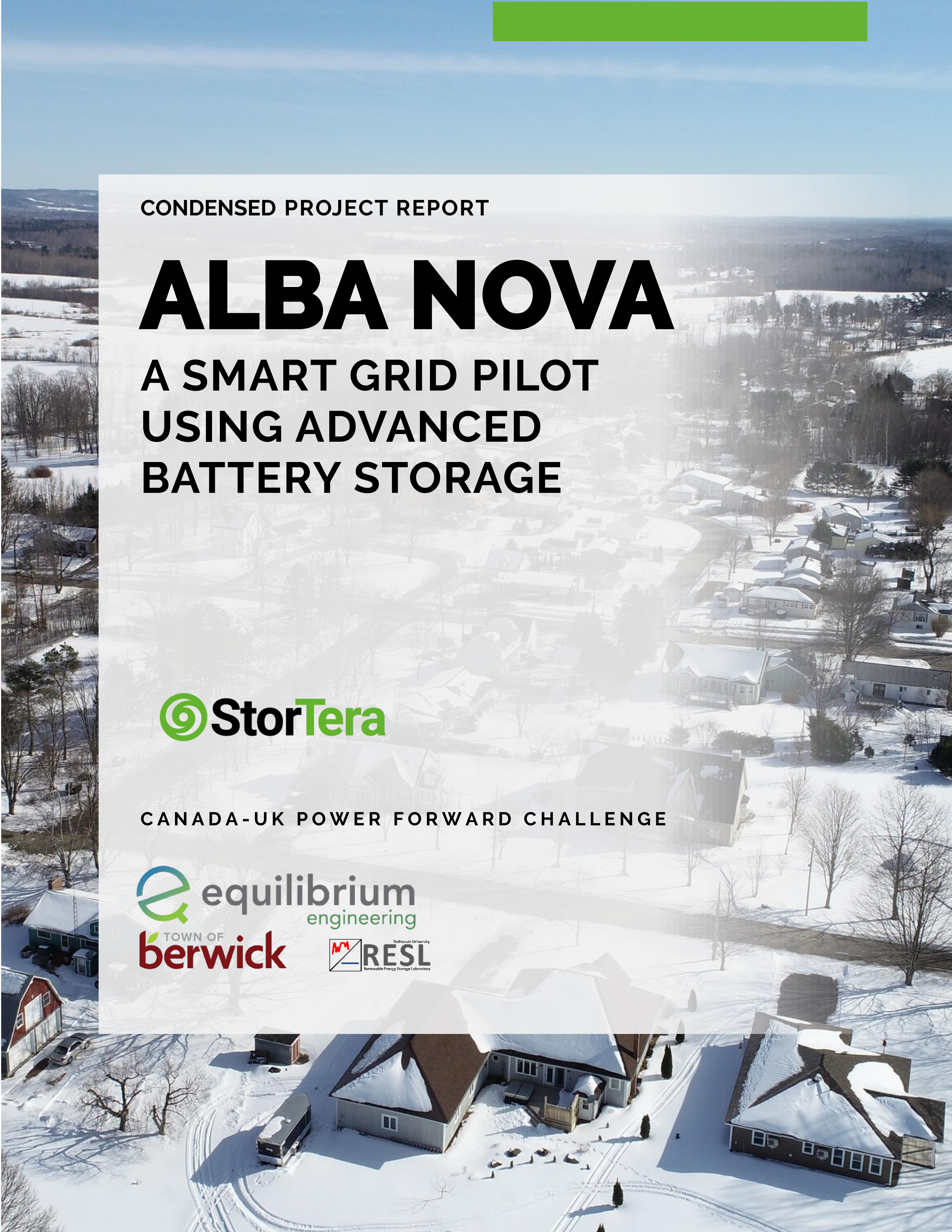

CONDENSED PROJECT REPORT

ALBA NOVA

A SMART GRID PILOT USING ADVANCED BATTERY STORAGE

StorTera

CANADA-UK POWER FORWARD CHALLENGE

equilibrium engineering

Town of berwick

Dalhousie University RESL Renewable Energy Storage Laboratory

1 PROJECT OVERVIEW

1.1 PROJECT INFORMATION

Table 1: Project Basic Information

Project Title:	**Alba Nova: A Smart Grid Pilot Using Advanced Battery Storage**
Project Location(s):	Town of Berwick, Nova Scotia
Project Start Date:	October 20, 2019
Project End Date:	February 28, 2022
Lead Organisations:	Equilibrium Engineering Inc & StorTera Ltd.

1.2 PROJECT SUMMARY

1.1.1 PROBLEM STATEMENT

The potential benefits of smart grids are known; however, projects typically prioritise the needs of either the grid utility or the consumer. This approach limits their rapid deployment as the high capital costs must be supported by government intervention or significant price increases for consumers. Aside from being economically unsustainable, projects often fail to optimise renewables for all stakeholders, enable rapid electrification, or address local air quality issues. A lack of consumer engagement means that they don't see tangible benefits for energy price increases, and the challenge of behavioural change in tackling the climate emergency remains unresolved.

Affordable and clean electrification of heat is a significant challenge when oil and gas are cheaper than electricity and renewable energy is intermittent. The successful and rapidly deployable smart grid solution must be highly flexible and provide affordable decarbonisation for a diverse range of stakeholders with a variety of needs representative of society.

1.1.2 SOLUTION SUMMARY

The Alba Nova team has taken a revolutionary approach by developing a highly flexible smart grid that focuses on the needs of the consumer first and leverages benefits for the grid. This has been achieved by electrifying heating, adding renewable generation with smart residential and commercial energy storage, converting electrical loads to flexible loads, and introducing innovative systems for the grid to absorb more renewable energy.

Figure 1: System Solution Diagram

The solution is enabled by our key innovation, an energy storage platform called the TRAICON (tri-layer artificial intelligence controller). The TRAICON utilises neural network-based machine learning to analyse large datasets, monitor, optimise and proactively control all the connected assets. The project also demonstrates an innovative financing mechanism to reduce the upfront costs of the smart grid, making it possible to scale this solution more rapidly.

Our approach requires effective engagement with stakeholders, a deep understanding of the local grid requirements, renewable energy generation, energy usage and weather predictions. We optimise overall performance for both the consumer and the utility using accurate prediction algorithms and analysis of numerous high resolution data streams.

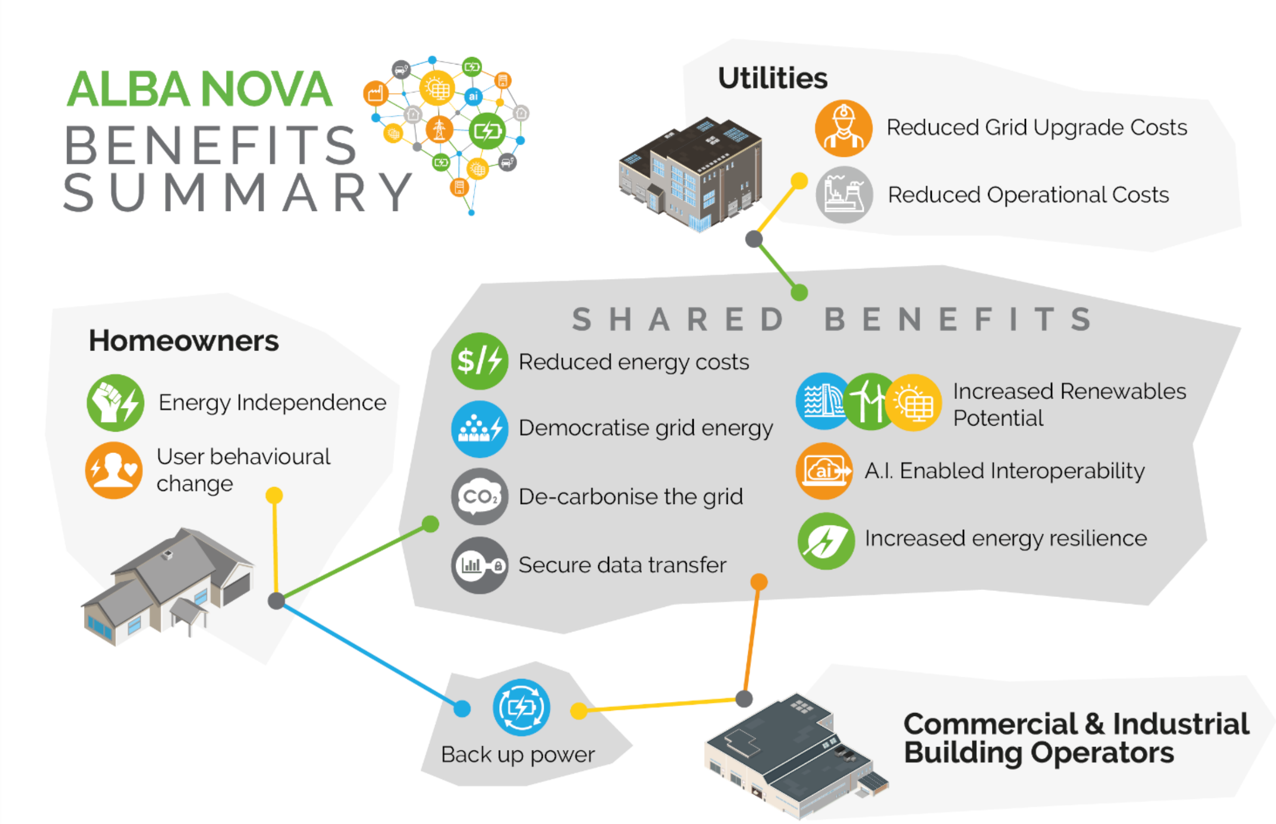

Figure 2: Benefits Summary

We have designed and integrated a wide range of hardware, software and controls to the Berwick grid comprising ten residential and two commercial installations. In total they provide 525kW of dispatchable power for over 2 hours with up to 600kW of controllable loads. We have modelled and tested several operational strategies to assess their benefits and determine the optimum control strategy for the Town of Berwick. This cost-efficient solution can be replicated worldwide.

1.1.3 BENEFIT TO STAKEHOLDERS

Our AI platform combines increased asset visibility, aggregation, network operation and access to revenue streams.

Electric Utility Benefits

- Demand side response reduces grid peak demand minimising need for back-up capacity and lowering network maintenance costs
- Aggregation platform provides visibility of flexible assets and lower cost utilisation than conventional generation through virtual power plant
- Distributed energy resource management system provides control of resources that reduce grid upgrade costs
- Energy system platform enables grid services revenue by providing flexibility services to other networks
- Optimum use of renewable energy through prediction algorithms

Residential and Commercial Customers Benefits

- Maximum self-consumption of solar generation
- Controllable loads and energy storage optimise use of off-peak energy and provide peak demand rebates
- Solar generation and energy storage exports to grid provide revenue through feed-in tariffs or net metering
- Distributed systems provide resilient energy supply and financial incentives for flexible loads
- Energy system platform enables peer-to-peer energy transfer and trading income

1.1.4 PUBLIC SUMMARY OF THE PROJECT

Smart grids help us adapt to changes in our electricity grid by using information and control more effectively. These changes include more large-scale renewable energy generation on the transmission grid, electrification of heating, solar generation on homes and charging electric vehicles. There are many users and variables in our future grid that must be integrated to continue providing secure, safe, and high-quality electricity. One of the key questions in smart grids is 'who benefits and who pays for the hardware, software and controls required?' The Alba Nova project set out to address this question by implementing a smart grid that optimises benefits for everyone and shares the costs.

Our project involved the design and installation of a smart grid solution in the Town of Berwick, Nova Scotia. This included the conversion of ten homes with solar PV panels, energy efficiency measures and intelligent battery systems as well as two large commercial battery installations at the town hall and ice hockey rink. The systems provide benefits to customers through maximising their consumption of solar energy, using low tariff grid energy, and providing back-up during outages. They also support the grid through reducing the peak demand, increasing the utilisation of renewable energy, and stabilising the grid.

The key innovation is the use of an artificial intelligence (AI) platform that manages data and control ranging from battery cell information to sophisticated algorithms that predict the solar energy and energy demand of customers for the day ahead. This cost-efficient solution can be replicated worldwide.

One of the StorHub commercial energy storage systems installed at the Town Hall in Berwick, Nova Scotia

One of the StorTower commercial energy storage systems being installed in Berwick, Nova Scotia

StorHub commercial system installation in Berwick, Nova Scotia

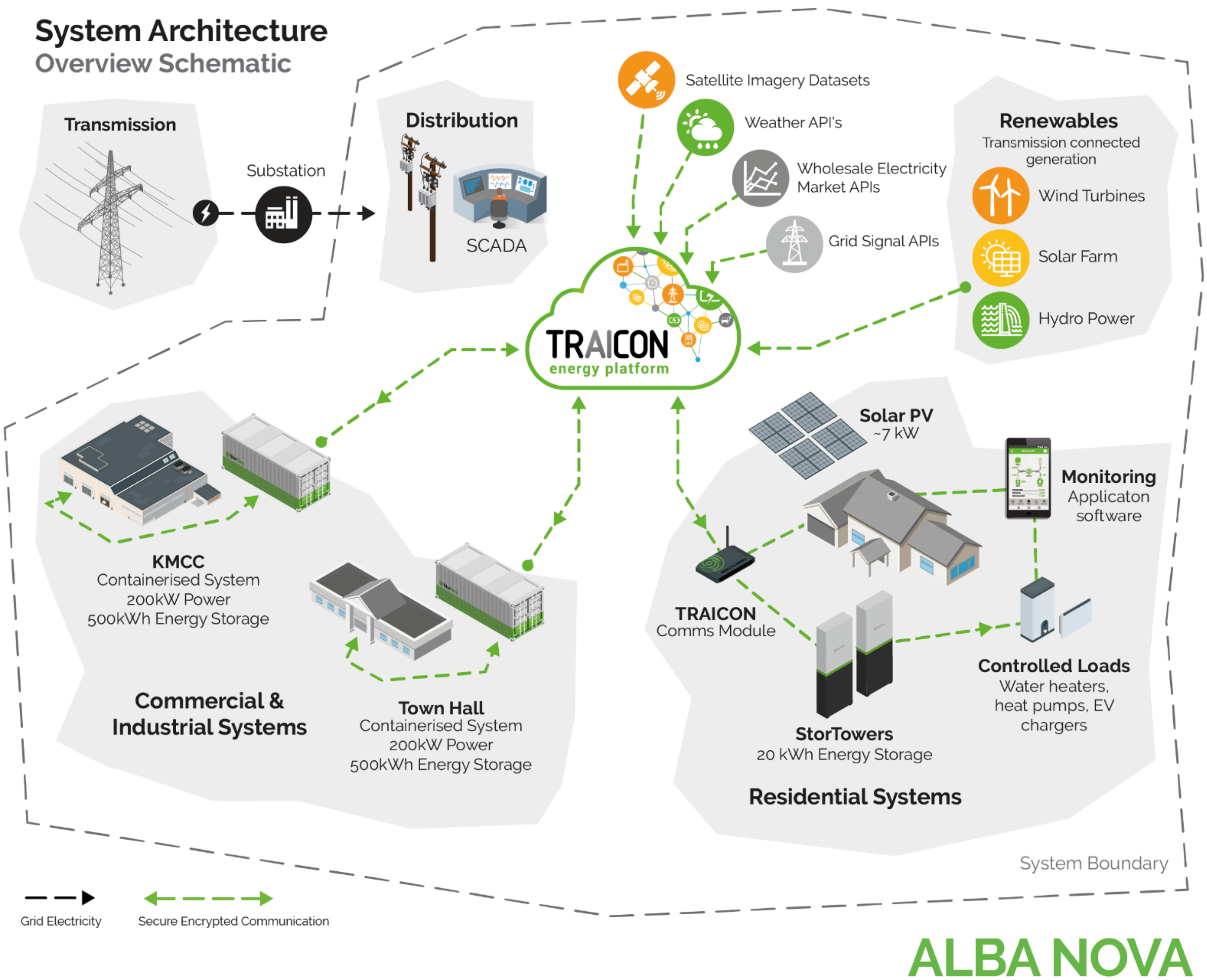

Figure 3: TRAICON energy platform system architecture

Our approach required effective engagement with stakeholders, a deep understanding of the local grid requirements, renewable energy generation, energy usage and weather predictions. We optimise overall performance for both the consumer and the utility using accurate prediction algorithms and analysis of numerous high resolution data streams. We have designed and integrated a wide range of hardware, software and controls to the Berwick grid comprising ten residential and two commercial installations. In total they provide 525kW of dispatchable power for over 2 hours with the capacity for up to 600kW of controllable loads. We have modelled and tested several operational strategies to assess their benefits and determine the optimum control strategy for the Town of Berwick. This cost-efficient solution can be replicated worldwide.

The project solution has helped decarbonise homes, businesses, and the grid while reducing the required grid infrastructure upgrade costs to absorb more renewable energy. For the first time in the industry, the Alba Nova grid has demonstrated the use of TRAICON to capture and integrate

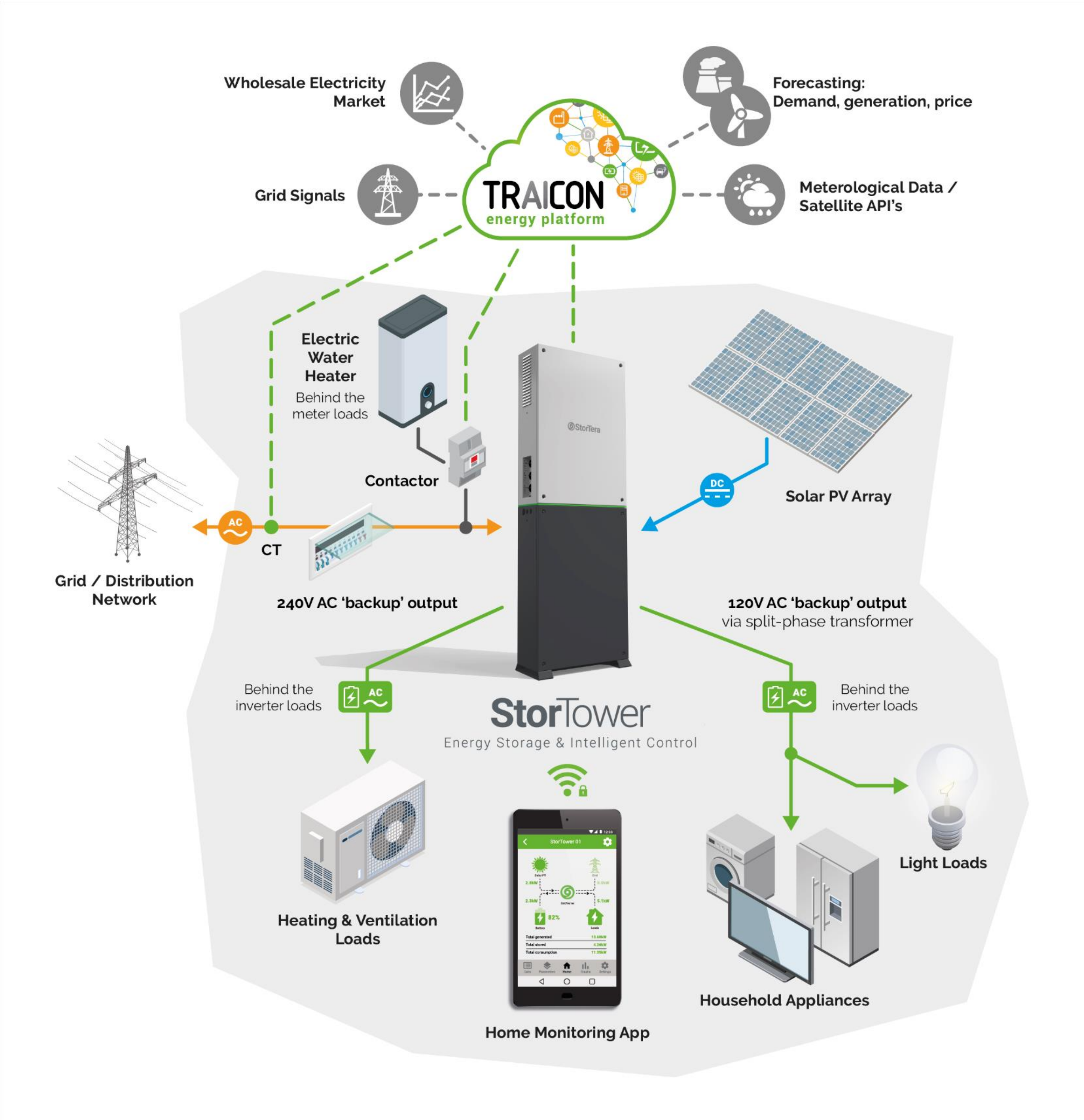

Figure 4: Residential Energy System architecture

The residential system is capable of providing the following services:

1. Network charge avoidance – behind the inverter loads powered by solar PV and battery reduce the grid utility peak demand when operated by the TRAICON and allow residences to avoid residential peak demand tariffs.

2. Demand side response – TRAICON can control "behind the inverter loads" so they only use grid energy during off-peak periods. In case the grid needs to shed loads, these DSR loads can still function only using battery power which amplifies the impact of DSR in an innovative way.

3. Demand side response of "behind the meter loads" – provisions are kept for three controllable grid fed DSR loads of up to 60kW in each house, amounting to 600kW of DSR loads in 10 residences, if suitable loads are connected. Presently, 4.5kW water heaters are connected to the TRAICON load controller in 10 houses, amounting to 45kW. These loads can be controlled by the utility to manage utility peaks and for other grid services.

4. Arbitrage –batteries and heat storage loads can be charged during network off-peak times and batteries can be discharged back to the grid during peak demand periods. This method helps to reduce the yearly winter-time peaks of Berwick Electric Commission. As the behind the inverter loads are powered both by solar PV and battery, there is sufficient battery capacity left in the battery for future grid services.

5. Peer-to-peer energy transfer – the TRAICON can provide residential peer-to-peer energy transfer. The peer-to-peer capability was developed for TRAICON and under this project, however, could not be implemented in the Town of Berwick due to significant regulatory challenges. The peer-to-peer capability of the TRAICON was successfully tested within a regulatory sandbox in the UK with EDF Energy in 2021. This demonstration was the first successful peer-to-peer project carried out in the UK and continues to operate.

6. Back up (storm readiness feature)

7. Situational awareness using App and stake holder behavioural change

8. AI based battery charging and discharging

The system hierarchy diagram of the Residential Energy System in Figure 8 illustrates how each requirement is connected to the system elements.

COMMERCIAL ENERGY SYSTEM

In order to address the needs of Berwick Electric Commission and the Commercial Building Operators of Berwick , a large-scale energy system was developed. This system has two energy storage systems with a rating of 250kW/500kWh capacity each, installed in two locations in the Town of Berwick - one at the Kings Mutual Century Centre and the other system installed at the Berwick Town Hall. This system can provide the following services along with the TRAICON System

1. Frequency Services - firm frequency services and enhanced frequency services are enabled by TRAICON for Mega Watt (MW) scale energy storage systems. This was tested and verified using a DVTPR. Thereafter validated by RESL.
2. Active and reactive power injection to the grid - this was tested and verified using a DVTPR. Thereafter validated by RESL.
3. Renewable Integration - wind energy absorption during network off-peak times to decarbonise the grid.
4. Discharging MW scale battery for peak shaving to support both utility and commercial customer.
5. Co-locating with renewable generation for future Solar PV installation.
6. Arbitrage services for the commercial customer (Kings Mutual Centre) to take advantage of off-peak tariff.
7. Storm readiness in both commercial sites - battery will be fully charged and ready to be deployed as an off-grid power supply.
8. Demand side response enabled for loads in commercial sites.
9. Backup power for the Town Hall.
10. AI based battery charging/discharging - this methodology is used to provide renewable integration, where as the AI will predict when there will be high renewable energy in the grid and will charge the battery, then discharge the battery when the renewable penetration is low.

A pictorial view of the commercial energy system is shown in Figure 10.

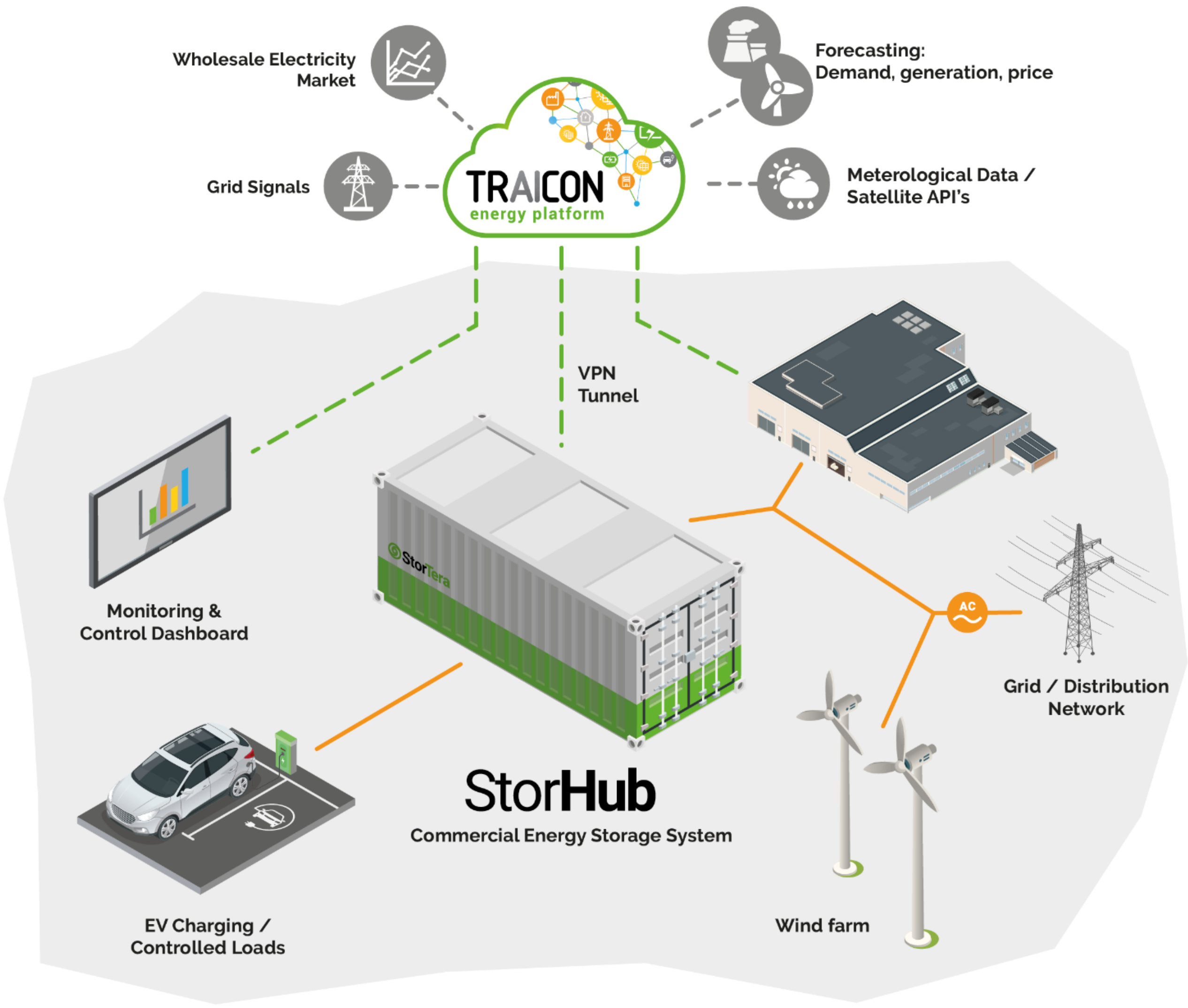

Figure 5: Commercial Energy System architecture

TRAICON SYSTEM

TRAICON is the main system platform which controls and manages the other two systems (Residential and Commercial) at the local level and platform level. This novel AI enabled platform uses neural network-based machine learning to analyse large datasets and proactively control all the connected systems.

The TRAICON energy platform consists of the following sub-systems:

- Demand side response (DSR)
- Asset aggregation platform leading to a potential virtual power plant (VPP)
- Distributed energy resource management systems (DERMS)
- Energy system platform (ESP)

The TRAICON is a significant step forward in the development of smart grids by its ability to provide all these benefits. It also leverages data-based value creation through AI-based predictions, provides control to utilities, integrates community energy systems, and provides value for end customers. We believe the TRAICON is truly the next evolutionary stage of modern smart grids.

The TRAICON uses AI at distributed levels and uses centralised data to make accurate predictions and provide control. The TRAICON consists of a lower tier AI BMS to increase battery cell life and efficiency of the battery system. Distributed controllers in the BMS are used to run artificial neural networks (ANNs) for control outputs. Dalhousie University in their verification process concluded that the AI based BMS provides a very high efficiency of 96.2% for battery modules.

The mid-tier of the TRAICON utilises a collection of large data sets from residential loads, commercial loads, residential PV generation, commercial renewable generation, commercial load profiles, and grid utility load profiles. The AI neural networks are configured using tensor flow to analyse data and to make decisions.
The top-tier AI looks at weather patterns, renewable generation data, and time-based human behaviour for decision making. For example, to predict the next day's PV generation and decide how much energy to store in the battery for optimum results, the TRAICON uses AI to analyse satellite imagery, solar PV data, battery voltage levels and load usage patterns.

The benefits provided by the TRAICON to both the end customers and the grid utility are as follows.

StorTower residential systems testing in Edinburgh, Scotland prior to shipping

4 CONCLUDING REMARKS

The Alba Nova project has addressed one of the key issues in the funding and operation of smart grids – it has delivered a solution that addresses the needs of both the utilities and their customers. This revolutionary approach to delivering a flexible smart grid solution has enabled controllable hardware that is suited to the energy requirements of each stakeholder and continuously optimised by an advanced AI platform. This has resulted in successfully providing Berwick with a solution that allows them to decarbonise while lowering costs and enhancing reliability. Validation has shown that the use of AI has provided 29% energy cost savings for homeowners, which are a result of rigorous AI algorithms at work.

The whole energy system design approach led to the electrification of all energy vectors for the ten residential participants, which under traditional circumstances would have increased costs for both the residents and the utility. Regular electrification requires reinforcement from the utility, but our solution has spread this cost between more stakeholders while providing distinct benefits for all parties.

The Alba Nova system addresses the challenge by introducing controlled efficiency and generation to the homeowners, transforming more than just their electricity use while also providing reinforcement to the utility. By bridging the gap between energy consumer and utility, the Alba Nova system has enabled both behaviour and regulatory change during the project and has proven successful in delivering a scalable, greener, and more efficient energy solution for Town of Berwick.

The Town Hall, Berwick, Nova Scotia