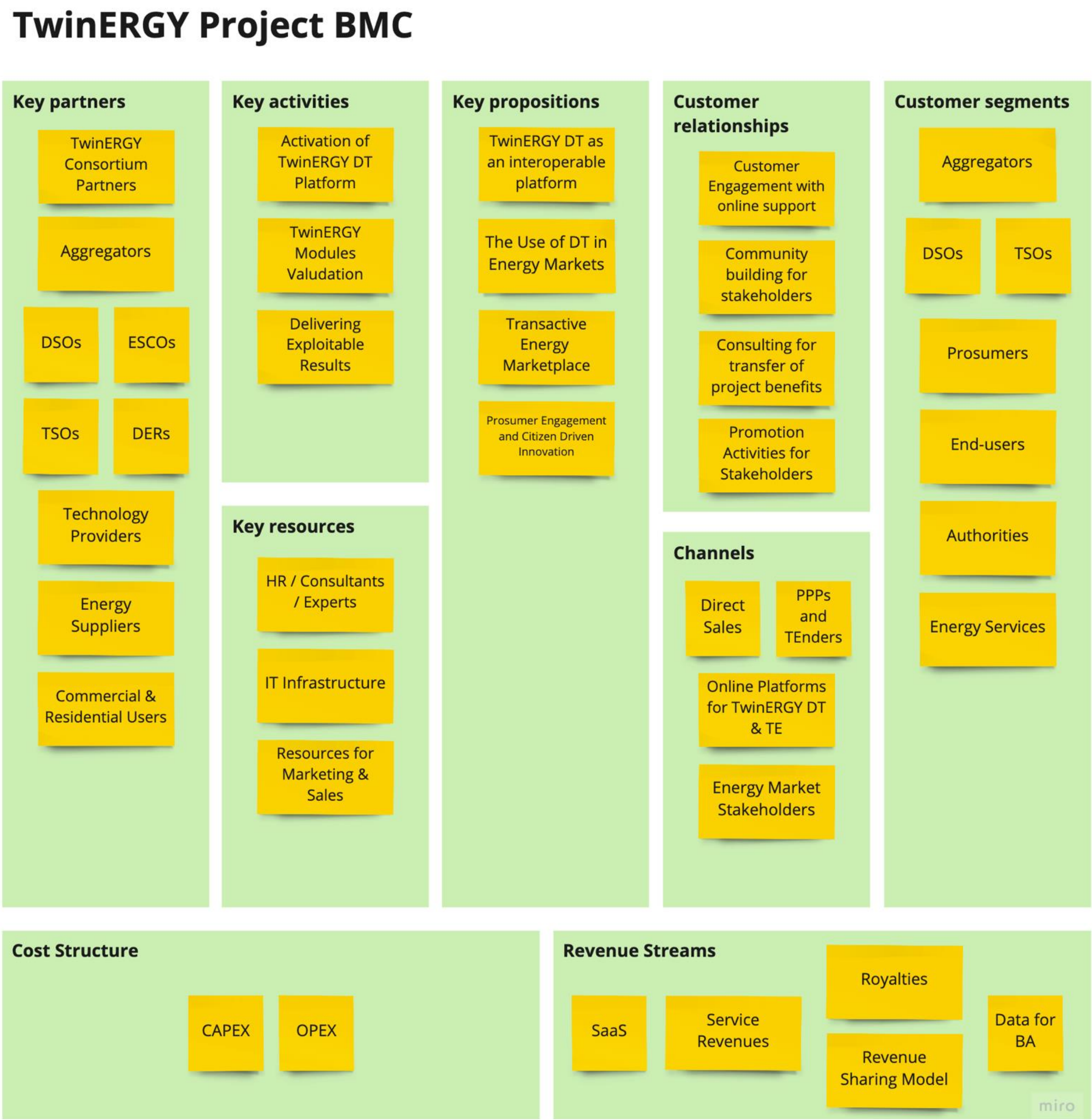

Figure 16 - TwinERGY Business Model Canvas (BMC)

For a better understanding of the of TwinERGY's BMC, in continuation follows a brief explanation of each section:

Value Proposition

TwinERGY is forming a multi-disciplinary framework with multiple innovations, which are targeting different actors for utilization of that innovation in the energy sector, thus creating new value propositions, which in turn, should provide tangible business benefits across the market. As illustrated previously in Figure 17, those key value propositions are summarized as:

- TwinERGY Digital Twin (DT) Platform
- Use of DT in Energy Markets
- Transactive Energy Marketplace
- Prosumer Engagement

Moreover, these points go much deeper into the value creation process and delivering improved value, as described in the TwinERGY GA (2020) and D4.3, where, in connection to the use cases of the project, the identified objectives delivering value are:

- Digital Twins with advances in artificial intelligence (AI) will make it possible to efficiently manage large portfolios of consumers, by using real-time monitoring, predictive analytics and automated response. By 2025, there will be 100 billion connected devices globally, with the greatest growth is expected in vehicles, connected wearables, home devices and building sensors, and this will be key to tapping the demand-side flexibility potential (TwinERGY GA, 2020).
- TwinERGY proposes a novel demand response scheme that takes into account of the consumer comfort level, while most existing Demand Response (DR) programs only use pricing signals to encourage consumers to alter their power consumption patterns, and the impacts on consumers have been overlooked (TwinERGY GA, 2020).
- TwinERGY will develop mass market customer offerings that succeed in giving small-account customers the personalization and individual control that they are seeking while also delivering the required economies and scale and margins for the energy services providers and power utility companies. And, whether it is business customers or mass market residential customers, customer relations have to be characterized by the ease, speed and simplicity of interaction that will be now possible on through Digital Twin platform (TwinERGY GA, 2020).
- TwinERGY promotes participation in a platform-oriented approach, which will allow multiple participants (service providers and consumers) to connect, interact with each other and create and exchange value. Airbnb, eBay and LinkedIn are examples of such platforms. TwinERGY platform will offer opportunities for

customer loyalty and lock-in and facilitate new revenue-sharing business models while allowing companies to maintain their focus on their existing core businesses (TwinERGY GA, 2020).

Although the initial focus is likely to be on services around smart energy use and demand response, ambitious additional services could be simultaneously delivered, as connected devices and the internet of things take root. Data monetization opportunities arise, including end user analytics related to energy consumption and in conjunction with trusted third parties, analytics from platform-generated data that would enhance new business opportunities and paid-for data-driven services that enable external players to exploit the value embedded in the platform generated data (TwinERGY GA, 2020).

Customer Segments

The innovation which TwinERGY is delivering, is tailored towards several players in the energy market, which have been identified and elaborated in the research done as part of the identification strategies in D2.2 and initially indicated in the main proposal document. Furthermore, in D4.1 and D4.2 strategies are developed, instructing how to properly target and engage these customer segments, in order to provide efficient and effective approach that will lead to full transfer of the value created during the course of the project towards the customers.

Customer Relationships

In order to properly establish the connection with the customers and build a positive relationship, TwinERGY aims to create a strong relationship which will attract customers to engage with the results of the project, so they can get the full benefit of the value creation and innovative solutions, which the project is providing. For this reason, several deliverables, such as, D4.1, D4.2, D11.2 are developed in order to lay the ground, not only to identify the customers, but how to engage them and reach them properly and efficiently.

Channels

Since proper delivery of the results are, as important as, the results themselves, TwinERGY has identified the best channels that will effectively transfer the project findings towards the customers. Again, in relations to what was previously stated above and referencing the deliverables D4.2 and D11.2, proper strategies are in place for selecting and utilizing the best channels.

Key Activities

This part from the BMC refers to the actions that TwinERGY is undertaking in order to make the business model work, and elaboration of the solutions which are bringing the value creation of the project into the business case of TwinERGY. In addition, to ensure that the platform is up and running and to validate the value creation of the TwinERGY modules, it is crucial to deliver the exploitable results to the energy market, in order to rip the full benefits of the project findings. Marketing and sales plan, developed throughout the course of the project (WP11) is helping in that direction, which apart from engagement and activation of the customers and stakeholders, will also be creating improved awareness, sales networks, start-up campaign etc.

Key partners

In order for TwinERGY business model to run properly, we need the input for several partners that will help bring the solution to the market. The key partners, as mentioned in the BMC, are all being evaluated and their contribution and activation elaborated throughout the project structure in WP2, WP3, WP4,

Key Resources

This section identifies the main resources needed for the TwinERGY model and TwinERGY platform, along with its modules, to properly operate and be active on the market as a value delivering solution. The resources used, and the ones selected, are the ones the most essential from operational perspective. The categories stated in the BMC, are broadly stated for better strategic evaluation and illustration, as each one of the mentioned, warrants a strategy on its own, as elaborated in TwinERGY Work Packages.

Cost Structure

The cost structure indicates the cost levels, which will be incurred in running this model and it is hugely related to the other blocks of the BMC. Therefore, it is important from an investment perspective, to have a clear overview on this aspect, in order to properly operate the business operations. For this purpose, we divide the cost of running the TwinERGY business model into two categories:

- CAPEX: Costs necessary for the technological consolidation of the solution, its industrialization and production.
- OPEX: Operational costs associated with the commercialization of the solution such as:

- Management;
- Legal;
- Administrative;
- Sales;
- Marketing and communications;
- Infrastructure costs.

Revenue Streams

The revenue is necessary in order to earn money and protect the existence of the business model. In the TwinERGY case the identified revenue streams are (Figure 18):

- SaaS - The software as a service (SaaS) revenue model is associated with regular, ongoing payments over a defined time period, in exchange for the use of a software application or other tool (MaRS, 2022).
- Service Revenues – Similar to the above mentioned field of SaaS, this revenue stream includes the sale of the platform services, by licence (monthly, annually), but also include provision of other services that TwinERGY can offer as a package deal (Consultancy, Expertise, Know-How etc).
- Royalties – Possibility exists for monetization of the IP that TwinERGY generates, since the innovative value creation of the project already attracts a lot of interest.
- Revenue Sharing Model – Since TwinERGY is comprised of a wider consortium, each partner can contribute to the business model, by opening its respective business network, and then participate in a revenue sharing model that will compensate for its respective actions and more importantly receive compensation, based the level and amount of those respective actions.
- Data for Business Analytics – As data is increasingly becoming the most valuable commodity in today's World economy, TwinERGY through the DT, creates a huge exploitable potential for revenue stream generation. This is provided, on the basis that, the DT creates valuable data inputs, which can be used for determining, forecasting and tailoring many future actions in the energy market worldwide, and can serve as foundation for multiple upcoming actions for energy players. Therefore, this data from the DT holds a huge value, which will be monetized through this revenue stream.

Figure 17 - TwinERGY Revenue Streams

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

6/ Improving the models for Transactive Energy and Virtual Power Plant

As indicated by Kufeoglu et al. (2019), digitalisation in the energy sector involves the creation and use of computerised information and processing of the vast amounts of data which is generated at all stages of the energy supply chain. It promises a lot for every segment of the energy ecosystem: households, prosumers, distribution, transmission, generation, and retail and is frequently stated as likely to lead to a transformation of the energy system. It is often associated with 'smart' energy, the Internet of Things (IoT) and Blockchain technology.

The main aim of digitalization is to improve efficiency. It enables better, cheaper, and faster monitoring, recovery and maintenance of the assets and components through 'smarter' grids (Diaz-Diaz et al., 2017). Smart households facilitate households' own solar energy production. The Internet of Things (IoT) will integrate smart appliances for savings and grid services (Diaz-Diaz et al., 2017). For instance, smart charging of Electric Vehicles can be a key provider in demand response. Blockchain which involves decentralized transaction verification will potentially empower individual customers to trade power and make payments in a seamless way.

Digitalization can help with better network and congestion management, assisting with the renewable generation intermittency problem, allowing more effective network monitoring and more efficient network operation. It also provides digital platforms for demand response, and Peer-to-Peer (P2P) energy and carbon credit trading (D2.3 - Papalexopoulos and Sulev, 2021).

6.1 Improved model - Transactive Energy

As described previously in section TE results, as well as, extensively in D2.3 from WP2, in an energy sector increasingly characterised by complex value creation networks, the integrated combination of material and services is gaining in relevance. In particular, existing business models with direct end customer contact are dependent on the integration of additional services in the long term. In this context, the analysis confirms that digitisation drives and enables the transformation of energy systems (Giehl et al., 2020). Many new companies are entering the market with innovative products based on digital solutions. Companies from the information and communication sector and other companies from outside the industry increasingly drive the change (Diaz-Diaz et al., 2017).

This is, in particular, valid for new services that go beyond the mere supply of energy. For example, software, automation and platform solutions or solutions for sector coupling with the related areas of mobility and heat are gaining importance. Here, new entrants from other sectors can provide essential skills for the provision of innovative value propositions by entering the energy sector. However, traditional companies in the energy industry can also expand their product portfolio based on their expertise within their value creation network (D2.3 - Papalexopoulos and Sulev, 2021).

Therefore TE as shown on Figure 15 and Figure 16 provides overview of how this concept is implemented during the TwinERGY project.

Furthermore, several research papers done (Schwidtal et al., 2022; Granath and Holmlund, 2020; Mastandrea, 2021), suggest and provide indications of the particles that are forming the BMC for transactive energy platform, in a similar fashion to what we have been evaluating internally in D2.3, as part of the project, as well as, throughout the course of the TwinERGY project itself. Therefore, we can establish an improved BMC for TE as illustrated on Figure 19.

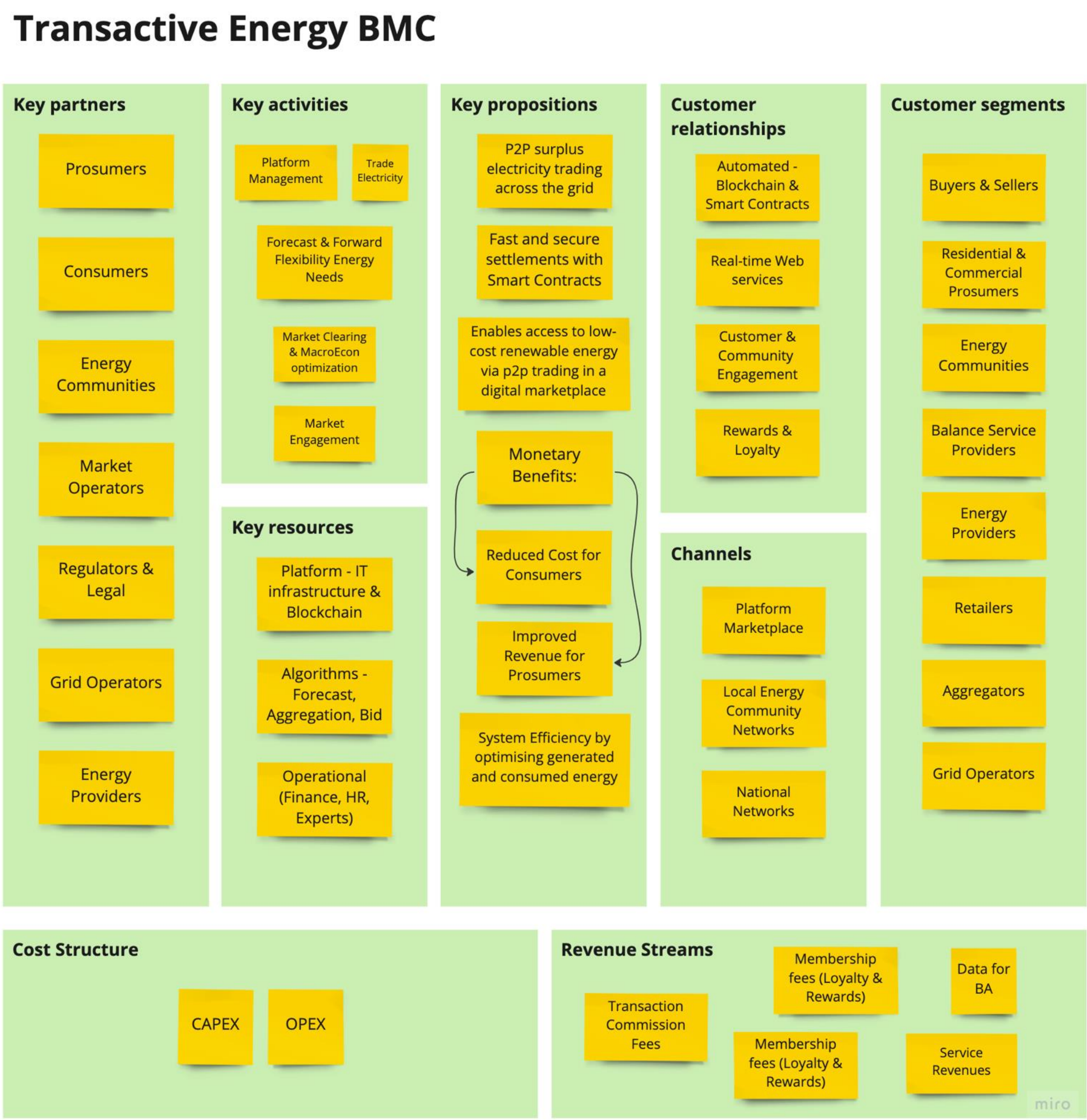

Figure 18 – Enhanced TwinERGY Transactive Energy BMC

The main value proposition elaborated previously in Section 4.2 and in D2.3, strengthen with additional research resources (Schwidtal et al., 2022; Granath and Holmlund, 2020; Mastandrea, 2021) give us the final result for TE platform value creation for the future energy markets.

The **key value proposition** and **value creation** comes from the fact that the TE platform enables direct interaction of the participants, without interruptions and intermediaries, facilitated and powered by a blockchain system with enabled smart contract, which regulates and automates the contract and transaction executions, either directly or indirectly. In this way, the decentralized, trustworthy and immutable infrastructure of the TE platform warrants proper and nearly real-time transaction execution, guaranteeing the added benefit and value creation for its users. It stimulates the sale of renewable resources, where prosumers can directly choose local renewable generation and can share their energy production with others. They can negotiate the price with other players on the market, in order to get improved revenues. Furthermore, through elimination of intermediaries and automation of the execution of transactions through smart contracts, also be able to reduce, if not altogether eliminate unnecessary cost (Schwidtal et al., 2022; Granath and Holmlund, 2020; Mastandrea, 2021).

6.1.1 Blockchain and Decentralization in the Energy Sector

In their research, Kufeoglu et al. (2019), refers to Blockchain as a novel technology that eliminates one single central authority by creating a new consensus mechanism, which could be quite useful in energy trading. This is mainly because, the use of this technology enables creation of a platform which can connect supply and demand directly and solve the issue of lack of trust between the participants in the energy grid. Moreover, this trust creates the opportunity of reduced cost of transactions by eliminating the intermediary which is there to provide that trust in the first place. Blockchain as a disruptive information technology, is a consensus system that can build trust between transaction parties thus helping to achieve a fair, thrustless, transparent, and flexible environment. Particularly, for the energy sector, Blockchain can initiate the shift of the trading ecosystem from a centralised to decentralised one. And this is done by several actions, such as: removing the dependencies of intermediaries, multiple integrated services, consolidation of daily energy consumption etc (D2.3 - Papalexopoulos and Sulev, 2021).

6.2 Improved model -Virtual Power Plant

Virtual Power Plants (VPPs) aggregate DER units and offer them to the energy market. The aggregated DERs maintain reliability of renewable energy resources and address grid congestion. VPPs can be managed by third-party aggregators, BRPs, or suppliers. VPPs provide a variety of services to power plant operators, industries, public services, energy suppliers, and grid operators. VPPs create new business opportunities for aggregators and suppliers. Moreover, VPPS, provide various opportunities to stakeholders, such as energy trade, network services, and balancing services (Ma et al., 2017).

A VPP consists of generation units, energy storage, and Information Communication Technology (ICT) and they can be used in operations as VPPs for Trade, Balancing, and Network Services. The actors in the VPP structure are outlined in Figure 20.

Actor	Offers	To
VPP aggregator	Market access Ancillary services Balancing services Buy and sell electricity Network services	DER owners TSO BRP Wholesale Market DSO
DER owner	Produce electricity Direct control	VPP aggregator VPP aggregator
BRP	Settle the imbalance Accurate forecast of supply and demand Bilateral contracts [29]	Market VPP aggregator VPP aggregator
Policy maker	Energy rules	All actors

Figure 19 - Actors in Virtual Power Plants (VPPs) (Ma et al., 2017)

Designed to provide flexible grid services that are not highly dependent on the specific locations of the DER assets, VPPs are ideal for applications such as frequency regulation, peak demand management and secondary and tertiary reserves. They also enable energy trading in wholesale markets on behalf of DER owners who would otherwise not be able to participate on their own. VPPs can act as an arbitrageur between DERs and diverse energy trading floors (A. Papalexopoulos, 2021).

It is important to note that this is in contrast to the location-specific (e.g., tied to locations of specific assets such as feeders), primarily distribution system-focused grid services enabled by distributed energy resource management systems, or DERMS (A. Papalexopoulos, 2021).

Today's VPPs offer an ideal optimization platform for providing the supply and demand flexibility needed to accommodate the fast-ramping needs of renewables, to balance wind and solar intermittency and to address corresponding supply forecast errors. For example, if one wind power source generates more energy than predicted and another generates less, a VPP will balance the two, resulting in a more accurate forecast. In addition, the wind power becomes a more reliable source of capacity in the market. Often, in energy markets, market participants fire up large and less efficient power plants to grapple with small gaps in demand. They may deploy a 600-MW gas plant when only 5 MW is needed. With a VPP, when the TSO asks for 5 MW, the VPP will do two things. It will look for places to reduce load, so the system may not need all of the 5 MW. It will also look for places where it can self-generate electricity by discharging batteries, or dispatching wind or solar facilities (D2.3 - Papalexopoulos and Sulev, 2021).

VPPs incorporate short-term load, distributed generation forecasting and aggregation capabilities. They perform near real-time shifting of commercial and residential net loads to provide the services needed by the grid. Under the control of a VPP, demand on the system can be optimized and tweaked automatically, making day-ahead call-outs a thing of the past (A. Papalexopoulos, 2021).

VPPs have the ability to go beyond simple load curtailment and to leverage continuous communications and bi-directional control to deliver dispatchable grid support. As a result, aggregated DERs can be orchestrated by VPPs with second to minute response speeds (A. Papalexopoulos, 2021).

By design, VPPs can coordinate and control more efficient and clean sources of distributed energy so there's no need to overbuild or deploy fossil-fuel plants to balance electric demand and supply. The objective is to feed an automatic generation control signal to VPP that indicates the TSO's needs a certain amount of capacity at a certain point in time. The system can then go get that capacity within the bounds of what is currently available, at a specified confidence range, such as 2 MW with 95% confidence or 3 MW at 70% confidence (D2.3 - Papalexopoulos and Sulev, 2021).

6.3 Aggregation of Load Flexibility Tranches

As DERs proliferate and opportunities for active or flexible demand grow, "Aggregators" of these resources (or DER Aggregators or DERA) for the creating of the VPPs have the potential to help unlock the value of distributed resources and bring them into energy markets at scale. Aggregation is defined here as the act of grouping distinct agents in a power system (i.e., consumers, producers, prosumers, or any mix thereof) to act as a single entity when engaging in power system markets (whether wholesale or retail) or Transactive Energy trading (A. Papalexopoulos, 2021).

It is important to analyse the mechanisms by which aggregations create value. In many cases, aggregators are performing roles today that may not deliver value to power systems but rather reflect opportunities to arbitrage inadequate regulation. In other cases, aggregation delivers real value, but this value may become less significant in the future, as technological change reduces the costs of information provision, coordination, or transactions. Other activities may deliver enduring value (A. Papalexopoulos, 2021).

Aggregation has system value if it increases the social welfare of the power system. Private value is an increase in the economic welfare of a single agent or subset of agents. Private value creation may or may not align with system value creation. Aggregations with private value may create economic value for certain agents at the expense of system-wide economic efficiency (D2.3 - Papalexopoulos and Sulev, 2021).

We distinguish three broad categories of aggregation as follows:

1. Aggregations with *"fundamental"* value
2. Aggregations with *"transitory"* value
3. Aggregations with only *"opportunistic"* value

6.3.1 Fundamental Value of Aggregation

Fundamental value stems from factors inherent in the act of aggregation itself. In the context of the power system, aggregation may create fundamental value by capitalizing on economies of scale and scope and by managing uncertainty. Participation in electricity services markets incurs certain unavoidable costs. First, one must acquire or engage the owner of one or more energy resources (either centralized or distributed resources); second, if these resources are to interact with the market, they must be equipped with some level of information and communications technologies; third, energy resources and their owners must comply with power system regulations and market rules (A. Papalexopoulos, 2021).

Many of these costs include fixed and variable components. The existence of fixed costs may lead to a situation where the average cost of providing a service is higher than the marginal cost. In that case, the average cost of providing the service declines as the quantity of services provided increases. Thus, to the extent that there are fixed costs associated with participating in electricity services markets, there may be value in aggregation via *economies of scale*. Furthermore, to the extent that providing multiple services or products entails common technologies, transaction costs, acquisition costs, or knowledge bases, aggregation may create value through *economies of scope* (A. Papalexopoulos, 2021).

Finally, market parties have different risk preferences and capabilities to hedge against risks. A small agent may not be able to hedge against price risks while hedging products may be available to large agents (through contracts for differences for example). Therefore, DER Aggregators create value by managing uncertainty acting as intermediaries between a large number of small DERs and volatile markets to provide hedging solutions to market players (D2.3 - Papalexopoulos and Sulev, 2021).

In a nutshell, fundamental aggregations provide value by harnessing economies of scale and managing risks and uncertainties for participating DERs.

6.3.2 Transitory Value of Aggregation

DER Aggregators may create value as the power system transitions from current regulations and technologies to a more advanced smart grid future. Temporary value is not inherent to aggregation, but it may be unlocked by DER Aggregators. Opportunities for agents in the distribution system to increase system efficiency by engaging with the bulk power system are increasing as information and communications technologies enable loads to become more price-responsive and as DERs are increasingly deployed. However, market complexities, information gaps, lack of engagement, and other biases may prevent the value of DERs from being unlocked. DER Aggregators can create system value by managing or eliminating these factors. An agent may be capable of providing a service (or set of services) to the system but may lack the information required to do so effectively. For example, small DERs often lack information in a number of areas: when system peaks occur, what the prices are for various services they consume, what technologies are available to help them control consumption, what the prices of these technologies are, etc (D2.3 - Papalexopoulos and Sulev, 2021).

A DER Aggregator may be able to intervene to close gaps in information between an ISO and the various agents. Furthermore, a DER Aggregator can gain from economies of scale by processing information from multiple DERs, whereas costs would otherwise be multiplied by the number of DERs processing this information independently. It can also handle complex registration and bidding processes on behalf of the DERs they serve, enabling the system to benefit from the services these DERs provide and enabling them to benefit from previously untapped revenue streams (A. Papalexopoulos, 2021).

6.3.3 Opportunistic Value of Aggregation

Opportunistic aggregation may emerge as a response to imperfections in market design, regulation, or policy. This form of aggregation occurs when different DERs located at one or more sites aggregate to obtain private value in ways that don't increase the economic efficiency of the system as a whole. Opportunistic aggregation may work to restrict competition, especially for small DERs. We identify three categories of rules that can give rise to opportunistic aggregation: a) rules related to the procurement of balancing or ancillary services, b) rules related to the allocation of balancing costs or penalties for non-delivery of committed services to DERs, and c) inefficient locational price signals and/or network charges (A. Papalexopoulos, 2021).

6.4 Value Creation Framework - Virtual Power Plant (VPP) example

With the evaluation of the traditional energy business models and proposition of improved and decentralized business models, one can conclude that transactive energy models and dynamic VPPs are the way forward to achieve and harvest all technological potential that is at our disposal at this very moment (Giehl et al., 2020). With so much technological innovation and advancement, the players in the energy sector are obliged to look outside of the "traditional box" of solutions and provide new and advanced solutions for a better tomorrow.

An example of such solutions can be illustrated if one looks at the value network for the Virtual Power Plant Business Model. As seen in Figure 21, it shows a map of services, data, products, and energy flows of the business model prototype 'Virtual Power Plant'. Payment flows are opposite to the services and products and not depicted (Exceptions are possible, for example within the framework of mandatory notification obligations, which can result by information flows without a financing stream) (Giehl et al., 2020). The result illustrates the multitude and variety of customers, suppliers, and partners that a Virtual Power Plant requires. It also shows that a Virtual Power Plant only transports data. Concerning the electricity flow, the Virtual Power Plant is neither directly involved in generation nor transport. Such network can be created for all business models, identify gaps, help to close them, and offer practical use. Incentives can be established to fill these gaps in order to promote local value creation. For this purpose, the value creation network can identify gaps in the local business model landscape. Companies can use a value creation network for their business models or those of their customers to identify potential for (D2.3 - Papalexopoulos and Sulev, 2021).

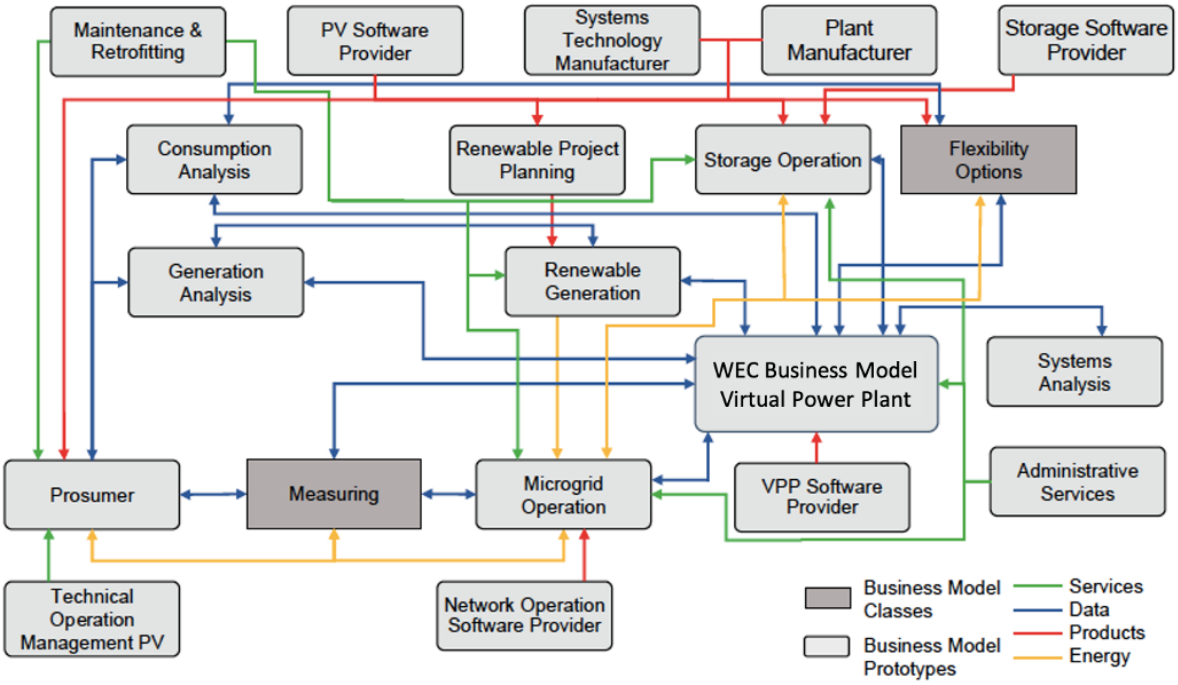

Figure 20 - Value creation network of a virtual power plant (VPP) (Giehl et al., 2020)

In analogy to what was previously argued in this chapter and supported by several research documents studied (Roozbehani et al., 2022; Xia-Bauer et al.,2021; Hamwi et al., 2020), one can illustrate several BMCs for VPP.

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

7/ The Business aspects of TwinERGY

Having previously extensively elaborated the business models (section 5 & 6; and D2.3), the products mix (D2.3), exploitable results (section 3 and 4), as well as the environment and market conditions (D2.2, D2.3, D2.4, D2.5) in which those results are generated, in this section though, we can explore the business and commercial aspects of the project potential.

7.1 Target Market and Key Stakeholders

Deliverable 2.2 (D2.2) deals with stakeholder analysis in order to be able to properly identify the key players in the market. In that respect, Figure 22 shows the identified stakeholders in this project.

End Users	• Residential Consumers (prosumers) • Commercial Users • Industrial Users • Distributed Energy Resources (DERs)
System Operators	• Distribution System Operators (DSOs) • Transmission System Operators (TSOs)
Autho-rities	• Policy Makers • Regulators
Energy Services	• Aggregators (Retailers and LECs) • Energy service companies (ESCOs)

Figure 21 - Stakeholder Identification (Source D2.2)

7.2 Solutions developed based on the Exploitable Results

As depicted in the TwinERGY GA (2020) combining all the activities together, TwinERGY aims to provide a set of solutions to enable consumer engagement into advanced demand response strategies reaching a level of "system maturity" for optimized multi vector integration. The individual technologies advanced during the projects will move largely from TRL5 to TRL8. The platform, which is the backbone of the project, holding the main commercial potential, as argued several times during the elaborations of this report, as well as, during the WPs and course of the TwinERGY project is summarized in Figure 23.

Module Name	TwinERGY Platfrorm
Partner	Consortium
Module Result Type	Software, Modules, Algorithms, Reports
Objective	TwinERGY platform is the backbone of the project and it is providing the necessary support for establishing the potential of the developed solutions
Target Groups	Retailers, Energy Communities, DSO, TSO, Aggregators, End Users
Exploitable Results and Value Proposition	
multi-disciplinary framework with multiple innovations which are targeting different actors fort utilization of that innovation in the energy sector, thus creating new value propositions which should provide tangible business benefits across the market. - Digital Twin Platform - Use of DT in Energy Markets - Transactive Energy Marketplace - Prosumer Engagement	
Positioning and Route to Market	
Short Term (2023)	- TRL 8 - Development
Medium Term (2023 - 2026)	- Commercial Global Rollout - Entering & growing strategies
Long Term (2026 – 2030)	- New functionalities to cover novel business models and market needs - Strategies for improvement and expansion

Figure 22 - Business Exploitation for TwinERGY platform

Consumer comfort / well-being assessment Module (TRL: 6-8) – Figure 24 - The tool is deployed in a building at the University of Patras (Greece) and is now being further developed enhance functionalities and efficiency enabling to undertake the load of the foreseen demonstrators.

Module Name	Consumer Well-Being
Partner	University of Patras
Module Result Type	Software & Report
Objective	The UPat corresponding research team to seize TwinERGY's opportunity and initiate a start-up in the road to market to commercialize the specific module.
Target Groups	Retailers
Exploitable Results and Value Proposition	
Result is obtaining consumers' comfort / well-being level using low-cost autonomous wearable devices through which data can be unobtrusively obtained and advance unsupervised classification techniques through which the obtained data shall be processed to formulate consumers' respective profiling.	
Positioning and Route to Market	
Short Term (2023)	TRL 7-8
Medium Term (2023 - 2026)	TRL9 – Market Entering and Establishing position strategies
Long Term (2026 – 2030)	Module updates with implication of growing strategies

Figure 23 - Business Exploitation for Consumer Well-Being Module

<u>Consumer demand flexibility profiling Module (TRL7-8)</u>: - Figure 25 - In TwinERGY, The IES Virtual Environment (VE) building analytics platform will be upgraded with respect to the calculational capabilities of flexibility variables both in their resolution and number. As the core component of the consumer Digital Twin new visualization capabilities will be introduced to enable the interaction with the end-users.

Module Name	Consumer and Neighbourhood demand flexibility profiling
Partner	IES R&D
Module Result Type	Software & Report
Objective	Digital Twin new visualization capabilities will be introduced to enable the interaction with the end users. New modelling modules will be added for dispatchable RES based generation, storage technologies and VPP optimization
Target Groups	Retailers, Energy Communities
Exploitable Results and Value Proposition	
It uses the capabilities of the consumer and communities Digital Twins methodology for calculating and profiling the potential flexibility and micro and macro level. The particular module is based both on physics-driven and data-driven modelling and simulation. Depending on the type of flexibility the appropriate modelling tool was deployed to calculate the amount of flexibility and its controllability aspects.	
Positioning and Route to Market	
Short Term (2023)	- TRL 8 - Development
Medium Term (2023 - 2026)	- Commercial application in Europe - 5-25 clients - Entering & growing strategies
Long Term (2026 – 2030)	Adding Digital Twin optimization Components - Strategies for improvement

Figure 24 - Business Exploitation for Consumer demand flexibility profiling Module

Community demand flexibility profiling Module (TRL6-8): - Figure 25 - The IES Intelligent Virtual Network (iVN) high-level district modelling tool for performing hierarchical demand aggregation and supply allocation. It will expand its internal databases on grid components and new modelling parts will be added for dispatchable RES based generation and storage technologies to perform detailed short-term grid planning, while the use of weather forecasting will introduce operational optimization of the VPP.

Home & Tertiary real-time Energy Monitoring Module(TRL7-8): - Figure 26 - This STAM tool, deployed in a University Building in Sassari (Sardinia), will be further developed to

Module Name	H&T Energy Monitoring
Partner	STAM Srl
Module Result Type	Software & Report
Objective	STAM's Home Energy Management platform is an operational service for home energy management. Extending the services with trading, modelling, decision and operation algorithms and the use of blockchain smart contracts will result in an integrated management platform.
Target Groups	Retailers, Energy Communities
Exploitable Results and Value Proposition	
This module leverages data from buildings and devices to optimize energy consumptions of buildings.	
Positioning and Route to Market	
Short Term (2023)	- TRL 8 - Development
Medium Term (2023 - 2026)	- Commercial application in Europe - 5-25 clients - Entering & growing strategies
	Adding Digital Twin optimization

Figure 25 - Business Exploitation for Home & Tertiary real-time Energy Monitoring Module

integrate with Digital Twins modular capabilities and serve a wide range of use cases both in terms of geography and building use.

DER management Module(TRL6-8): - Figure 27 - The basic features of the module for power flow optimization are already in the demonstration phase and the components of this module have been already used in the virtual plant context in several previous lab and field tests in multiple different research projects. It will be further developed, and parts of this module are used in several different applications individually or in combination to a certain extent which will be integrated.

Module Name	DER Management
Partner	TH OWL
Module Result Type	Report & Algorithm
Objective	The core idea of the DER module is the increase the flexibility of the electricity demand of the participating parties to comply with the varying production of RES. By doing so, energy communities can use the produced renewable energies more efficiently by shifting non time-critical consumptions to times, when more green energy is produced.
Target Groups	Retailers, Energy Communities
Exploitable Results and Value Proposition	
This module leverages data from buildings and devices to optimize energy consumptions of buildings.	
Positioning and Route to Market	
Short Term (2023)	- TRL 6-8 - Development
Medium Term (2023 - 2026)	- Entering & growing strategies
Long Term (2026 – 2030)	Adding Digital Twin optimization Components - Strategies for improvement

Figure 26 - Business Exploitation for DER Management Module

Risk Management and event handling Module (TRL 5-7): - Figure 28 - This tool has been significantly enhanced through different EU R&D projects (such as DAISY, RAMPART, EU Protect). The enhancement will enlarge the back-end database structure to allow interaction with service providers and improvement of the security and privacy structures.

Module Name	Risk Management
Partner	STAM Srl
Module Result Type	Report & Algorithm
Objective	The tool developed for the risk management in the Twinergy project has to deal with an array of threats and risks, stored inside the module database
Target Groups	Retailers
Exploitable Results and Value Proposition	
Provides development and implementation of a quantitative risk management application dedicated to the residential buildings.	
Positioning and Route to Market	
Short Term (2023)	TRL 7-8
Medium Term (2023 - 2026)	TRL9 – Market Entering and Establishing position strategies
Long Term (2026 – 2030)	Module updates with implication of growing strategies

Figure 27 - Business Exploitation for Risk Management Module

TwinEV module (TRL5-8): - Figure 29 - The TwinEV module is based on the Smart Charging Tool (SMAC) of ETRA. The aim within the project will be to complement the functionalities that will provide to SMAC giving it a more user-centric and cooperative approach and some profitability analysis.

Module Name	TwinEV
Partner	ETRA
Module Result Type	Software & Report
Objective	Novel, end user friendly, dynamic tariff EVs charging capabilities.
Target Groups	Retailers, Energy Communities
Exploitable Results and Value Proposition	
IT accounts for high-value services to EV users, such as minimum charging prices, maximum green electricity supply and different kinds of grid services.	
Positioning and Route to Market	
Short Term (2023)	- TRL 8 - Development
Medium Term (2023 - 2026)	- Commercial application in Europe - 5-50 clients - Entering & growing strategies
Long Term (2026 – 2030)	- New AI optimization components to cover Evs increased market penetration and customers needs. - Strategies for improvement

Figure 28 - Business Exploitation for TwinEV module

Transactive Energy Module (TRL7-8): - Figure 30 - WEC's Transactional decentralised trading platform will be enriched with further capabilities to serve novel block-chain enabled transactive market.

Module Name	Transactive Energy
Partner	WEC
Module Result Type	Software & Report
Objective	'Near real' time VPPs services into organized wholesale and retail markets.
Target Groups	Retailers, Energy Communities, Energy Market
Exploitable Results and Value Proposition	
It implements organized nodal electricity markets for the distribution grid, which are revolutionizing the relationships among customers, energy companies, and the grid under the new emerging transactive energy paradigm.	
Positioning and Route to Market	
Short Term (2023)	- TRL 8 - Development
Medium Term (2023 - 2026)	- Commercial Global Rollout - Entering & growing strategies
Long Term (2026 – 2030)	- New functionalities to cover novel business models and market needs - Strategies for improvement and expansion

Figure 29 - Business Exploitation for TE Module

Social Network Module (TRL 5-8): - Figure 31 - ED' mark platform (used in projects L4MS, DIH2 for creating access to manufacturing services), will be complemented with social nature functions and support Digital Twins feeding data.

Module Name	Social Network
Partner	ED
Module Result Type	Software & Report
Objective	The main goal of this module is to provide a handy mobile application that will essentially increase end-users awareness on energy issues, and trigger behavioural shifts when needed through self and community-based competition.
Target Groups	Prosumers, Customers, Energy Communities,
Exploitable Results and Value Proposition	
It promotes consumers' participation and engagement through Community-oriented engagement tools: Social comparison, Social competition/ community rewards and Social media. A mobile application provides an easy-to-use menu where the users can understand in different graphs and metrics for their energy savings achieved in different time scales. Quiz games are also available to engage the user getting more rewards which aim to provide some training on basic principles of energy consumption and usage.	
Positioning and Route to Market	
Short Term (2023)	- TRL 8 - Development
Medium Term (2023 - 2026)	- Placement in App Store and Play Store - Entering & growing strategies
Long Term (2026 – 2030)	- New functionalities and updates - Strategies for improvement and expansion

Figure 30 - Business Exploitation for Social Network Module

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

7.3. TwinERGY as a commercial entity

With the proposition to establish TwinERGY as an independent, fully functioning entity, which will provide the above listed product and services to the energy market in EU, for the time being, it is necessary to acknowledge its structure. Since the project is operated by a consortium with well-established track record for results and achievements and fully functioning panels, boards and management structure, a logical suggestion would be to keep the current structure and present itself to the market as a Joint Venture (JV). Before we go deeper into the management structure, we should mention here, that the newly formed company will be promoting and providing all products/services which come from the exploitable results of the TwinERGY project and offer them to the market. The shareholders will be all partners from the TwinERGY Consortium, which are interested in commercialization of the project results.

7.3.1 TwinERGY IPR Strategy

According to the TwinERGY Proposal Document (2020), the contours of intellectual property regime will be first defined in the consortium agreement, with full description provided in D1.8 Defining their intellectual property rights, partners will cover both foreground and background. Typically, foreground is owned by those who created it; however, in cases when multiple partners are involved, a joint ownership model is implemented, unless partners agree otherwise. All partners commit to inform each other of any intention to protect the intellectual property resulting from the project. By contrast, background includes any outputs/IPRs held by partners prior to signing the agreement, as well as any copyrights, trademarks or designs that were used for creating the foreground.

7.3.2 TwinERGY Vision

TwinERGY aspires to create the underpinnings of the future European energy marketplace, by providing a transactive framework, process and platform that enables key stakeholders to leverage on emerging energy technologies. In our project, developments such as micro- and local generation and storage, demand responsive systems, peer-to-peer trading, distributed ledger accounting and energy informatics are integrated in support of novel business models that democratise the future of energy and empower consumers and prosumers as cornerstones of the future energy market (D4.4).

7.3.3 TwinERGY Organizational Model

As mentioned previously, the most applicable structure for the consortium to go to the market would be through a Joint Venture (JV) model. The main characteristics of a JV, as described in the eDREAM project are:

- The reason for a JV is usually a specific project, thus it can be constituted for long-term or short-term.
- JV is able to combine resources and expertise. Indeed, in a JV each company can benefit from the other's talent.
- This kind of organization can be informal (a handshake) or formal. The contract used is the JV Agreement that sets out all the partners' rights and obligations.
- The use of the economies of scale offers participants savings, which is particularly appropriate with technology advances that are costly to implement. Moreover, other cost savings in a JV can include sharing advertising or labour costs.
- A JV can create a separate business entity (corporation, LLC or partnership), to which the owners contribute assets, or operate jointly as separate entities.

Further to this, the organizational and managerial structure for day-to day activities should be organized through General Assembly as the ultimate decision-making body of the consortium composed of one representative of each partner of the consortium, which can be chaired by the Project Coordinator. In this case, the Project Coordinator, can assume the position of a General Manager or CEO of the new entity, along with several other Executive directors that will support the CEO in their respective areas of expertise. Executive Board, as the supervisory body for the execution of the operational activities, which shall report to and be accountable to the General Assembly, will be established as well (TwinERGY GA, 2020).

The formation of a management team, that will support the Executive board and the Executive directors, with relations to the day-to-day operational activities, is the next step in the organizational structure formation, where each partner will hold a managerial position linked to their respective module/product/service offering, and run operations (Marketing & Sales, Development, Customer Service).

7.3.4 Marketing & Sales

It is widely known and accepted that Marketing and Sales activities are extremely important part to have in every business connected and dealing with commercialization of a solution/idea/project. For this reason, TwinERGY has dedicated a lot of work, through

WP2, 4, 11 to properly reach, engage and attract the targeted potential customers in order to sell the idea and later the service/product of TwinERGY business model.

7.3.5 TwinERGY Financials

Through discussions with consortium partners, stakeholders and partner's own professional networks, moreover, with support of the research done throughout the course of the TwinERGY project, multiple inputs and financial indicators have been identified, which can help us project the possible, forecasted financial statements for the project. Following up on the costs and revenue streams of the suggested business model, we can summarize the results if such actions are undertaken and TwinERGY as a solution is taken to the market.

Cost as one of the key blocks in the BMC, is comprised from CAPEX and OPEX, where CAPEX is more on the technological side providing technical inputs, that are needed for proper operation of the product/solution, while the OPEX is related to the operational side of the business, related to managerial, operations and marketing activities. Money spent on CAPEX purchases is not immediately reported on an income statement. Rather, it is treated as an asset on the balance sheet, that is deducted over the course of several years as a depreciation expense, beginning the year following the date on which the item is purchased (Smith and Li, 2021).

On the other side, the revenue generation streams were explained in the business model section and those are coming from multiple sources related to the key value propositions which the platform is offering to the energy market.

INCOME (SALES)	TREND	2023	2024	2025	2026	2027	Total	IND %	2023	2024	2025	2026	2027
TwinERGY Platform (SaaS)		€ 10.365,00	€ 598.065,00	€ 1.324.789,00	€ 6.749.139,00	€ 22.493.763,00	€ 31.176.121,00	12%	40%	58%	54%	72%	89%
Service Revenues		€ 15.771,00	€ 254.046,00	€ 389.327,00	€ 1.381.241,00	€ 764.217,00	€ 2.804.602,00	18%	60%	25%	16%	15%	3%
Royalties		€ -	€ 143.014,00	€ 345.992,00	€ 254.604,00	€ 525.383,00	€ 1.268.993,00	19%	0%	14%	14%	3%	2%
Revenue Sharing		€ -	€ 27.139,00	€ 109.272,00	€ 179.383,00	€ 577.003,00	€ 892.797,00	11%	0%	3%	4%	2%	2%
Data for BA		€ -	€ 4.601,00	€ 299.111,00	€ 760.545,00	€ 1.025.681,00	€ 2.089.938,00	20%	0%	0%	12%	8%	4%
TOTAL SALES		**€ 26.136,00**	**€ 1.026.865,00**	**€ 2.468.491,00**	**€ 9.324.912,00**	**€ 25.386.047,00**	**€ 38.232.451,00**	**80%**	**100%**	**100%**	**100%**	**100%**	**100%**

Figure 31 - Revenue projections

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Figure 32 illustrates the projected revenue streams based on our research, and from here one can have an overview of how each revenue stream contributes to the general revenue mix of the proposed TwinERGY business models, when and if established on the market. The trend analysis illustratively shows a quick overview of the revenue stream through the years and can provide a notification if something is wrong, even on a first glance. The second part of the table shows the percentage contribution of how much that particular revenue stream participates in the revenue mix, for that particular year or time period.

COST OF SALES	TREND	2023	2024	2025	2026	2027	YEARLY	IND %	2023	2024	2025	2026	2027
Platform Inputs to COGS		€ 396.334,00	€ 1.203.680,00	€ 3.257.945,00	€ 6.490.851,00	€ 11.114.920,00	€ 22.463.730,00	12%	94%	83%	83%	79%	81%
Network Cost		€ 7.920,00	€ 136.320,00	€ 301.650,00	€ 351.065,00	€ 504.225,00	€ 1.301.180,00	18%	2%	9%	8%	4%	4%
Waranties		€ 5.227,00	€ 82.149,00	€ 230.954,00	€ 772.881,00	€ 728.934,00	€ 1.820.145,00	19%	1%	6%	6%	9%	5%
AWS fees		€ 11.550,00	€ 22.000,00	€ 67.889,00	€ 347.829,00	€ 756.338,00	€ 1.205.606,00	11%	3%	2%	2%	4%	6%
Retention Cost		€ -	€ 3.600,00	€ 24.092,00	€ 58.037,00	€ 140.775,00	€ 226.504,00	20%	0%	0%	1%	1%	1%
3rd Party integration		€ -	€ 7.500,00	€ 39.000,00	€ 80.400,00	€ 125.919,00	€ 252.819,00	10%	0%	1%	1%	1%	1%
Alnalytics		€ -	€ -	€ 11.703,00	€ 98.446,00	€ 313.022,00	€ 423.171,00	10%	0%	0%	0%	1%	2%
TOTAL COST OF SALES		**€ 421.031,00**	**€ 1.455.249,00**	**€ 3.933.233,00**	**€ 8.199.509,00**	**€ 13.684.133,00**	**€ 27.693.155,00**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Gross Profit		**-€ 394.895,00**	**-€ 428.384,00**	**-€ 1.464.742,00**	**€ 1.125.403,00**	**€ 11.701.914,00**	**€ 10.539.296,00**		**-4%**	**-4%**	**-14%**	**11%**	**111%**

Figure 32 - Cost of sales

In the similar fashion, Figure 33, illustrates the cost of sales which are greatly affected by

Figure 33 – Operating expenses

the COGS element for provision of the services through TwinERGY platform to the final customer and the additional inputs with are required for proper operation of the COGS element of the mix. Additionally, Figure 33 summarizes the results from previous Figure 32, where the revenues are forecasted and provides one cumulative estimation of the Gross Profit in the current forecasted state based on our evaluation and research.

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

EXPENSES	TREND	2023	2024	2025	2026	2027	YEARLY	IND %	2023	2024	2025	2026	2027	YEAR %
Personnel expense		€ 158.000,00	€ 180.000,00	€ 370.000,00	€ 495.000,00	€ 440.500,00	€ 1.643.500,00	12%	38%	34%	28%	24%	9%	18%
Sales & Marketing		€ 129.900,00	€ 150.000,00	€ 525.000,00	€ 1.149.700,00	€ 2.277.100,00	€ 4.231.700,00	9%	31%	29%	39%	56%	47%	46%
General & Admin		€ 90.000,00	€ 110.500,00	€ 139.800,00	€ 255.000,00	€ 667.320,00	€ 1.262.620,00	2%	22%	21%	10%	12%	14%	14%
R&D		€ 29.000,00	€ 47.000,00	€ 220.000,00	€ 135.000,00	€ 1.390.000,00	€ 1.821.000,00	8%	7%	9%	17%	7%	28%	20%
Misc. (unspecified)		€ 7.000,00	€ 35.000,00	€ 77.000,00	€ 28.000,00	€ 110.000,00	€ 257.000,00	3%	2%	7%	6%	1%	2%	3%
TOTAL EXPENSES		**€ 413.900,00**	**€ 522.500,00**	**€ 1.331.800,00**	**€ 2.062.700,00**	**€ 4.884.920,00**	**€ 9.215.820,00**	**34%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Net Profit		**-€ 808.795,00**	**-€ 950.884,00**	**-€ 2.796.542,00**	**-€ 937.297,00**	**€ 6.816.994,00**	**€ 1.323.476,00**		**-61%**	**-72%**	**-211%**	**-71%**	**515%**	**100%**

Finally, Figure 34 shows the operating expenses needed for business day-to-day operations and how they affect the gross profit, previously calculated, in order to provide the reader with the final Net Profit (Loss) of the TwinERGY proposed business model. Of course, one should note here that these are forecasts based on simple estimations and assumptions, therefore, deeper analysis is required before this business model is actually considered for launching on the energy market.

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7.3.6 TwinERGY Pro Forma Income Statement

INCOME (SALES)	TREND	2023	2024	2025	2026	2027	Total	IND %	2023	2024	2025	2026	2027	
TwinERGY Platform (SaaS)		€ 10.365,00	€ 598.065,00	€ 1.324.789,00	€ 6.749.139,00	€ 22.493.763,00	€ 31.176.121,00	12%	40%	58%	54%	72%	89%	
Service Revenues		€ 15.771,00	€ 254.046,00	€ 389.327,00	€ 1.381.241,00	€ 764.217,00	€ 2.804.602,00	18%	60%	25%	16%	15%	3%	
Royalties		€ -	€ 143.014,00	€ 345.992,00	€ 254.604,00	€ 525.383,00	€ 1.268.993,00	19%	0%	14%	14%	3%	2%	
Revenue Sharing		€ -	€ 27.139,00	€ 109.272,00	€ 179.383,00	€ 577.003,00	€ 892.797,00	11%	0%	3%	4%	2%	2%	
Data for BA		€ -	€ 4.601,00	€ 299.111,00	€ 760.545,00	€ 1.025.681,00	€ 2.089.938,00	20%	0%	0%	12%	8%	4%	
TOTAL SALES		**€ 26.136,00**	**€ 1.026.865,00**	**€ 2.468.491,00**	**€ 9.324.912,00**	**€ 25.386.047,00**	**€ 38.232.451,00**	**80%**	**100%**	**100%**	**100%**	**100%**	**100%**	
COST OF SALES	**TREND**													
Platform Inputs to COGS		€ 396.334,00	€ 1.203.680,00	€ 3.257.945,00	€ 6.490.851,00	€ 11.114.920,00	€ 22.463.730,00	12%	94%	83%	83%	79%	81%	
Network Cost		€ 7.920,00	€ 136.320,00	€ 301.650,00	€ 351.065,00	€ 504.225,00	€ 1.301.180,00	18%	2%	9%	8%	4%	4%	
Waranties		€ 5.227,00	€ 82.149,00	€ 230.954,00	€ 772.881,00	€ 728.934,00	€ 1.820.145,00	19%	1%	6%	6%	9%	5%	
AWS fees		€ 11.550,00	€ 22.000,00	€ 67.889,00	€ 347.829,00	€ 756.338,00	€ 1.205.606,00	11%	3%	2%	2%	4%	6%	
Retention Cost		€ -	€ 3.600,00	€ 24.092,00	€ 58.037,00	€ 140.775,00	€ 226.504,00	20%	0%	0%	1%	1%	1%	
3rd Party integration		€ -	€ 7.500,00	€ 39.000,00	€ 80.400,00	€ 125.919,00	€ 252.819,00	10%	0%	1%	1%	1%	1%	
Alnalytics		€ -	€ -	€ 11.703,00	€ 98.446,00	€ 313.022,00	€ 423.171,00	10%	0%	0%	0%	1%	2%	
TOTAL COST OF SALES		**€ 421.031,00**	**€ 1.455.249,00**	**€ 3.933.233,00**	**€ 8.199.509,00**	**€ 13.684.133,00**	**€ 27.693.155,00**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
Gross Profit		**-€ 394.895,00**	**-€ 428.384,00**	**-€ 1.464.742,00**	**€ 1.125.403,00**	**€ 11.701.914,00**	**€ 10.539.296,00**		**-4%**	**-4%**	**-14%**	**11%**	**111%**	
EXPENSES	**TREND**													
Personnel expense		€ 158.000,00	€ 180.000,00	€ 370.000,00	€ 495.000,00	€ 440.500,00	€ 1.643.500,00	12%	38%	34%	28%	24%	9%	18%
Sales & Marketing		€ 129.900,00	€ 150.000,00	€ 525.000,00	€ 1.149.700,00	€ 2.277.100,00	€ 4.231.700,00	9%	31%	29%	39%	56%	47%	46%
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TOTAL EXPENSES		**€ 413.900,00**	**€ 522.500,00**	**€ 1.331.800,00**	**€ 2.062.700,00**	**€ 4.884.920,00**	**€ 9.215.820,00**	**34%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Net Profit		**-€ 808.795,00**	**-€ 950.884,00**	**-€ 2.796.542,00**	**-€ 937.297,00**	**€ 6.816.994,00**	**€ 1.323.476,00**		**-61%**	**-72%**	**-211%**	**-71%**	**515%**	**100%**

Figure 34 - Pro Forma Income Statement

8/ Conclusions

This deliverable provides a conceptual overview as a fusion between business exploitation and innovative business plan, which integrates results from several previous WPs and deliverables (WP2,3,4,6,7; D2.2, D2.3, D2.4, D2.5, D4.3, D6.4), while also providing an overview of the new market opportunities and exploitable project results from business perspective and how those can impact, shift and most importantly improve the business models in the energy markets.

The unique value that this document creates is coming from the ability to fuse the results throughout the course of the TwinERGY project and provide additional value creation by creating improved scenarios for better value delivery of the project.

Starting from the market analysis and the forces existing in the Pilot countries, this deliverable is exploring the forces that exist in Pilot countries, comprehend their impact, and use that knowledge to drive the next step of value creation in your business models. With market conditions and forces at the forefront, including economic, technical, and regulatory obstacles, this report sublimes findings from previous deliverables, which arms the TwinERGY project with the tools to overcome any barrier and emerge as a leader in innovation and strategy. Backed by comprehensive research, including KPIs, use cases, and stakeholder analysis, this report provides a clear understanding of the players and conditions for the development of successful business models.

As the understanding of the market though the market analysis cleared the way in terms of which direction the project should take, it is possible to move on, to the elaboration of the exploitable results, which the project has achieved. The identified main exploitable results are the following: TwinERGY Platform, TwinERGY Modules and TwinERGY Products/Services. Each of them has been evaluated and elaborated, extensively, in the respective project WPs and deliverables and again tackled in this paper, looking for best approach of how to improve the results for the future. In that respect, this report identifies strategic advantages that the project carries through its results, in the forms of the 'Digital Twins at the heart of the energy management system' (D4.3) and the development of 'Digitally-enabled Energy Marketplace (Transactive Energy)' (D4.3).

The elaboration of these unique key strategic advantages, started in D2.3 and is being improved in this report, thus, helping to create the business models canvas (BMC) for TwinERGY as an independent, powerful business models, which aims to deliver ultimate improved value creation. Additionally, these inputs enable the improvement of several

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other business models, such as, the digitally enabled transactive energy marketplace, powered by blockchain and supported by smart contract, in order to provide seamless and automated, secure transactions. The BMC captures and visualises the key blocks in order to understand the real power and potential of this model. In analogy to this, comes the elaboration of the aggregator business model, with attention to VPPs, as a driver that is poised to be of extremely big value for the future operations and optimization of the flexibility markets and the whole energy market in general.

At the end, the report touches upon the classic elements of the business plans, in terms of target market, product/service mix, marketing and especially the financial projections, in order to give a positive push of TwinERGY towards real market commercialization.

The potential of TwinERGY is tremendous, riding on the back of the strategic exploitable advantages, novel solutions and innovative business models, it lays the ground for successful launch to the market, in order to be able to share all values that have been created as part of the project. World famous corporations (Google, Ford, GM) have already announced that they will be creating alliance in order to tackle novel solutions (VPPs and TE) in the energy market (Reuters, 2023). TwinERGY, already ripping the benefits of having the exploitable business results, first hand, has a huge first mover advantage, which is extremely highly regarded not only as opportunity for value creation and delivery, but also from investors perspective, as a lighthouse for what the future on the energy market will bring. This deliverable report, backed up by the information from previous WPs and deliverables is creating the foundation for the next deliverables to build upon and bring the project to a successful commercialization and new frontiers.

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Appendix

Appendix 1 - High Level Use Cases

- *HLUC01 – Home Energy Management*

The energy management in residential consumer premises is tackled through the monitoring of energy flows, the maximization of self- consumption and self-sufficiency and the reduction of the costs for the users enhancing their active role in energy efficiency processes. For that purpose, data is gathered (static and dynamic), processed and analysed. In order to go deeper into the objectives of this particular HLUC, it is subdivided into different specific goals, which are called Primary Use Cases (PUC) and Secondary Use Cases (SUC): (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC01.01. Increase the building observability
- PUC01.02 Flexibility modelling
- PUC01.03 Optimal flexibility management system
- PUC01.04 Control of the smart devices
- SUC01.01 H&T EMS GUI development

- *HLUC02- RES generation in domestic and tertiary buildings*

This Use Case creates further Renewable Energy Sources (RES) and the appropriate infrastructure to share these resources both in public and private buildings. This HLUC is developed in the four pilot sites, focusing on the possibility for this RES resources to participate in Demand Response campaigns and in the Energy trading platform. To delve further into this particular HLUC, it is processed into different PUC: (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC02.01 Dispatch of existing RES in domestic and tertiary buildings to minimise cost/carbon emissions
- PUC02.02 Optimal future energy storage to maximise RES production
- PUC02.03 Maximum future RES capacity according to the physical constraints of the pilot site, as well as present/future V2G capacity as determined by the TwinEV module
- PUC02.04 Optimal CHP solution specific to the pilot site in terms of capital costs and network capacity

- PUC02.05 Optimal scenario of future energy storage and RES to minimise energy costs for the end user/carbon emissions
- PUC02.06 Optimal domestic and tertiary demand response, based on RES, to minimise cost/carbon emissions

▪ *HLUC03- Grid capacity enhancement utilizing E-mobility*

This Use Case studies the potential use of EV smart charging as an asset for Grid Purposes (stabilizing the integration of RES and allowing the participation in energy flexible markets). Furthermore, promotes the decarbonization of neighbourhoods using EVs. This HLUC can be also divided into different Primary Use Cases (PUC): (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC03.01. Booking a charge session
- PUC03.02. Smart Charging to follow grid requests
- PUC03.03. Smart Charging to maximize RES integration (green electricity)
- PUC03.04. Smart Charging to minimize charge costs
- PUC03.05. Smart Charging to minimize time of charge
- PUC03.06. Searching of the most suitable station
- PUC03.07. Grid Management

▪ *HLUC04- Prosumer's empowerment in Local Energy Trading Markets*

This Use Case provides solutions to Transactive Energy Use Cases as well as enabling the gird decentralization and democratization by the connection of micro-grid operators, DER managers and end users. The core of this HLUC is the promotion of a transactional platform that will offer to sell flexible energy loads and excess capacity to an open market with micro-grid operators (e.g., IoT devices, buildings, substations) at a Local Energy Market (LEM). This HLUC is depicted into two different PUCs: (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC04.01. Recording transactions of energy: Recording transactions of energy distributed back into the grid or to a private or public storage facility, recording transactions of energy between prosumers and Recording transactions of energy between prosumer consortia
- PUC04.02. Calculation and broadcasting of LEM pricing compared to DNO/DSO pricing.

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- *HLUC05- Enhance grid flexibility through DER Management*

This Use Case determines how grid congestion management is operated and tested through the study of combined network data, loads and RES production and different forecasts. The aim is to improve the grid's flexibility and stability, as well as local RES share. This HLUC can be separated into three different PUCs: (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC05.01. Grid status calculation and bottleneck detection
- PUC05.02. Prediction of energy consumption and RES production
- PUC05.03. Utilizing the Virtual-Power-Plant

- *HLUC06- Consumer's engagement in Demand Side Management Programs utilizing feedback mechanisms*

This Use Case generates a demand-side intervention strategy to be applied at a residential level, describing how DSO/Retailers can provide a feedback mechanism increasing residential awareness, engagement to enhance the decrease of residential energy use and increase demand flexibility at residential places. For that purpose, this HLUC is going to be addressed through two distinct PUCs as follows: (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC06.01. Increase residential demand flexibility
- PUC06.02. Decrease residential energy use

- *HLUC07- Consumer's engagement in Demand Response programs utilizing a socio-economic context*

This Use Case implementing a set of social context drivers for energy-related behaviour by exploiting social interaction and cultural values. The aim is to influence energy exchanges between households relying on consumer's attitudes towards benefits and comfort. This HLUC can be split into three different PUCs: (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC07.01. Social marketing to engage customers via competition
- PUC07.02. End users' engagement on utilization of shared DERs

- PUC07.03. Enable co-creation for end consumers, service providers and public authorities.

- *HLUC08- Consumer's engagement in Demand Response programs utilizing personalized comfort/health-oriented services*

This Use Case shows the utilization of low-cost wearable devices from which physiological data can be obtained. This is facilitating the utilization of classification techniques that comprise a combination of depicted consumer's comfort/well-being leading to the human-centric approach that is utilized at Demand Response campaigns. This HLUC is realized in these Primary Use Cases (PUC): (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC08.01. Wellbeing best practice for indoor environment conditions
- PUC08.02. Physiological parameter and comfort feedback monitoring
- PUC08.03. Comfort relation within DR optimal solution

- *HLUC09- Consumer Engagement in Demand Response Programs Utilizing Digital Twin Prediction Capabilities for Dynamic VPPs*

This Use Case is focusing on consumer engagement in Demand Response programs, which are based on Digital Twins. In this HLUC, different dashboards are created with the purpose of generating relevant information regarding home/building/community demand response campaigns based off price and carbon emission factor for electricity at a specific time. This HLUC can be addressed into two different PUCs: (D4.3, D2.2, TwinERGY Proposal 2020)

- PUC09.01 Explicit Demand Response Automation and display at a consumer and community level.
- PUC09.02 Implicit Demand Response Calculation and Communication to the end user at both a community and consumer level.