InnoEnergy Sidewalk Program

Business Case: Team Lutellica

Team Members

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Dated: 17th February 2019

Executive Summary

One of the greatest challenges of the 21st century is the menace of climate change. There has been seen a great increase of penetration of renewable technologies especially wind, in the last decade to rid of fossil-based production in the electricity sector. The increased share of intermittent renewables also implies that there are times when there is a surplus of electricity in the system and the full potential of these technologies is not materialized. On the other hand, a large number of off-grid activities such as concerts, festivals and construction sites are still powered by using fossil-based energy sources such as diesel generators. As team Lutellica – we see an opportunity here to make use of storage by using excess energy from wind farms at times of wind curtailment and transporting them to where they are needed such as off grid construction sites, festivals and concerts etc. The solution not only provides clean energy to events but also facilitates the integration of renewables in the energy sector in a cost that is very much competitive to what is being offered by non-renewable fossil-based sources.

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1. Mission Statement

Our mission is to pave way to a carbon neutral society by assisting the integration of renewable technologies and replacing fossil-based modes of energy for off-grid activities.

2. Business Description

The increasing penetration of renewables, especially wind energy, has led to a number of challenges. The varying characteristics of wind generation combine with limited forecasting ability makes it challenging to integrate it into the grid. Due this nature of the wind, there are times when grid is so congested that a wind farm has to be curtailed to ensure the reliability of the whole system. The problem of wind curtailment is a serious issue and it increases with increasing penetration of wind energy.

Table 1 shows an increase in wind curtailment with increasing penetration of wind energy for some EU countries. The wind curtailment ratio represents the wind energy curtailed out of total wind energy installed capacity. In Germany specifically, the increasing share of wind energy has resulted into increased wind curtailment.

Table 1 - Curtailment Rates in selected EU countries (Source Bundesnetzagentur, 2017)

Country	Year	Wind penetration ratio (%)	Wind Curtailment Ratio (%)	Wind Curtailed (GWh)
Germany	2011	8.00	0.80	410
	2012	8.00	0.70	358
	2013	8.10	0.90	480
	2014	9.10	2.10	1221
	2015	14.60	3.50	3060
UK	2012	3.90	0.40	45
	2013	5.90	2.00	380
	2014	7.00	3.10	659
Ireland	2012	14.50	2.50	103
	2013	17.40	3.50	171
	2014	18.20	4.40	236
Spain	2012	16.20	0.30	121
	2013	19.00	2.10	1166

According to a study (Svenningsson, “Energiewende continued – tackling the challenge of coal”), in 2015 about 4 TWh of wind energy was curtailed in Germany as shown in Figure 1. It was seen that a wind farm located in the North of Germany which was curtailed more than 32 % of the time in 2017 alone wasting a massive 134 GWh of wind energy.

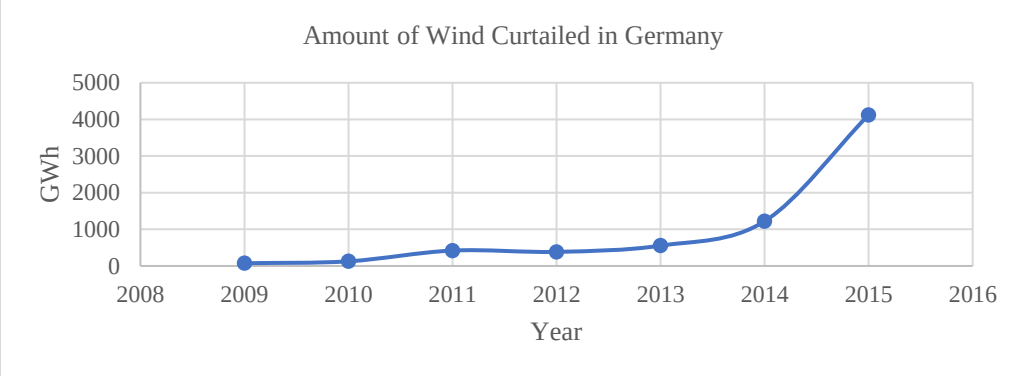

Figure 1- Wind Energy Curtailment in Germany (Source: Bundesnetzagentur, 2017)

On the other hand, the event industry, mostly comprising of festivals and musical concerts, relies primarily on diesel generators to fulfill the power requirements. These generators emitted about 1.2 billion kg of CO2 in UK in 2013 and about 380 million liters of diesel was used. On top of that, the diesel generators that these festivals are oversized, such that the average generator load is 10-20 % while ideal range is 50-70 %. This also leads to high emissions.

We see an opportunity in both situations making excess use of curtailed energy at the wind farms to meet the energy demands of the off-grid activities that are at present being met by fossil-based technologies i.e. diesel generators.

3. Products or Service

The proposed solution is a service-based model and is aimed to utilize the curtailed wind energy to provide power for off-grid applications like construction sites, festivals and concerts. The missing piece of the puzzle is battery storage. The curtailed wind energy is used to charge the mobile battery storage. Once fully charged, the battery is transported to customer premises to provide power to off grid application like festivals, music concerts, and construction sites that usually rely on diesel generators. This is shown in Figure 2.

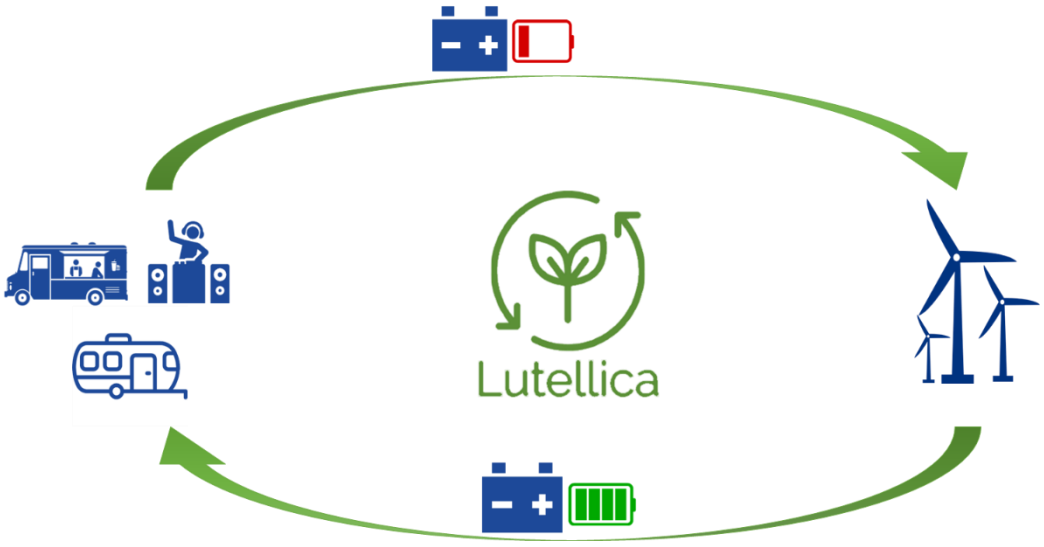

Figure 2 - Lutellica Business Model

It should be noted there that since during wind curtailment wind farms are not allowed to inject electricity into the grid, the batteries must be transported at the location of the wind farm to be charged. By making use of electric storage our solution mainly provides the following value proposition:

- The increased integration of renewable energy – reduced wastage of renewable energy due to wind curtailment.
- Clean energy for off-grid applications which usually rely on diesel generators. A single proposed storage system will save 8.4 million kg of C02 emissions over its lifetime.

4. Marketing Strategy

The Marketing Mix defined below explains the value that we will bring to our clients as well as the channels, communication, and cost that will be associated with our services.

Customer Segment

Lutellica provides its energy services to help industries and small businesses to start moving in the direction of carbon neutrality. Our services are tailored specifically to the energy needs of small business such as festivals and events, as well as large industries like Mining and Construction. Further, we are also providing services to reserve capacity market to reduce idle time of our assets. With a shortage of available alternatives to diesel generators plus the environmental and health pressure usually associated with emissions, our services provide a cost-effective alternative to replace diesel generators.

The rental power market currently is dominated by diesel generators with a market size of 80.77%, as shown in Figure 3.

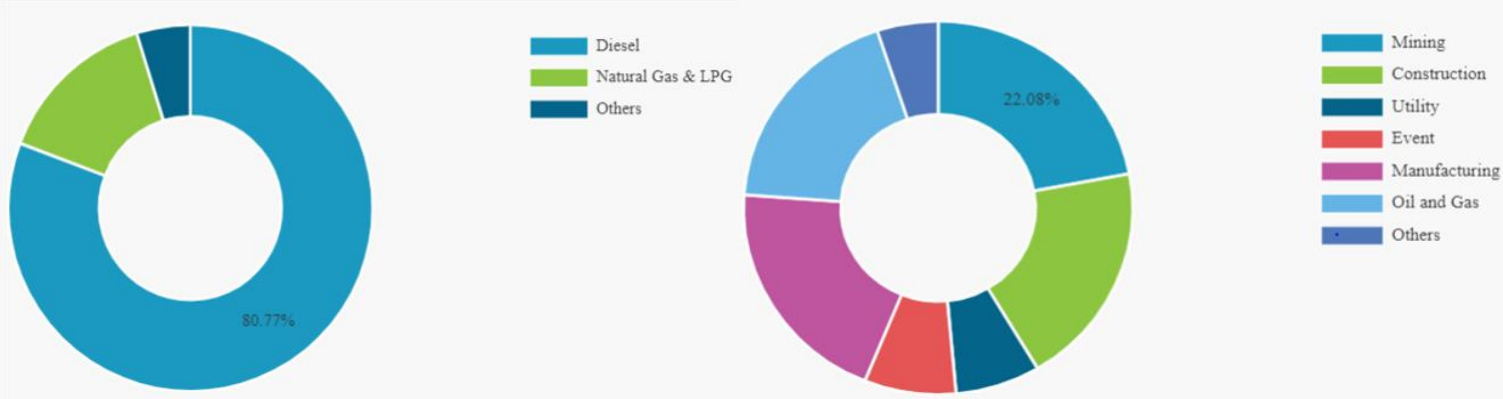

Figure 3(a) - Global Rental Market Share by Fuel Type Figure 3(b) - Global Rental Market Share, by End-Use

(Source: Fortune Business Insight, 2018)

The largest customers of the rental power market are Mining and Construction industry, both taking around 22% of the market share of the demand. Moreover, according to fortune business insight 2018, the rental power market is estimated to grow linearly over the next 6 years up to $20 Billion in 2026 as shown in Figure 4. Realizing the steady growth of the rental power market with Mining and Construction industry consuming a large portion of diesel power, Lutellica plans to concentrate on these two industries as our primary target market.

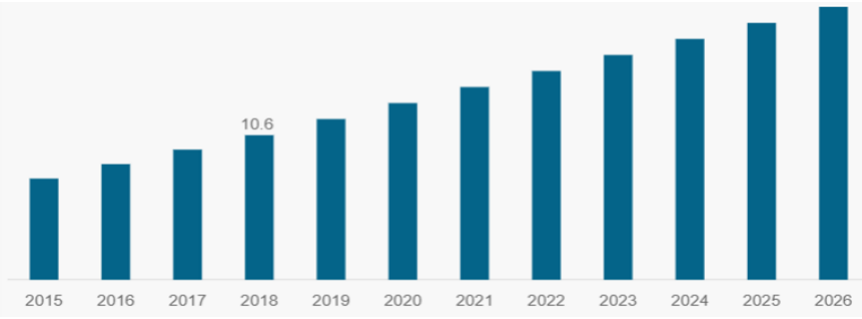

Figure 4 - Global Power Rental Market Size 2015-2026 (US $ Billion)

(Source: Fortune Business Insight, 2018)

Pricing Strategy

Lutellica will work with value-based pricing strategy as our services provide environmental and health and safety benefits in addition to being cost-competitive against diesel generators. This places Lutellica in a strategic position to ask for a premium for providing sustainable energy services.

Our services are priced using a baseline LCOE (levelised cost of electricity) of a generic diesel generator that is 0.5 $/kWh. The minimum base price of LCOE for our batteries is set at 0.25 $/kWh which is then topped with a premium for our value-based services. Lutellica will determine a different pricing structure for customers in each market (construction, events, reserve capacity market). This will be expressed to the client as a per-deliverable fixed price in a quote. Clients can determine which parameters they require from our services such as capacity, energy, and rental duration. In time, Lutellica will need to define a more structured pricing strategy to cater in different clients.

Customer Outreach Strategy

Our initial focus will be in the construction and mining industry in Sweden. Both the industries are known have demand for sustainable energy source. In the mining industry there is a need for non-emission producing generation sources to avoid costs of building ventilation systems. Similarly, the construction industry needs energy sources that does not produce emissions in closed spaces such as tunnels and urban areas. Once we secure clients from these industries, we will expand to other markets where we can provide flexibility services to the reserve capacity market. Our locations and focus will expand as we add more battery assets to our inventory.

We will use several channels to promote Lutellica. Through participation in business creation programs like the Sidewalk program, we will make contacts with key industry professionals, investors, contractors and small business resources in the area. Once we have established a minimum viable product for piloting our product/services, we will further participate in green energy competitions to increase our exposure and make valuable contacts for future business.

5. SWOT Analysis

Strengths

1. Innovative Business Case:

   The proposed service offers an innovative business case that allows our product (batteries) to be used for multiple operations (allows stacking of revenues). Thus, offsetting the cost of batteries that are otherwise considered very expensive.

2. Green Energy from Renewables:

   The wasted wind energy due to curtailment is used to charge the batteries which not only provides a cheap source of energy to charge the batteries but at the same maximizing the utilization of installed renewable energy capacity. Thus, 100% of clean energy is provided to off-grid customers.

3. Improved Operating Conditions:

   The batteries improve operating condition as compared to diesel generators along with providing 100% clean energy. Through our interaction with the construction industry, we have found out that batteries reduce noise pollution, improve the quality of air which has a direct impact on the health & safety of workers, and reducing the material flow at a construction site as no diesel is needed.

Weaknesses

1. Capital Intensive:

   The initial investment to acquire batteries is high. The feasibility study was conducted for three battery storage systems and I was found that average price of a battery storage system of size 1.5 MWh is around 1 million USD including power electronics.

2. Operational Inflexibility:

   As mentioned in the competitor's analysis section, batteries offer less operational flexibility as compared to diesel generators. Diesel generators keep producing energy as long as the fuel is present while batteries can only provide the amount of energy that is stored in it.

3. Absence of Wind Farms:

   Since the batteries are charged from the wind farm, the distance of site where service is needed should not be too large as it increases the transportation cost.

Opportunities

1. Favorable Legislative Conditions:

   Presently, there are a lot of legislations envisioned that offer a favorable landscape. The European Green Deal aimed to reduce 50% of GHG emissions by 2030 along with making Europe carbon neutral by 2050. Similarly, the increasing importance of battery storage is being recognized at the European level and the creation of European Battery Alliance is a clear example. Similarly, there is already legislation in place for noise pollution and the event industry might have to pay carbon tax due to the use of diesel generators as well in the future.

2. Decreasing Costs of Li ion Batteries:

   The cost of Li ion batteries is decreasing faster than expected due to high interest of automobile and power industry. Bloomberg reported a 73% drop in the price of lithium-ion batteries in 2016 as compared to 2010. Furthermore, it is projected that the price of lithium-ion batteries will drop to 73 $/kWh in 2030 as compared to 273 $/kWh in 2016. Such projections make this technology very attractive.

3. Sustainability Awareness:

   There has been an increasing trend within the event and construction industry to become more sustainable due to increased awareness among the public. Presently, most of the focus is on recycling, reusing materials, and energy efficient equipment. However, in terms of power, they rely heavily on diesel generators. Thus, once this proposed service is proven it has the tendency to generate high interest from such industry.

4. Increasing Wind Penetration:

   IEA, in its recent outlook, stated that wind has the potential to power the whole world. Similarly, at European level, there are ambitious goals to increase the wind capacity. Such an increase in wind capacity will make wind curtailment a common occurrence to keep the security of the grid. This will increase the application energy storage at wind farms on one hand but also make balance services more expensive due to the loss of system inertia. This increase in balance reserve pricing will increase the revenues from frequency reserve market.

Threats

1. Resistive Mindset:

   One of the target market segments is construction industry which is rather conventional as compared to the event industry. Construction industry relies heavily on diesel generators and site management might depict a resistive mindset to this new concept.

2. New Technological Advancements:

   Some radical technological advancements, like new battery chemistry, substantial decrease in the price of hydrogen fuel cell or green fuel, might pose a threat to the proposed service.

6. Operations Overview

Some aspects of operations have already been mentioned in Section 3: Products or Service. Since our battery assets are a valuable source of clean energy with a wide variety of application, we can provide services to multiple markets where sustainable energy is required. Lutellica's first customers will be from off-grid areas such as events, mining and construction industry. Initially, we will aim at replacing diesel generators in areas where the energy requirement is low. For instance, some equipment on construction sites or events that could be more efficiently powered with batteries than diesel generators. After we have established a firm customer base in these areas, we will be in a better position to expand to reserve capacity market with a larger portfolio of assets.

7. Competitor Analysis

The off-grid activities are predominately powered by diesel generators at present in the market and in terms of technology, the diesel power rental companies and operators will be our main competitor. It is observed that although the renting price of a generator is quite low, it is the additional cost of fuel that carries the real cost. Thus, renting a generator will cost the customer about 0.5 $/kWh while our battery service solution would cost about 0.249 $/kWh. However, this price of the battery storage system is the marginal price, or the price at which break-even is achieved at the end of project lifetime, and the service price must be higher than this to include the profit margins. The marginal price of battery storage service is almost half of the price per unit of renting a diesel generator This is shown Figure 5.

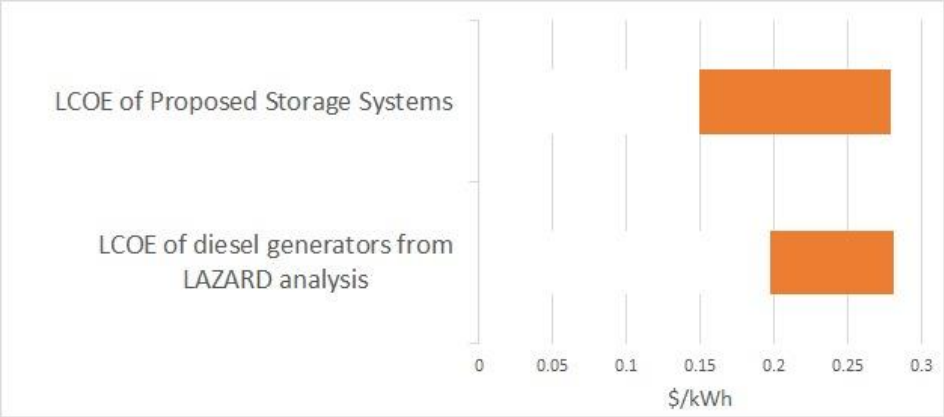

Figure 5 - Levelized Cost of Storage Comparison with Diesel

These numbers were obtained by comparing generic Li-ion battery costs and commercially available battery products LG-chem and Tesvolt with commercially used Atlas Copco Generator QAS150, the characteristics of which are given in Figure 6.

Generator QAS150		
Power (kW)	120	
CO2 emission (kg/liter)	2.6	
Load rating	100 %	75%
Operating hours	12.5	16.67
Total energy produced (kWh)	1500	1500
Fuel consumption (liters/hour)	32	27.7
Fuel price ($/liter)	1.3899	1.3899
Total fuel price ($)	555.96	641.80
Rent per day ($)	173.8	173.8
Total price ($)	729.76	815.60
Total CO2 emissions (kg)	1040	1200
Price per unit ($/kWh)	0.4865	0.5437

Figure 6 - Diesel Generator Levelized Cost Comparison Parameters (Source: Atlas Copco)

In addition, the obvious value proposition over diesel generators is the huge impact of reduction of CO2 emissions making the concerts greener, which in turn improves the overall user experience and enhances the brand value of the event. Along with diesel generators, in terms of technology, hydrogen fuel cells could also be a potential competitor in the future, however the technology is not yet mature enough and not readily deployed to power off grid activities at present.

An analysis was performed based on the existing solutions already available in the market that are based on different technologies (e.g. diesel generators, hydrogen) and for solutions present in the market utilizing the same technology (i.e. Li Ion batteries).

The following parameters were mainly used to evaluate the possible solutions:

- Ease of Access
- Cost to Consumer
- Emissions
- Health and Safety

Figure 7 shows a competitor grid analysis based on the perceived score of different technologies in terms of the above-mentioned parameters.

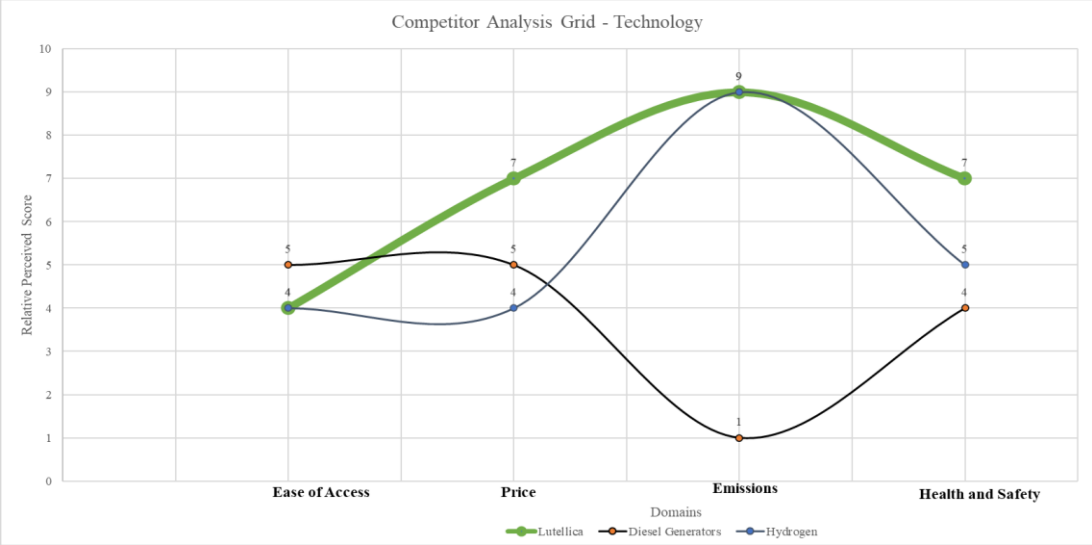

Figure 7 - Competitor Analysis Grid Based on Technology

However, there are at present some companies in the market, that offer charged batteries to off-grid users. One such startup is called “Greener” and is operational in Netherlands. However, their service is not cheap as they use grid electricity to charge their batteries and in addition to that it is not completely clean energy as it depends on the carbon intensity of grid electricity. The perceived competitor analysis is presented in Figure 8.

Figure 8 - Competitor Analysis Grid Based on Same Technology

8. Financial Plan

For the financial plan a storage unit of 1.5 MWh is considered. This is the maximum size of storage that can be constructed and transported in a shipping container. A cash flow analysis is conducted to identify the cash inflows and outflows. In the analysis, it is considered total cycles of battery storage systems are equally divided among each year.

Cash Outflows

A storage unit of 1.5 MWh from TESVOLT Gmbh will cost about 1.3 million $. The total O&M cost over the project lifetime of 10 years is 0.5% of total capital cost (6.9 K$). The charging cost considered is 38.6 $/MWh which is the average wholesale electricity price in Germany. In the subsequent years, an increase of 0.55% in charging cost is considered. The total charging cost incur is shown in Figure 9.

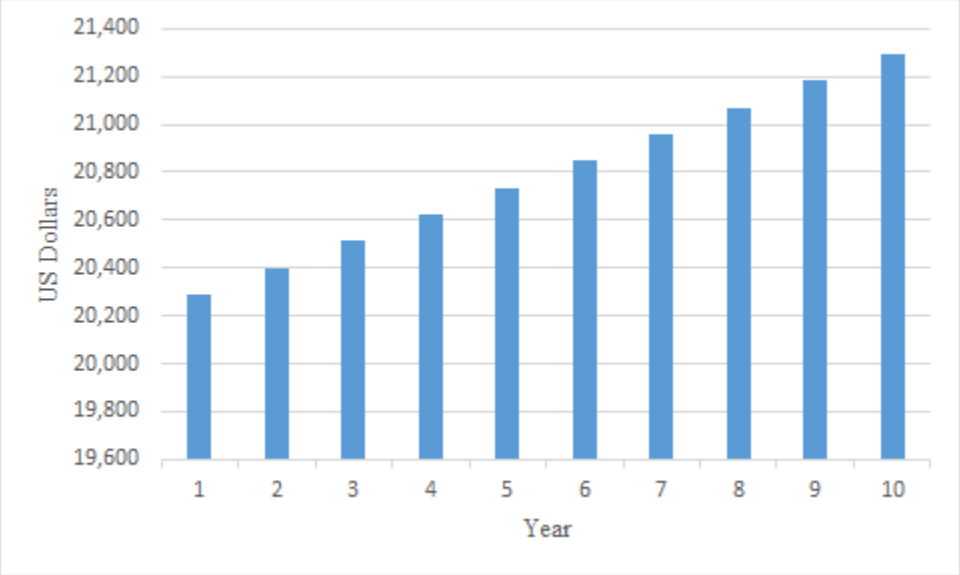

Figure 9 - Charging Cost Incurred During Each Year

Cash Inflows - Revenues

The business model is based on stacking up the revenue streams. Thus, two revenue streams are considered by assuming that battery cycles are equally divided between these two:

1. Frequency Reserve Revenues: The battery storage unit can be used to provide frequency reverses. It is assumed that storage unit is pooled in the reserve market for 4 months (January, February, November, December) each year. Since in winters the prices of frequency reserves are higher than summers. The capacity price is assumed to be constant at 30 $/kW/hr (average in Sweden) for each day (daily auction). The energy price ($/kWh) is not considered for simplification.

2. Off-grid application: The off-grid application consists of event industry and construction industry. The event and construction activities increase during summers. The pricing is considered to be competitive to diesel generators, as discussed in Section 7 Competitor Analysis**.** Thus, a price of 0.6 $/kWh is considered for the calculation of revenues from the off-grid application.

Figure 10 shows both above-mentioned revenues stacked together. The break-even is almost at the completion of 5th year. The detailed cash flow calculations are shown in **Appendix A**

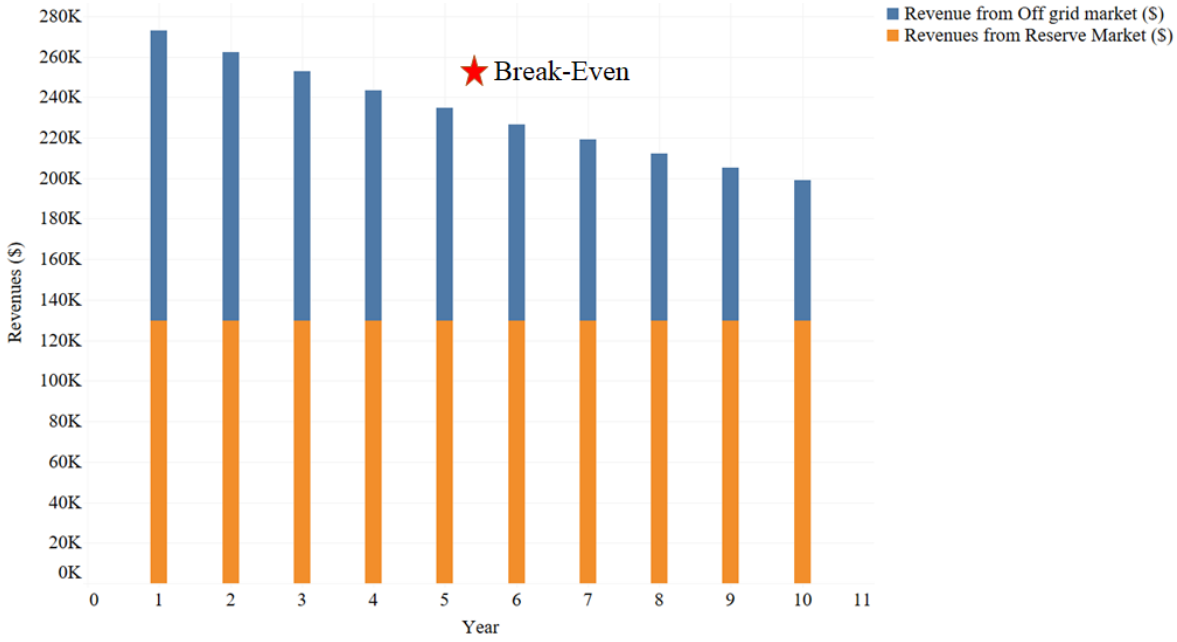

Figure 10 - Stacked revenues from a single storage unit of 1.5 MWh

9. Appendix

Appendix A

Following are the cost and technical specifications for the TESVOLT battery systems that are used in Section 7 Competitor Analysis and Section 8 Financial Plan.

Key Specifications			
Power (kW)	**1500**		
Total energy (kWh)	**1,500.00**		
Total Capital cost ($)	**1,379,523.60**		
O&M (% of capital cost)	0.50		
Efficiency **	98.00		
O&M ($)	**6,897.62**		
Charging cost ($/kWh)	0.04		
Charging cost escalator (%)	0.55		
life time(years)***	10.00		
DOD (%)	100.00		
DOD cycle/day	1.00		
Operation days/year	350.00		
Total cycles utillized	3,500.00		
Transport Cost ($/kWh)	0.61038		
Yearly increase in transport cost (%)	1.00		
Discount rate (%)	4.50		
End of life energy retained (%)	70		
Degradation each year	0.03		
Cycles not utilized	3,500.00		
Capicity price ($/kW)	0.03	Days in a year for Reserve market	120
Energy price ($/kWh)	0.0734952	Pricing ($/kWh)	0.6
Percentage utilization	50		

Product specification - Tesvolt	
Total energy (kWh)	50
Available energy (kWh)	50
Capacity (Ah)	940
Power (kW)	50
Nominal voltage (V)	900
Cycles	7000
DOD (%)	100
Weight (Kg)	550
Dimmension [L x W x H] (m)	[0.6 x 0.6 x 2.3]
Cost (Euros) *	38924
Cost ($)	43984.12
cost of inverter ($)	2000
capital cost incld inverters ($)	45984.12

Container construction	
Size	40 ft standard
Total storage units	30
Total weight (kg)	16500

*Price quotation from powernsun

**efficiecny taken into account from available energy and total energy

***available in 10 years warranty

Figure 11 - Specifications of TESVOLT battery system

Below is a cash flow analysis on which the financial analysis presented in Section 8 is based.

YEARS	1	2	3	4	5	6	7	8	9	10	Total
Capcity kWh	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	
Total kWh stored (1)	525,000.00	525,000.00	525,000.00	525,000.00	525,000.00	525,000.00	525,000.00	525,000.00	525,000.00	525,000.00	5,250,000.00
Total kWh available (2)	499,065.00	483,630.00	468,195.00	452,760.00	437,325.00	421,890.00	406,455.00	391,020.00	375,585.00	360,150.00	4,296,075.00
Total kWh available corrected (3)	477,574.16	442,874.48	410,277.69	379,667.03	350,931.90	323,967.53	298,674.70	274,959.45	252,732.81	231,910.55	**3,443,570.31**
Total kWh available for Contruction	238,787.08	221,437.24	205,138.84	189,833.52	175,465.95	161,983.77	149,337.35	137,479.72	126,366.40	115,955.28	1,721,785.16
Total charging cost ($)	20,289	20,401	20,512	20,624	20,736	20,847	20,959	21,070	21,182	21,293	207,913.06
Total transport cost ($)	320,448.75	323,653.24	326,857.73	330,062.22	333,266.70	336,471.19	339,675.68	342,880.17	346,084.65	349,289.14	3,348,689.46
Cycles for reserve service (4)	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	
Total reserve capacity revenues ($) (5)	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	
Total reserve energy revenues ($) (6)	0	0	0	0	0	0	0	0	0	0	
Total reserve revenues ($) (7)	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	129,600.00	1,296,000.00
Total charging cost corr ($) (3)	19,415.45	18,681.57	17,974.89	17,294.42	16,639.23	16,008.40	15,401.04	14,816.31	14,253.38	13,711.45	**164,196.14**
Total transport cost corr ($) (3)	306,649.52	296,378.97	286,424.32	276,777.41	267,430.21	258,374.79	249,603.35	241,108.23	232,881.90	224,916.95	**2,640,545.66**
Total reserve revenues corr ($) (3)	124,019.14	118,678.60	113,568.04	108,677.55	103,997.66	99,519.29	95,233.77	91,132.79	87,208.41	83,453.03	**1,025,488.28**
Total contruction revenues ($)	143,272.25	132,862.34	123,083.31	113,900.11	105,279.57	97,190.26	89,602.41	82,487.83	75,819.84	69,573.17	1,033,071.09
										LCOS ($/kWh)	**0.92**
										LCOS ($/MWh)	**919.30**
										Total revenues ($)	**2,329,071**

(1) The total energy stored in the battery = [capacity] * [DOD cycle/day] * [operation days/year]

(2) Total enegy available during discharge by taking into account the round trip efficiency and DOD = [Total kWh stored] * [efficiecny] * [DOD]*(1-[Degradation each year])

(3) Accounting for the discount rate by multiplying with 1/(1+[dicount factor])^[year]

(4) cycles not utilized for charging the feastivals. Thus, available to provide the reserve service

(5) Total reserve capacity revenues = [# cycles not utilized] * [Power of storage system] * [Capcaity price]

(6) Total reserve energy revenues = [# cycles not utilized] * [Capacity of storage system] * [Energy price]

(7) Total reserve revenues = [Total reserve capacity revenues] + [Total reserve energy revenues]

Figure 12 - Detailed Cash Flow Analysis