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NOVICE

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D6.2 Report on Validation Results

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EXECUTIVE SUMMARY

The aim of the NOVICE project over the last 3 years has been to develop and demonstrate a new business model for Energy Services Companies (ESCOs) in building retrofit that would improve the business case for Energy Performance Contracts (EPC). By considering the flexibility potential of the onsite energy assets during the design of the building renovations, this business model has the potential to provide energy efficiency savings to buildings and demand response services to the grid, thus creating a dual revenue stream that can reduce the payback period of the building renovation as a whole. In order to validate the business model, the NOVICE project team have attempted to apply these ideas at suitable demonstration sites.

Initially, the project team planned to find a site at which they could recommend a package of energy efficiency and demand response measures, install them under an EPC, then monitor the impact of the measures on site energy consumption, revenues generated and thermal comfort of occupants in order to use real site data to validate the proposed NOVICE business model. The intention was to use the demonstration site to validate the assumptions used in the modelling work undertaken as part of Work Package (WP) 5. The NOVICE project team made significant efforts to try to secure a demonstration site where a dual services project could be implemented and directly monitored. Although several sites expressed interest, in the end, for different reasons that are described in detail in section 2.1 of this report, no building owner agreed to the project implementation. This has pushed the NOVICE team to find other solutions to demonstrate the business model, involving a mix of metered data and theoretical assessments.

Since no demonstration site showed willingness to implement an EPC that would include demand response services, the NOVICE team decided to validate the model by overlaying a theoretical evaluation of the facility's energy efficiency and demand response potential onto the site's measured energy consumption. The NOVICE business model is considered successfully validated if it manages to produce an impact on the overall project payback period, more specifically, if it reduces the payback period of a dual services EPC when compared to a traditional EPC project that considers energy efficiency alone.

Noel Lawler Green Energy Solutions (NLGES) provided a theoretical assessment of energy efficiency and demand response potential for one of their clients, a supermarket in Kilkenny, who agreed to share the data with the NOVICE consortium. This report looked at the financial metrics for the business model with the ultimate goal of assessing whether the demand response component would reduce the overall payback period of the project.

The analysis identified the following energy efficiency upgrades that resulted in a total reduction in site energy consumption of 36%:

- Upgrade existing lighting systems to LEDs.
- Improvements to the control and operation of the store's HVAC system.
- Upgrade the refrigeration system including using new refrigerant to comply with F-gas regulations.
- Install heat recovery to use waste heat from the refrigeration system to preheat domestic hot water.
- Install solar PV panels to the roof of the supermarket.

After all the energy efficiency measures have been implemented, it is expected that a reduction in total site energy consumption (electricity, heat, PV) of 36% can be achieved and the total annual energy savings for the site (electrical + thermal) amount to 963,381 kWh (see Table 5-2 for more detail). It can be seen that while the refrigeration measure has a high initial cost, it achieves a considerable reduction in energy consumption of 75% compared to the previous system. The energy efficiency measures reduce site electricity consumption by 39%, which can be reduced by a further 30% with the installation of PV panels. In total, this amounts to a reduction in site electricity consumption of 57%. The overall payback period associated with installing this package of measures at the supermarket is 11.8 years. This represents the business as usual case for a traditional EPC.

The NOVICE dual service model includes demand response services as well as energy efficiency measures as part of an EPC. The NOVICE business model for this demonstration site analyses the impact of participating in the Irish demand response programmes alongside the proposed energy efficiency measures to simulate an enhanced EPC. To this end, NLGES obtained a quote for flexibility services at this site from an Irish demand response aggregator. The aggregator determined that the HVAC and refrigeration equipment found at the supermarket site can be used in programmes that require fast response time with short duration and on-site backup generator can be used to provide flexibility for longer duration events. It is estimated that by participating in the combination of demand response programmes recommended by the aggregator, the supermarket could realise a further €13,000 per year in additional revenues at no additional capital cost.

From the resulting analysis, it is found that the overall project payback period does indeed reduce from 11.8 years to 10.7 years, simply from selling the site’s flexibility to the electricity grid. This equates to a 9.3% improvement in the payback period through combining energy efficiency with demand response compared to energy efficiency alone. This decrease in project length comes at no additional cost to the building owner. If the building owner would also consider the installation of 150 kW battery storage system on site at an additional capital cost of €83,500, then the payback period of the project can be further reduced to 9.9 years, equating to an overall improvement of 16.1% (from 11.8 years to 9.9 years). The reduction in payback period is an important result that improves the business case for traditional EPCs, making it easier for ESCOs to sell this type of project to their clients. This of course, is based on the Irish demand response market prices and regulations, and therefore will differ in other European countries where the markets have reached a different level of maturity. The output of this task will feed into the final description of the business model in Task 7.5 – Business model determination.

CONTENTS

LIST OF TABLES

ABBREVIATIONS

ADE	Association of Decentralized Energy
AHU	Air Handling Unit
BMS	Building Management System
CAPEX	Capital Expenditure
D	Deliverable
DFFR	Dynamic Fast Frequency Response
DHW	Domestic Hot Water
DR	Demand Response
DSU	Demand Side Unit
EE	Energy Efficiency
EPC	Energy Performance Contracting
ESCO	Energy Services Company
FFR	Fast Frequency Response
F-gases	Fluorinated gases
GW	Gigawatt
HVAC	Heating, Ventilation and Air conditioning
kW	Kilowatt
kWp	Kilowatt peak
LED	Light Emitting Diode
MIC	Maximum Import Capacity
MoU	Memorandum of Understanding
MW	Megawatt
NLGES	Noel Lawler Green Energy Solutions
NOVICE	New Buildings Energy Renovation Business Models incorporating dual energy services
O&M	Operation and maintenance
POR	Primary Operating Reserve
PV	Photovoltaic
PVGIS	Photovoltaic Geographical Information System
refr.	Refrigeration
RM1	Ramping Margin 1
RRD	Replacement Reserve - Desynchronized
SOR	Secondary Operating Reserve
STOR	Short Term Operating Reserve
tCO2	tons carbon dioxide emissions
TOR1	Tertiary Operating Reserve 1
TOR2	Tertiary Operating Reserve 2
TSO	Transmission System Operator
WP	Work Package

1 INTRODUCTION

1.1 NOVICE IN BRIEF

The aim of the NOVICE project over the last 3 years has been to develop and demonstrate a new business model for Energy Services Companies (ESCOs) in building retrofit that would improve the business case for Energy Performance Contracts (EPC). By considering the flexibility potential of the onsite energy assets during the design of the building renovations, this business model has the potential to provide energy efficiency savings to buildings and demand response services to the grid, thus creating a dual revenue stream that can reduce the payback period of the building renovation as a whole. This could drive market uptake of the EPC model in Europe, making it more attractive to building owners and investors. In order to validate the business model, the NOVICE project team have attempted to apply these ideas at suitable demonstration sites. For the purpose of this report, the NOVICE business model is also referred to as the 'dual services' model.

1.2 OBJECTIVE OF THE REPORT

The objective of this report is:

- To define and calculate the financial metrics for the demonstration site required to test and validate the business model.
- To assess whether the inclusion of demand response reduces the payback overall payback period of building retrofit projects examined.
- To quantify the extent to which payback period is reduced by considering both energy efficiency and demand response during building retrofit project.

This is achieved by using data supplied by Noel Lawler Green Energy Solutions (NLGES), one of the NOVICE partners, for a supermarket site in Ireland and performing the necessary calculations to examine the impact of a dual services approach on the payback period of a package of energy related projects that could be delivered using an EPC.

1.3 LIMITATIONS

Initially, the project team planned to find a site at which they could recommend a package of energy efficiency (EE) and demand response (DR) measures, install them under an EPC, then monitor the impact of the measures on site energy consumption, revenues generated and thermal comfort of occupants in order use real site data to validate the proposed NOVICE business model. The intention was to use the demonstration site to validate the assumptions used in the modelling work undertaken as part of Work Package (WP) 5. At the time that the work on WP5 was conducted, the NOVICE project was attempting to obtaining an agreement for implementing the project in a youth hostel in the UK, therefore several elements of WP5, (including D5.2 - Report on technical and economic characteristics for selected buildings and D5.5 - Technical specifications for demonstration retrofitting projects), focussed on that building. However, the owners of the youth hostel decided not to go ahead with the implementation of the suggested package of measures, as they felt it would cause too much disruption to their business. The validation exercise in this report, therefore does not relate to the specific building described in D5.2 and D5.5 but can still be compared to the modelling of building archetypes described in D5.4 Report on revenue flows and feasibility studies by building type and country.

As discussed in more detail in section 2.1, it was not possible to find a suitable demonstration site at which all elements of the NOVICE dual services project could be implemented and validated. In light of this, the partners had to come up with a new method for demonstrating the NOVICE business model. As such, the dual services model is not validated against the assumptions in WP5, but whether or not it manages to have a positive impact on the payback period, and therefore the contract length of the project.

One important element that was discovered from this demonstration facility is that in Ireland, a site is allowed to participate in all the different flexibility services (fast frequency response, primary, secondary, tertiary operating reserve etc.) at the same time. This is quite a unique situation in Europe. In most other countries, the building owner would have to choose only one demand response scheme to participate in for the whole period of the contract varying from a single day to a whole year, depending on the specific market conditions. This extraordinary condition for Ireland was not considered in D5.4 - Report on revenue flows and feasibility studies, so in that report, it was assumed the sites could only participate in one demand response service at a time. Therefore, depending on the technical conditions in the building the actual revenue flows for buildings in Ireland could be greater than those that were presented in that report.

2 METHODOLOGY FOR BUSINESS MODEL VALIDATION

2.1 FINDING DEMONSTRATION SITES

Initially, the NOVICE project plan was to find demonstration sites from the portfolios of existing clients of project partners. However, the following barriers were encountered and prevented the existing clients from participating in the project:

- Most of the clients working with the project partners preferred not to enter into an Energy Performance Contract because they would rather self-finance energy efficiency projects.
- The available projects were in an advanced stage (either fully designed or already implemented energy efficiency measures) with no possibility to change the scope to include demand response.
- Smaller ESCOs that are establishing themselves in the market do not have the capacity to adapt their business model to include DR and aggregation at this stage as it could significantly increase their cost of sale.
- For potential demonstration sites located in countries where the EPC/ESCO market is relatively immature, the addition of demand response to the contract increases complexity to the point where clients no longer wish to engage in an EPC. This is the case in Austria.
- The analysis from D3.4 – SWOT Analysis for the Joint Services Business Model (Southernwood et al., 2018), shows that even in countries where the EPC/ESCO market is mature, an immature demand response market makes it impossible to fully implement the NOVICE dual service model in tertiary buildings because the financial and/or administrative burdens of aggregation weakens the business case for participation (e.g. Germany).
- In some countries where demand response market is mature and aggregation is allowed, the aggregators only want to work with large amount of flexibility, therefore reducing the spectrum of available sites to very large industrial sites (e.g. Germany).
- Many clients and building owners that were approached to participate felt that the outcome of installing the recommended energy efficiency measures was not worth the level of disruption to their business. This is the case with the youth hostel in the UK that was included in many of the WP5 delvierables.

2.1.1 Site 1: Leisure Centres in Dublin, Ireland

After careful consideration, the most suitable client available from NGLES's portfolio was Dublin City Council, who already had an EPC with NLGES covering 3 of the leisure centres in the city. Although not an ideal demonstration site since the buildings were already under EPC and already had energy efficiency measures installed, the Council were willing to allow demand response to be added to the scope of works covered by the contract, provided this did not introduce additional risk to the Council or impact negatively on building operation. Due to the type and size of equipment found in the leisure centres, the flexibility potential of this site related only to load shedding.

The project team intended to use the Dublin leisure centres to explore the contractual issues associated with ESCOs, Aggregators and third parties working together, as well as allowing the financial impact of DR events on contract length and return on investment to be investigated. However, due to regulatory restrictions in Ireland on Demand Side Units (DSUs) that require aggregators to bid into the market with defined DSUs each year, the buildings could not participate in a real demand response event. The project team therefore decided to carry out a simulated demand response event in October 2018 with the main goal being to determine the feasibility of demand response in small to medium sized leisure centres, while assessing its impact on the indoor air conditions and the perception of thermal comfort of the occupants.

The experiment was carried out by installing suitable communications equipment that could simulate a Dispatch request from the Transmission System Operator (TSO) by sending a signal to the Building Management System (BMS) to adjust the necessary set points and control parameters to reduce site load. The simulated demand response event involved shutting down all non-essential HVAC equipment for 2 hours between 5pm and 7pm on a weekday evening, the busiest time period for leisure centres. The experiment, which is presented in more detail in D6.1 – Report on performance metrics calculations, showed that approximately 40 kW of flexibility is available at each leisure centre, which is too small to be of interest as a DSU to most aggregators in Ireland. However, as a result of this successful EPC, Dublin City Council have tendered for another EPC for nine additional leisure centres, using the same EPC template previously used, and have allowed inclusion of demand response measures, if they are proven to be economically viable.

2.1.2 The search for a second demonstration site

In addition to considering sites from the portfolio of project partners, the consortium also contacted a number of third parties to try to find a suitable second demonstration site but due to the same reasons cited above, this proved to be difficult. Joule Assets initiated conversations with several of their ESCO clients including a UK based ESCO called OptimEyes who indicated that they may have a suitable UK based demonstration site for NOVICE. OptimEyes agreed to provide data relating to a youth hostel that they were working with on a possible EPC project. The data provided by OptimEyes was used to perform a desktop energy audit and to inform the results of WP5. However, the client has decided not to implement any of the measures recommended by the NOVICE team as they did not wish to disrupt their operation.

Also from Joule Assets' network of project developers, iPower - a UK based ESCO – showed interest in sharing data from a project they were planning to implement in a potentially suitable office building in Scotland. The scope of the project was to install rooftop PV panels with battery storage which would allow the client to either use the generated energy onsite, to store it in the battery or to provide frequency response services to the grid. While the client was willing to consider an EPC and to change the scope of the project to add energy efficiency measures, the site's energy consumption was considered too small to bringing this site within the scope of NOVICE.

2.1.3 An alternative approach

Given the above mentioned difficulties encountered while trying to find a suitable demonstration site and the short time available for the actual implementation of a dual energy services project within the timeframe of the NOVICE project, the project team considered demonstrating different elements of the business model at different demonstration sites. The new plan was to look for specific data from clients of project partners (ESCOs or aggregators) that have already implemented either energy efficiency or flexibility projects. While not ideal, this approach would allow the use of real energy and cost data from a site that had already undertaken an energy efficiency or demand response project to determine the 'business as usual' case. If the site had already implemented energy efficiency measures, then a theoretical evaluation of the site's potential for flexibility would be overlaid on it to give the 'dual services' case. If the site had only participated in demand response programs, then the site's theoretical 'dual services' case would be determined by assessing the potential for energy efficiency projects. These theoretical 'dual services' cases could then be compared to the actual 'business as usual' cases to determine whether the dual services approach would have strengthened the business case for the building renovation project.

Kiwi Power (the NOVICE aggregator partner) approached a number of its clients to request that they share the energy consumption, energy efficiency measures implementation and demand response data with the project team. At first, several organisations seemed willing to participate, and showed their eagerness to be involved in innovative forward-thinking initiatives. This included a hotel management company, an industrial manufacturer and a hospital. However, their engagement waned as the specific data requests came through, and dwindled further once the impact of the Coronavirus hit due to facilities teams operating with a skeleton staff and shifting their operational priorities towards closing down sites. Therefore, the project was unable to access additional site data from Kiwi Power's client base to support the NOVICE project.

2.1.4 Site 2: Supermarket in Kilkenny, Ireland

NLGES also contacted a number of their clients to ask if the same data could be shared with the NOVICE project and to develop an assessment of the site's potential for demand response and energy efficiency. NLGES were successful in obtaining agreement from a supermarket chain in Ireland and they managed to secure most of the required information before the Coronavirus lockdown began in Ireland. This site is therefore presented in this report as the second demonstration site that is used to demonstrate the dual services business model and the rest of this report focusses on delivering a full analysis of the potential for dual services at this site.

2.2 DATA ANALYSIS

2.2.1 Data gathering

A list of the data required from potential demonstration sites was compiled by the project partners and was intended to be used for the following purposes:

- To validate the business model;
- To calculate the performance metrics associated with the building (see D6.1 – Report on performance metrics calculations, for full details of the performance metrics selected and their calculation);
- To perform a financial analysis of the proposed dual services projects from the perspective of potential investors using Joule Assets' in-house financial validation software tool, eQuad (see D7.3 – Report on the financing to stimulate the NOVICE dual energy services scheme, for the full details and results of this financial analysis).

For the full list of data that was requested from potential demonstration sites, please consult APPENDIX A – Data required from sites.

The data requested included elements relating both to the energy efficiency and to the demand response parts of the project. The list shows both the minimum acceptable data set that would allow business model validation and the ideal data set that would allow the project team to gain deeper insights into the business model validity. The project team also specified which information would be published as part of the NOVICE project public deliverables to allow the client to verify that they were comfortable with the level of data protection and privacy that could be offered.

In terms of energy efficiency, it was important to know which energy efficiency measures ("Projects") had already been implemented, the date of implementation, the approximate capital cost for the implementation of those measures and the energy (and therefore cost) savings that resulted from those upgrades. In order to trace the baseline loads of the demonstration site, 15-minute metering data was required for electricity and monthly data for natural gas consumption for a period of 12 months before energy efficiency measures were implemented. This allowed the real 'business as usual case' to be calculated for the demonstration site. As the theoretical evaluation of some measures is based on past projects implemented by NLGES, energy interventions that were conducted in other similar sites have also been used as input.

Moreover, a list of the existing equipment and their respective capacity was provided by the supermarket's facility management team. This list was used by the aggregator, along with the 15-minute consumption data for the 2019 calendar year to estimate the potential revenue stream from demand response.

Finally, to assess the reduction in electricity and natural gas billing, the current energy tariffs and contracted Maximum Import Capacity (MIC) were needed.

2.2.2 Methodology for data analysis

The supermarket's facility management team provided 15-minute sub-metering data for the year 2019, for some of the most energy intensive (electricity consumers) systems, such as: lighting, HVAC and refrigeration. These values were used to trace the baseline consumption and peak power for the different systems that consumed electricity. The baseline was then overlaid with the expected energy reductions that were based on metered performance already achieved in similar sites at which the supermarket chain has already applied energy efficiency interventions. Since the measured data was given every 15 minutes, the value that was received is for the average power in that period, which can be assumed to be constant, since it is in a short-interval.

In terms of heating data, NLGES had access to the monthly natural gas consumption in the store from March 2019 to February 2020. Since the baseline analysis was made for the full calendar year of 2019, the January and February 2019 natural gas consumption was considered equal to the same period in 2020.

2.3 Methodology for business model validation

Initially, the plan for the NOVICE project was to have a demonstration site where both energy efficiency and demand response measures were implemented as a bundled project. The validation of the business model would have used metered data from the demonstration site and actual revenues from energy bills to compare to the energy and financial model developed in WP5. The modelled work in WP5 is based on the OptimEyes site, however the hostel management team decided not to implement the project, since it would disrupt their operation and hence there is no direct link between the WP5 models and the supermarket site presented here.

Since no demonstration site showed willingness to implement an EPC that would include demand response services, the NOVICE team decided to validate the model by overlaying a theoretical evaluation of the facility's energy efficiency and demand response potential onto the site's measured consumption. The NOVICE business model is considered successful if it manages to produce an impact on the overall project payback period, more specifically, if it reduces the payback period of a dual services EPC when compared to a traditional EPC project.

The thermal comfort of occupants when the facility is participating in demand response programs has been assessed in a different demonstration site that was provided by NLGES.

3 DEMONSTRATION SITES

3.1 SITE DESCRIPTION

The site chosen to validate the NOVICE business model is a supermarket in Kilkenny, Ireland. The store is divided into two main retail areas: textile (selling clothes and shoes) and grocery (selling food and drink). The stock and administrative rooms are all found on the second floor of this site. The retail area amounts to 4,347 m^2.

The store's operating hours vary depending on the day of the week as follows: 9am to 7pm Monday, Tuesday, Wednesday and Saturday; 9am to 9pm Thursday and Friday; and 11am to 7pm Sunday.

Space cooling is provided by chillers that are only used for short periods during summer months. This equipment is included in the HVAC meter. The HVAC system includes three Air Handling Units (AHUs), of which, one serves the textile area and the other two serve the grocery area. Space heating and domestic hot water (DHW) is provided by natural gas fired boilers. A central Building Management System (BMS) controls the energy systems.

Of the total energy consumed by the store (2,670 MWh per year), electricity consumption accounts for 56%, and natural gas consumption accounts for the remaining 44%. As expected for a supermarket, the systems that consume the most electricity are lighting and refrigeration. The store's HVAC systems consumes less than half as much electricity as the refrigeration system (see Table 3-1). The "power" fraction refers to less significant electricity consumers used across the site with less potential for energy savings, such as lifts, bailers, or computers. Other miscellaneous equipment and energy uses not accounted for under any other category are covered under the label "Other".

Table 3-1: Energy consumption distribution for the demonstration site

System	Energy Consumption (kWh)	% of total electricity consumption
Lighting	466,398	31%
Refrigeration	443,540	29%
HVAC	184,061	12%
Other+Power	410,144	27%
Electricity total	**1,504,143**	

3.2 PROJECTS ALREADY IMPLEMENTED – THE BUSINESS AS USUAL CASE

For the purpose of this deliverable, the measures presented here will be assumed to have been implemented under an EPC, even though in reality, the lighting had already been replaced, while the other measures are estimates of this particular site's potential for energy saving based on the known savings achieved at other sites in the same supermarket chain that have already implemented these measures. This is the 'business as usual' case with which the NOVICE model will be compared.

3.2.1 LED lighting

This site had already undergone a LED lighting upgrade in August 2019. The energy savings resulting from this upgrade could be measured directly through the lighting metering data provided by the supermarket. A reduction in lighting consumption of 47.2% was registered when compared to the old lighting system and overall electricity consumption dropped by 15%.

3.2.2 Refrigeration upgrade

The suggested interventions to upgrade the refrigeration systems have not yet been implemented at this particular site. However, the expected savings from these measures can be estimated with a high degree of confidence because metered energy data from other stores in the same supermarket chain that have already undertaken this upgrade was available for the analysis.

The refrigeration upgrade is mainly motivated by the need to switch to a safer and more environmentally friendly refrigerant. Energy savings from refrigeration upgrades consist of two elements: Firstly, the use of more efficient refrigeration technology results in a 75% reduction in energy consumption when compared to the old refrigeration system, (based on measured consumption at other stores before and after replacement); secondly, this more efficient system creates the opportunity to recover waste heat and use it to heat water, thus displacing heat generated by fossil fuelled boilers on the site (see section 3.2.3 for further detail). A dual benefit of both electrical and thermal savings is therefore achieved from a refrigeration upgrade.

3.2.3 Heat recovery

Currently, domestic hot water (DHW) supply temperature is 10^{o}C from the mains water supply and is heated to 60°C by the boiler. The installation of a heat recovery system that uses waste heat from the refrigeration system to pre-heat DHW would raise the supply temperature to 30°C, resulting in additional savings on natural gas (9% reduction in total site gas consumption).

3.2.4 HVAC upgrade

Based on both NLGES and the supermarket owner's previous project experiences, the HVAC upgrade is estimated to reduce the electricity consumption of the HVAC system by at least 15% (representing approximately 2% of the overall electricity consumption). The interventions on HVAC include adjusting the ventilation flow rates and control strategy, fixing of leakage problems and replacement of faulty sensors.

3.2.5 PV panels

A solar PV array with a capacity of 243 kWp allows for a further 30% reduction in final electricity consumption from the grid over and above the savings achieved from the energy efficiency measures described in sections 3.2.1 to 3.2.4. This site is particularly suitable for the installation of PV systems since there are no surrounding buildings or structures that can cause shading (which lowers the PV output), and there is a considerable amount of available roof space. Moreover, the electrical consumption profile of the store closely matches the typical electrical output pattern of PVs, with peak store consumption and peak PV output occurring at around the same time of day (11am to 2pm). In order to ensure the system is not oversized and that system output closely matches the current demand, PV panels will initially be installed on one section of the available roof area. This ensures that there is potential for future capacity upgrades if site energy demand increases (e.g. due to the installation of EV chargers in the car park). The proposed PV array would generate approximately 30% of the overall electricity used on site after implementation of the energy efficiency measures described above.

4 NOVICE BUSINESS MODEL VALIDATION

The NOVICE dual service model includes demand response services as well as energy efficiency measures as part of an EPC. The NOVICE business model for this demonstration site analyses the impact of participating in the Irish demand response programmes alongside the proposed energy efficiency measures, to simulate an enhanced EPC. To this end, NLGES obtained a quote for flexibility services at this site from an Irish demand response aggregator.

Currently, there are two ways that a consumer can be engaged in demand side management schemes in Ireland. The first consists in providing incentives to consumers to shift their loads to off peak hours, which is achieved through different tariffs for electricity during the day to try to avoid consumption on peak hours (implicit demand response). The second opportunity is helping EirGrid (the Irish Transmission System Operator), to maintain grid frequency in a range of +/- 1% of 50 Hz (explicit demand response). This is a second by second exercise of balancing demand with supply. To do this, EirGrid pays energy users that have the ability to act quickly on the consumers assets (in some situations as fast as 1 second), to decrease and shift demand or turn on back-up generation or storage to stabilise the grid. Usually, assets are managed by a third party (demand response aggregator) who combines the flexibility potential of the assets of several clients in order to exceed the (high) minimum requirements for participation on ancillary services market.

This service does not affect the client's operations since each asset on site will be available for a different kind of scheme with different response times. For example, a HVAC system can be shut down for a short period of time without affecting significantly the air quality of the space and the client can receive monetary compensation for that (see D6.1 Report on Performance Metrics Calculations for details of the impact of turning off HVAC systems for two hours on thermal comfort of leisure centre users).

In the case of the supermarket described above, the HVAC and refrigeration equipment will be used in programmes that require fast response time with short duration and the on-site backup generator will be used to provide flexibility for longer duration events. Table 4-1 presents in more detail the exact available demand response services in which the demonstration site can participate, as well as the length of the demand response event. The last column shows which of the store's equipment will participate in each type of demand response event and indicates the approximate system capacity involved.

Table 4-1: Demand response services available for the participation of the demonstration site

Service Name	Acronym	Response	Duration	System that is participating
Fast Frequency Response	**FFR**	2 s (.15 s)	10 s	HVAC/Refr. (54.2 kW)
Primary Operating Reserve	**POR**	5 s	15 s	HVAC/Refr. (54.2 kW)
Secondary Operating Reserve	**SOR**	15 s	90 s	HVAC/Refr. (54.2 kW)
Tertiary Operating Reserve 1	**TOR1**	90 s	5 m	Generator (136 kW)
Tertiary Operating Reserve 2	**TOR2**	5 m	20 m	Generator (136 kW)
Replacement Reserve - Desynchronised	**RRD**	20 m	40 m	Generator (136 kW)
Ramping Margin 1	**RM1**	1 h	1 h	Generator (136 kW)
Capacity	**DSU**	1 h	2 h	Generator (136 kW)

The site can participate in these demand response schemes without any need for CAPEX, as all of the systems that are needed for participation are already installed, as part of the energy efficiency project. The next subsection presents an option that the owner can opt for, in order to increase the revenues from demand response.

4.1 Investment Opportunity for demand response

To increase the revenues from demand response schemes, battery storage technologies can be used. As battery technology develops and costs substantially drop, this solution for energy storage becomes increasingly more attractive, in particular for a site with PV generation.

Battery storage technologies can provide multiple and stackable revenue streams (from gird services, peak shifting, storing energy generated on site and tariff arbitrage). For the purpose of this report we are only evaluating the potential revenues from providing services to the grid, for which we can report more exact and non-variable values. Lithium ion has become the technology of choice globally for the delivery of fast responding grid services and in recent years the industry has witnessed significant reductions in deployment costs whilst, simultaneously, improvements in performance and reliability.

Relating to Table 4-1, the battery can generate revenues by participating in the following shorter demand response services: FFR, POR, SOR, TOR1, TOR2.

A 150 kW system would be large enough to back-up the whole site load.

5 CALCULATIONS & RESULTS

5.1 ENERGY EFFICIENCY

As explained in section 2, the expected reduction in site energy consumption results from:

- Overlaying the results obtained through similar energy interventions at other sites for HVAC and refrigeration on top of the baseline consumption.
- Reduction in lighting energy consumption directly measured from metered data.
- Avoided energy consumption through the installation of a PV array and on-site use of the energy generated from this system. This was calculated using the European Commission's tool PVGIS which calculates the performance of a PV array given its characteristics and weather data at the proposed site location. Note that in Ireland, there is no export or feed in tariff for energy generated from solar PV, so energy generated must be consumed or stored on-site.

Table 5-1 shows the expected energy savings, the capital expenditure, the resulting annual monetary savings on energy bills, and the expected simple payback period for each of the proposed measures as well as the payback period for the entire package of measures.

Summing up, the previously mentioned measures come at a cost of approximately €1,496,099 and produce annual cost savings of around €122,300. This leads to a simple payback time of 11.8 years which is typical for EPCs. However, the majority of the capital cost is related to the refrigeration upgrade, which at €1,000,000, accounts for more than two thirds of the overall project cost. This upgrade was not motivated by energy or cost savings but rather the need to comply with the European Commission F-gas regulation, (a protocol that looks to reduce the impact of greenhouse gases), including fluorinated greenhouse gases (F-gases) on climate change. When considered alone, the payback period of replacing the refrigerant is 27 years and it would be difficult for any business to justify this cost in the absence of regulation. However, including the refrigeration upgrade with the other energy efficiency measures puts the overall payback period for the whole package of measures at 11.8 years which is more typical of an EPC. Even so, most private sector organisations would still consider this to be too long.

Table 5-1: Details of Energy Efficiency Measures

Energy Efficiency Measure	Energy Savings (kWh)	Capital cost (€)	Annual Savings (€)	Payback Period (years)
Lighting	220,140	203,000	53,421*	3.8
Refrigeration	332,655	1,000,000	36,592	27.3
HVAC	27,609	12,000	3,037	4.0
PV	279,879	251,099	29,250	8.6
Heat recovery	103,098	30,000	4,849	6.0
Total	**963,381**	**1,496,099**	**127,149**	**11.8**

** Figure includes energy savings, maintenance savings, energy credit, ACA allowances and MIC reduction*

After all the energy efficiency measures have been implemented, a reduction in total site energy consumption (electricity, heat, PV) of 36% can be achieved and the total annual energy savings for the site (electrical + thermal) amount to 963,381 kWh (see Table 5-2). It can be seen that while the refrigeration measure has a high initial cost, it achieves a considerable reduction in energy consumption of 75% compared to the previous system. The energy efficiency measures reduce site electricity consumption by 39%, which can be reduced by a further 30% with the installation of PV panels. In total, this amounts to a reduction in site electricity consumption of 57%.

As previously mentioned, the installation of a heat recovery system to use the heat rejected from refrigeration, reduces the thermal energy for domestic hot water heating by 45%, or 9% of all the thermal energy of the building.

Table 5-2: Impact of Energy Efficiency Measures

System		Before		After		Reduction in Energy Consumption (%)
		Energy Consumption (kWh)	GHG emissions (t CO_2)	Energy Consumption (kWh)	GHG emissions (t CO_2)	
Electrical	Lighting	466,398	204	246,258	108	47%
Electrical	Refrigeration	443,540	194	110,885	49	75%
Electrical	HVAC	184,061	80	156,452	68	15%
Electrical	Other+Power	410,144	179	410,144	179	0%
Electrical	**Electrical total**	**1,504,143**	**657**	**923,739**	**404**	**39%**
	PV array *			-279,879	-122	30%
Thermal	Space Heating	926,454	190	926,454	190	0%
Thermal	Heat recovery (DHW)	240,000	49	136,902	28	43%
Thermal	**Heating total**	**1,166,454**	**238**	**1,063,356**	**218**	**9%**
Total (el. Total + PV + heat. Total)		**2,670,597**	**896**	**1,707,216**	**500**	**36%**

** Reduction of PV measure applied to total "after" electricity consumption*

5.2 DEMAND RESPONSE

The demand response figures from Table 5-3 are the result of a quote from an Irish aggregator that estimated the potential revenues from the site's participation in demand response schemes, as presented in section 4. To be able to assess the site's flexibility potential, the aggregator required the site's annual electrical load prior and post energy reductions, in the form of 15 min data, a precision that ensures the reliability of the results.

The range of demand response activities and services available to this site is independent of whether or not the energy efficiency measures previously mentioned have been implemented. In other words, we could apply for exactly the same type of services to the grid even without the implementation of the energy efficiency measures. However, the revenues from demand response in the NOVICE model are lower (€13,000) compared to simply participating in demand response schemes without having implemented any energy efficiency projects (€16,000), as shown in APPENDIX B Table 10-1. The revenues decrease because the average available load on site becomes lower after the energy efficiency interventions.

Table 5-3: Demand Response revenue estimates from an Irish aggregator

Service name	Response within	Cumulatively Respond For	System Participating	Revenue for client (€)			
				2020/21	2021/22	2022/23	Total
FFR	2 s	10 s	HVAC, refr.	788	992	992	2772
POR	5 s	15 s	HVAC, refr.	1828	2094	2094	6016
SOR	15 s	90 s	HVAC, refr.	1106	1266	1266	3638
TOR1	90 s	5 m	Generator	2194	2513	2513	7220
TOR2	5 m	20 m	Generator	1882	2156	2156	6194
RRD	20 m	60 m	Generator	850	974	974	2798
RM1	1 h	3 h	Generator	182	209	209	600
			Total	8830	10204	10204	29238
DSU	1 h	2 h	Generator	2822	2810	3008	8640
			Grand total	11652	13014	13212	37878

Participation in these services produces an additional revenue of approximately €13,000 per year. However, the Irish aggregator is only confident of these revenues for a relatively short period (3 years with possibility of renewing the contract twice, each time for a further 18 months). The reason for this is that the demand response market in Ireland is still maturing, therefore fluctuation and variability in requirements and pricing is expected in the coming years. This uncertainty prevents most aggregators from committing to contract durations of more than 3 years. Revenues from frequency response might increase in the future because as more renewables come onto the grid, there will be a greater need for frequency response to balance their intermittency. As a result, there is likely to be a greater requirement for fast frequency response services making it likely that either the tariff will increase, because the services are more valuable to network operators, or the site will be called on to participate more frequently, which will lead to greater revenues. In contrast, revenues generated from the traditional load shedding form of demand response (i.e. turning equipment off for 1-2 hours) have reduced significantly over the last three years as more sites with generators have made their capacity available. It is unlikely that this value will recover, and it may even be possible for the value to fall even further.

For the purpose of NOVICE business model, the revenues from demand response are assumed to be constant for the duration of the EPC. This is considered an acceptable assumption because while revenues from frequency response may increase, the revenues from load shedding may decrease in the coming years, so on average, the revenues from demand response as a whole are likely to remain approximately constant.

Since aggregators usually offer the installation of the communications equipment that enables the dispatch of assets in response to a signal from the network operator free of charge, there is no capital cost to the building owner for participating in demand response services. The NOVICE business model assumes that this will remain the case when the ESCO and the aggregator collaborate to offer joint services to their clients. The impact of the addition of demand response revenues on the project payback period is shown in Table 5-4. The payback period decreases from 11.8 to 10.7 years, or 9.3%, under the assumption that demand response revenues will stay constant for the duration of the EPC.

Table 5-4: Impact of demand response revenues on the project.

Energy Efficiency Measure	Energy Savings (kWh)	Capital cost (€)	Annual Savings (€)	Payback Period (years)
Lighting	220,140	203,000	53,421	3.8
Refrigeration	332,655	1,000,000	36,592	27.3
HVAC	27,609	12,000	3,037	4.0
PV	279,879	251,099	29,250	8.6
Heat recovery	103,098	30,000	4,849	6.0
Total	**963,381**	**1,496,099**	**127,149**	**11.8**
Demand Response	-	-	13,000	-
Total	**963,381**	**1,496,099**	**140,149**	**10.7**

In conclusion, if the project had been conducted through an EPC that included a demand response component, the overall project payback period would have reduced by 9.3%, from 11.8 to 10.7 years, thus reducing the contract duration indeed.

5.2.1 Battery Option for Demand Response

As discussed in section 4.1, investing in a battery storage technology can increase the demand response revenues, as these would be added to the other flexibility revenues previously presented. The same aggregator has given the following quote for the 150 kW battery storage system:

Table 5-5: Battery storage revenues quote from the aggregator

Service name	Response within	Response time	System Participating	Revenue for client (€)			
				2020/21	2021/22	2022/23	Total
FFR	2 s	10 s	Battery	7333	9226	9226	25785
POR	5 s	15 s	Battery	5058	5794	5794	16646
SOR	15 s	90 s	Battery	3060	3505	3505	10070
TOR1	90 s	5 m	Battery	2420	2772	2772	7964
TOR2	5 m	20 m	Battery	2076	2378	2378	6832
RRD	20 m	60 m	Battery	0	0	0	0
RM1	1 h	3 h	Battery	0	0	0	0
			Total	19947	23675	23675	67297
DSU	1 h	2 h	Battery	0	0	0	0
			Grand total	19947	23675	23675	67297

The aggregator selected the batteries to participate in TOR1 and TOR2 services, which conflicts with the generator, since we can't use both assets on the same service. It can be seen from Table 5-3 and Table 5-5 that the battery generates a slightly higher revenue for TOR1 and TOR2 services compared to the generator due to the battery having lower deployment costs per kWh. It has been therefore decided to use the battery instead of the generator for participating in the Tertiary Operating Reserves.

The total revenues that can be obtained from demand response services, using the HVAC system, the generator and the battery are presented in Table 5-6. For the purpose of the demonstration of the NOVICE model, it is assumed, similarly to the previous section, that a revenue of €32,000 can be obtained for the entire duration of the proposed EPC.

Table 5-6: Total revenues from demand response services quoted by the aggregator

Service Name	Response within	Response time	System Participating	Revenue for client (€)			
				2020/21	2021/22	2022/23	Total
FFR	2 s	10 s	HVAC, refr.	788	992	992	2772
			Battery	7333	9226	9226	25785
POR	5 s	15 s	HVAC, refr.	1828	2094	2094	6016
			Battery	5058	5794	5794	16646
SOR	15 s	90 s	HVAC, refr.	1106	1266	1266	3638
			Battery	3060	3505	3505	10070
TOR1	90 s	5 m	Battery	2420	2772	2772	7964
TOR2	5 m	20 m	Battery	2076	2378	2378	6832
RRD	20 m	60 m	Generator	850	974	974	2798
RM1	1 h	3 h	Generator	182	209	209	600
			Total	**24701**	**29210**	**29210**	**83121**
DSU	1 h	2 h	Generator	2822	2810	3008	8640
			Grand total	**27523**	**32020**	**32218**	**91761**

The impact of installing a 150 kW battery for participating in demand response services is presented in Table 5-7. The battery has a capital cost of €81,000 and an installation cost of €2,500. For a battery of this size, the O&M cost is negligible compared to the capital cost (Brinsmead, Graham, Hayward, Ratnam, & Reedman, 2015). The yearly annual revenue from participating in all the demand response schemes with the HVAC system, the generator and the battery amount to €32,000. The addition of revenue from demand response reduces the EPC contract length from 11.8 to 9.9 years, or 16%.

Table 5-7: Impact of flexibility services on the project business case

	Capital cost (€)	Annual Savings (€)	Project Payback Period (years)
Traditional EPC	1,496,099	127,149	11.8
Flexibility services	83,500	32,000	2.6
Total Dual Services Project	1,579,599	159,149	9.9

5.3 Capital Cost of Works

The total cost of works to implement all the measures described above amounts to €1,496,099 (not including battery storage option) broken down as follows:

- The major proportion of the total can be attributed to the refrigeration upgrade, with a CAPEX of around €1,000,000, driven mainly by a need to comply with F-gas regulations. Refrigeration operation and maintenance costs remain unchanged regardless of the type of refrigerant used.
- The actual cost of the lighting upgrade was €203,000. The reduction in maintenance costs as a result of upgrading to LEDs (which have a much longer life than other types of lighting) is based on an analysis that the client had carried out at other sites which results in a typical payback of 3.8 years for lighting projects when maintenance savings are included.
- The cost of the HVAC interventions was estimated at €12,000 based on similar projects at other supermarket sites in the same chain. The HVAC savings are derived from a conservative assessment of potential savings and include maintenance savings as part of the business case.
- The cost of installing heat recovery was also estimated from past experiences in other stores in the same supermarket chain which shows that this measure typically has a payback time of 6 years. Back calculating from the estimated annual savings of €4,849 per year puts the capital costs at approximately €30,000.
- NLGES past experience in installing PV arrays was used to calculate the capital costs of €205,099. The savings have been calculated using the European Commission's tool PVGIS and an average of €1,537 cost for operation & maintenance has been deducted from the annual savings of €30,787.
- The installation of demand response equipment comes at no cost to the client.
- The total cost of a 150 kW battery storage system is €83,500 including initial investment, installation and O&M costs. As the disposal costs were not included in the analysis for all the other energy efficiency measures, the cost for the disposal of the battery has not been included in this analysis either.

5.4 Payback period

If the NOVICE dual service approach had been executed at this site, there would be an increase in revenue of €13,000 annually from the inclusion of demand response opportunities, when compared to a typical EPC which only implements energy efficiency measures. This would have resulted in a reduction of the payback period from 11.8 to 10.7 years - in other words, a 9.3 % improvement. These payback times are typical of EPC contracts but considered too long by most commercially driven organisations in the private sector. It is therefore important to note that most of the investment cost was not directed towards energy/cost reduction, but rather to comply with the F-gas regulation. If this refrigeration measure, which on its own has a payback period of 27 years, is not implemented as part of the EPC, then the overall project payback period would be reduced to 5.5 years for energy efficiency measures alone. The addition of demand response revenue to the project would reduce this value further, to 4.8 years – 12.6 % improvement.

This demonstrates that the demand response component of the NOVICE model has an impact ranging from 9.3 % to 12.6 % reduction in payback period, and therefore contract length, at no additional cost to the building owner.

However, if the building owner is willing to additionally consider battery storage technologies, a 150 kW battery backup system would produce enough demand response revenue to reduce the payback period of the project from 11.8 years to 9.9 years or by 16%.

6 DISCUSSION OF RESULTS

6.1 ECONOMIC IMPLICATIONS OF THE NOVICE DUAL SERVICE MODEL

The NOVICE dual services model builds on the traditional EPC to add a component that allows the building owner to maximise the potential revenues from their energy assets by selling their flexibility potential to the electricity grid via the services of a demand response aggregator.

As previously discussed, deploying the NOVICE model at this supermarket site would result in approximately €13,000 per year of additional revenues compared to a typical EPC that would include only the energy efficiency measures. This approach would bring the same amount of energy savings, cost the same to implement in terms of capital expenditure, and as discussed in Deliverable 6.1, would not negatively impact on thermal comfort or building occupants or business operation. Moreover, an agreement between the ESCO and the building owner can be specified within the EPC to define the range of indoor conditions that the building owner is willing to accept under normal operation and during a demand response event.

The demonstration site that was used to calculate the financial implications of such a project, has shown that for this particular site, the overall payback period of the project can indeed be reduced from 11.8 to 10.7 years - 9.3 % in this case. This reduction in payback period is significant and at no additional cost to the building owner. If they are willing to make an additional investment in a total system backup battery of 150 kW, then the revenues from demand response increase even further. The addition of the battery storage system can reduce the project payback period further, from 10.7 years to 9.9 years. Total reduction of payback period, including system backup battery, amounts to 16.1%. However, most of the investment cost was not directed towards energy/cost reduction, but rather to comply with the F-gas regulation. If this refrigeration measure, is not considered a part of the EPC, then the overall project payback period would be reduced significantly to 5.5 years for energy efficiency measures alone.

A reduced payback period for packages of energy renovation projects has a number of benefits:

- Reduced EPC duration may make this a more attractive business model for building owners, particularly those in the private sector which typically favours investments with high rates of return.
- Building owners may consider packages of deeper building renovations as the additional revenues from demand response brings into scope projects that would otherwise not be economically viable.
- The dual services approach gives ESCOs that offer it a unique selling point in a crowded market and could potentially assist them to win more clients in new sectors since the business case of the package of energy efficiency measures proposed is more persuasive.
- Investors in energy efficiency projects, whether they are the owners of the building, ESCOs or third party investors benefit from this dual services approach by recovering their investment more quickly and creating the ability to reinvest in new projects sooner.

6.2 CONTRACTUAL ELEMENTS - MODEL MOU

The NOVICE partners, particularly Kiwi Power (aggregator) and NGLES (ESCO), sought to establish a working arrangement between aggregators and ESCOs for the purposes of combining the revenue streams of energy and efficiency and demand response in a single and unified approach to an asset owner. The arrangement was formalised in a memorandum of understanding (MoU), the details of which can be found in Annex 1 of the public deliverable D4.2 - ESCO Aggregator MoU (Bucur & Vernon, 2019). The document describes the bilateral agreement between an aggregator and ESCO, their common line of action, their roles and responsibilities in implementing energy management and demand response, the aim for adopting clean energy efficient technologies and achieving continual energy efficiency improvements. The aggregator's role is to extract the maximum value from the energy assets that are covered by the EPC through offering their flexibility potential to the electricity system operators while avoiding negative impacts on the comfort of the building occupants and building operation. The ESCO seeks to minimise the energy consumption of buildings, to ensure that it meets the building owner's thermal comfort requirements as efficiently as possible. The aggregator therefore acts as an intermediary between the ESCO and the TSO to implement efficient demand response mechanisms and handle all the legal and regulatory aspects of doing so.

From the point of view of the client, one of the incentives to work with an ESCO is that projects are often offered on a turnkey basis which removes much of the complexity and technical hurdles to implementing several energy efficiency projects in parallel. Demand response is extremely complex with several programmes available dependent on the asset type, its available flexible load, the time in which it can respond to a dispatch signal and the redundant time required between dispatch signals for the asset to "recharge". Each of these programmes is only accessible via a contract with the relevant TSO, which requires extensive pre-qualifications and testing to ensure dispatch signals can be implemented successfully and to desired outcomes. Medium sized assets must be aggregated together to meet minimum thresholds and to ensure any interruptions in availability can be mitigated by the pool of aggregated assets. Therefore, at the outset an MoU between aggregators and ESCOs appeared to be the ideal tool to maintain a seamless, single point of contact service to clients while adding the complex and dynamic aspects of demand response to the revenue generating options available. NLGES have signed two separate MoUs with two aggregators different aggregators. In each case the MoU was modified slightly from the version that was submitted in D4.2 - ESCO Aggregator MoU (Bucur & Vernon, 2019) to accommodate the requirements and preferences of each aggregator.

6.3 Market Developments

In order to provide estimates and agree an EPC with the client, the ESCO must be able to understand and predict revenue streams over the proposed duration (typically at least 5-7 years) with a high degree of confidence in its accuracy. Energy prices and therefore the savings offered by implementing energy efficiency measures are well understood and predictions can be based on current prices, industry estimates of future prices, and inflation, alongside standard accounting metrics for investments such as net present value. However, demand response programmes typically have shorter contract durations and the values between them, and over time, can vary significantly.

As an example, in the UK there have been significant reductions in revenues on some Demand Response programmes in the relatively short period of time since they were first established. For example, the Short Term Operating Reserve (STOR) provides an availability payment to assets for the times when it makes itself available for dispatch (an additional payment is made for utilisation if an asset is actually dispatched), and the value of this availability payment in April 2020 has reduced by 64% over the period of the NOVICE project (see Table 6-1). The value of Dynamic Fast Frequency Response (DFFR) in the UK has also decreased over the same time period. Some demand response programmes use a market model with dynamic pricing further increasing the complexity of accurate forecasts.

Table 6-1: Selected variations in demand response programmes between 2017 and 2020 (Source: National Grid)

Programme	**£ / MWh Jan 2017**	**£ / MWh Jan 2020**	**% change**
Dynamic Fast Frequency Response (DFFR)	£21.46	£13.09	-39%
Programme	**£ / MWh April 2017**	**£ / MWh April 2020**	**% change**
Short Term Operating Reserve (STOR): Availability payment	£5.12	£1.85	-64%

There are several structural reasons why the Demand Response market has seen reductions in revenues in recent times. A key aspect is that large gas and coal fired power stations are still able to bid into the market (e.g. Capacity Market and STOR). With their large capacity they can undercut more financially intensive storage. In addition, National Grid (the UK TSO) has deployed new hedging strategies, moving from focussing on security of supply 12 months ahead, to procuring the 2 GW of STOR capacity just 4-5 months ahead and causing downward pressure on prices as providers compete more intensively. There have been many more players entering the market as more assets realise the potential of their flexible load and this increased supply is also causing prices to fall. DFFR, which has a response time of within 2 seconds, has seen a high penetration of storage assets that were not in the market a few years ago. This has also caused the market for Static FFR (full response within 30 seconds) to be very limited as frequency responses can be managed by the faster reacting DFFR market. Lastly, National Grid holds some bilateral contracts other commercial contracts which can negate the need for open tender and open markets.

Conversely upward pressure on prices are also expected in the near to medium term. In the UK the Government announced its intention to move to a net zero carbon economy by 2050 (Department for Business Energy & Industrial Startegy, 2019) and the carbon intensity of the energy sector will be critical in achieving that target. Increasing the carbon price could limit the downward pressure on the market price of high capacity carbon intensive generation types (such as the large coal and gas plants described earlier). The Association of Decentralised Energy (ADE) recognise the importance of flexibility and working with government they aim to ensure flexible resources receive “appropriate price signals” that enable further innovation to incorporate assets such as electric vehicles (Energy UK, Association for Decentralized Energy, & BEAMA, 2020). This is a clear recognition that simply adding flexible assets into a market will not solve the problem, and that appropriate market structures and prices are needed to maintain revenues for the enabling organisation, (such as demand response aggregators), to continue to operate.

The analysis presented in this section takes the UK market as a case study because it is one of the most mature markets in Europe, but it is likely that most European countries will experience similar pricing complexities as they mature. Therefore, the NOVICE MoU template forms a good basis for negotiations between the ESCO and the aggregator for providing demand response services to a new or existing ESCO client. However, given the complexity of the contract and dynamic nature of demand response prices it may not be possible to have a generic agreement for all client types in all instances. In addition, the MoU cannot provide enough certainty to support the EPC over its full contract length so other forms of formalising the relationship between ESCO and aggregator may need to be considered in future.

6.4 ENHANCED EPC TEMPLATE

The NOVICE team have developed a series of recommendations on how to enhance a traditional EPC template in order to include clauses on demand response. These suggestions can be found in the public deliverable 4.1 - Model Structure of the New EPC Template (Vavallo, 2018).

Successfully implementing the EPC in three leisure centres in Dublin and seeing the energy savings materialize, Dublin City Council have tendered for another EPC for nine additional leisure centres, using the same EPC template previously used, and have allowed inclusion of demand response measures, if they are proven to be economically viable. This shows great potential for the NOVICE model to enter the Irish ESCO market.

In the Irish market, revenue rates for demand response are only agreed for a maximum of 3 year periods, which falls short of the usual EPC contract length. This situation adds some uncertainty and risk to the ESCO as the financial modelling for the demand response elements can only be made for the first 3 years. At the end of this period, the market is tested again, at which point both the demand response rates and the demand response provider may have changed.

Moreover, the margins on demand response appear to be small for individual sites so aggregation of sites in large numbers is what gives its commercial viability for the aggregator. In practice, this means that an ESCO is likely to take little margin on demand response services from the aggregator. However, its revenue contribution will help to accelerate the site's break-even point and is therefore still of interest to the ESCO.

Although the NOVICE project has, to date, resulted in two signed MoUs, the feedback received from aggregators that have engaged with the project has highlighted a lethargy to sign. This can largely be explained by the fact that aggregators require high volumes, but in a maturing market, ESCOs will only present them with limited opportunities. In conclusion, ESCOs cannot add much volume to an aggregators sales pipeline and therefore an MoU may not seem particularly attractive to many aggregators.

7 CONCLUSION

This report aimed to validate the dual services business model proposed by the NOVICE project. The difficulties in finding a demonstration site as well as the limitations of this study have been presented and discussed here. The validation was performed by analysing the results of a theoretical assessment of a site's potential for installing a package of energy efficiency measures and participating in demand response programmes. The aim of this analysis was to determine whether adding a demand response component to a traditional EPC would improve the payback period of the project significantly thus improving the business case for energy efficiency upgrades and leading to increased building renovation rates.

The case study is a supermarket, located in Ireland, which has considerable potential for energy efficiency, and is able to achieve a 36% reduction in the site's total annual energy consumption through installation of a package of energy efficiency measures. The capital cost of implementing the proposed package of measures, the associated operational costs and the monetary savings from reduced energy bills and lower maintenance costs lead to a payback period of 11.8 years. This payback period is considered quite high for an EPC, especially for a private sector client, but this is mostly due to inclusion of an upgrade to the refrigeration system, which in itself has a payback period of 27 years. The refrigeration system upgrade was considered necessary to allow the site to conform with the F-gas regulation, rather than being included based on financial considerations.

A quote has been prepared by a local demand response aggregator, which shows the revenues from the site's participation in all of the different demand response services throughout the period of the contract. The site could sell flexibility to the grid that could amount to approximately €13,000 per year, for the next three years, with a possibility to extend the contract twice, for 18 months extra each time. If the revenue from demand response is considered stable for the duration of the project, then the demand response component could reduce the payback period of the project from 11.8 years to 10.7 years, or by 9.3 %. If a 150 kW battery storage system is additionally considered, then the demand response revenues can be increased, thus reducing the project payback period from 10.7 years to 9.9 years. This demonstrates that demand response could potentially reduce the payback period, hence the contract length, by up to 16%.

Even though the demand response market is considered to be highly unstable by financial institutions, the combination of the different schemes for demand response services improves the business case for flexibility. While the revenues from load shedding have decreased during the past few years and will most likely continue to fall, the revenues from fast frequency response are becoming more promising. This is because they help stabilize the intermittency caused by the increased integration of renewables in the electricity grid. As more demand response markets in counties around Europe mature and stabilise, the opportunities for a NOVICE approach to building renovations that combines revenues from both energy efficiency and demand response will become more feasible for ESCOs and aggregators around Europe.

8 REFERENCES

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9 APPENDIX A – DATA REQUIRED FROM SITES

9.1 ENERGY EFFICIENCY MEASURES DATA REQUIREMENTS

Data requests	Minimum requirement	Ideal (if available)	Minimum publishing requirements
List of EE measures installed	List of main EE measures installed in last 1-3 years	List of all measures installed in last 3 years	General list of the types of measures installed
Installation dates for each EE measure	Approximate date of install/completion	Actual date of install/completion	Not published
Cost of installation of EE measures	Approximate total cost of the package of measures installed	More detailed breakdown of costs in terms of capital costs (design, equipment purchase, installation, other) and operational costs (maintenance, management, M&V, other) - broken down by measure or by project.	Total cost approximations
Electricity consumption	Monthly electricity consumption data for at least 6 months before installation of first EE measure and 6 months after installation of latest EE measure; or 1 full year before/after EE improvement	15 minute electricity consumption data from 12 months before installation of the first EE measure to 12 months after installation of the most recently installed EE measure	Annual electricity consumption figures and total reductions achieved through the package of EE measures

Gas consumption	Monthly gas consumption data for at least 6 months before installation of first EE measure and 6 months after installation of latest EE measure; or 1 full year before/after EE improvement	60 minute gas consumption data from 12 months before installation of the first EE measure to 12 months after installation of the most recently installed EE measure	Annual gas consumption figures and total reductions achieved through the package of EE measures
Oil/other fuel consumption (if applicable)	Estimate of annual oil/other fuel consumption in kWh/litres/kg of fuel before/after EE improvement	Daily/weekly/monthly measurements of oil or other fuel consumption	Annual oil/other fuel consumption figures and total reductions achieved through the package of EE measures
Electricity price	Site does not provide any data - we assume an average electricity price/kWh based on location and annual consumption and published electricity prices	Actual electricity price/kWh from a sample electricity bill, including any changes over the time period being assessed	Not published
Gas price	Site does not provide any data - we assume an average gas price/kWh based on location and annual consumption and published gas prices	Actual gas price/kWh from a sample gas bill, including any changes over the time period being assessed	Not published
Oil/other fuel price (if applicable)	Site does not provide any data - we assume an average oil/other fuel price/kWh based on location and annual consumption and published fuel prices	Actual oil/other fuel price/kWh from a sample invoice, including any changes over the time period being assessed	Not published
Other site charges (e.g. max capacity, climate change levy, etc.)	Site does not provide any data - we assume these charges based on site location, size and industry standards for these prices	Actual cost of other charges from sample electricity, gas, oil and other fuel bills/invoices	Not published

Funding source for the EE installations	Site does not provide any data - we assume the project was self-funded	Client gives breakdown of funding source i.e. percentage self-funded, grant funded, loan funded etc, plus details of any interest charges on the loan, loan term etc.	Statement of whether a grant or loan was received
Incentives received (e.g. feed in tariffs, renewable heat incentives, capital allowances)	Site does not provide any data - we assume which incentives the project has received based on what was installed, and the incentives available in the country at the time of installation	Breakdown of payments received through each incentive scheme	Total value of incentives received

9.2 Demand response data requirements

Data requests	Minimum requirement	Ideal (if available)	Minimum publishing requirements
DR equipment installed	List of equipment installed		General list of equipment installed
Installation date	Approximate date of install/completion	Actual date of install/completion	Not published
Cost of installation DR equipment	Approximate total cost of the package of measures installed	More detailed breakdown of costs in terms of capital costs (design, equipment purchase, installation, other) and operational costs (maintenance, management, M&V, other) - broken down by measure or by project.	Total cost
In which DR programmes is the site participating?	List of DR programmes	List of DR programmes	List of programmes

Revenues from DR	Total annual revenues from all programmes	Annual revenues broken down by DR programme and/or DR event	Total annual revenue
Further details on DR participation		Number of dispatches/year under each programme, date/time of each dispatch, revenue received from each dispatch. Multiple years of data would be beneficial if available particularly if tariffs/availability has changed over time	Average number of dispatches per year

9.3 OTHER INFORMATION THAT COULD BE USEFUL

Data requests	Minimum requirement	Ideal (if available)	Minimum publishing requirements
Indication of occupant comfort	Any anecdotal evidence of impact of DR participation or EE measures on thermal comfort/business operation	Any measured data e.g. internal temperature data covering the period being assessed	General impact on thermal comfort/business operation
Site details	Sector, building floor area, approximate location, approximate staff numbers, typical occupied hours, biggest energy consuming areas/equipment	changes in usage of facility before/after EE improvement (production, staff, used floor area, etc.)	Basic site details

10 Appendix B: Demand response revenues pre energy reduction

This section presents the quote that the aggregator has prepared for the site if the supermarket would decide to participate in demand response, without implementing any energy efficiency measures. Table 10-1 presents the revenues that can be obtained by participating in various demand response schemes with the following systems: HVAC and refrigeration with a capacity of 71.4 kW and the generator total site load of 168 kW. The revenues are higher than after the energy efficiency measures because the site load is higher, therefore there is more capacity for participating in demand response programs.

Table 10-1: Demand response quote for the supermarket pre energy reduction

Service name	Response within	Response time	System Participating	Revenue for client (€)			
				2020/21	2021/22	2022/23	Total
FFR	2 s	10 s	HVAC, Refrigeration	1038	1306	1306	3650
POR	5 s	15 s	HVAC, Refrigeration	2407	2758	2758	7923
SOR	15 s	90 s	HVAC, Refrigeration	1456	1668	1668	4792
TOR1	90 s	5 m	Generator	2710	3104	3104	8918
TOR2	5 m	20 m	Generator	2325	2663	2663	7651
RRD	20 m	60 m	Generator	1050	1203	1203	3456
RM1	1 h	3 h	Generator	225	258	258	741
			Total	11211	12960	12960	37131
DSU	1 h	2 h	Generator	3486	3471	3715	10672
			Grand total	14697	16431	16675	47803