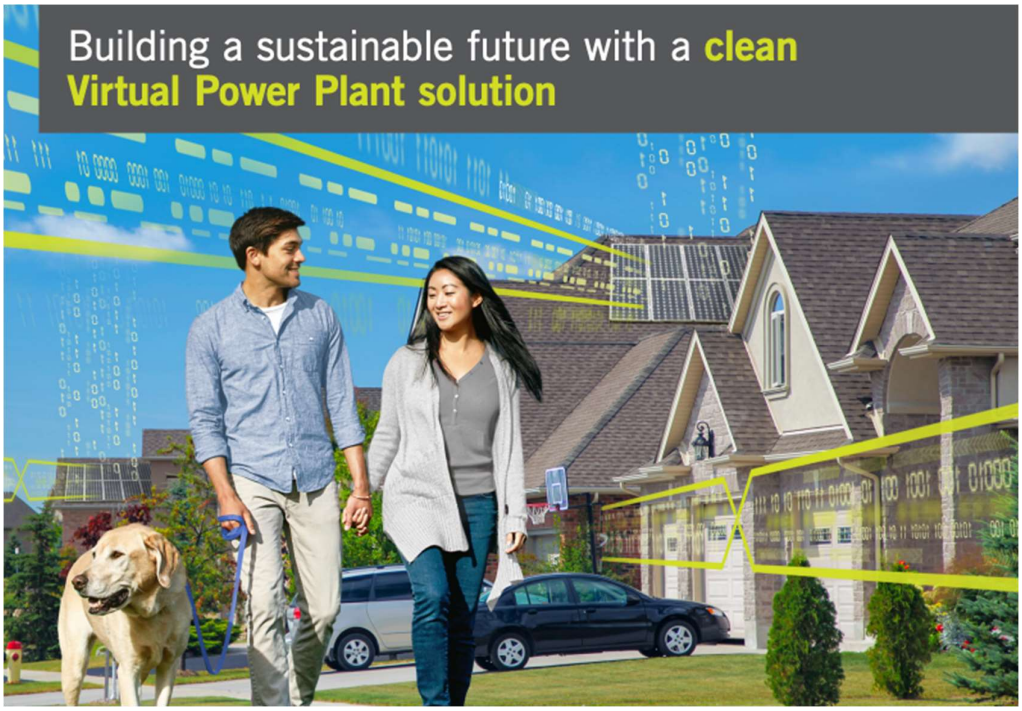

Power.House™ Hybrid (image above from https://www.alectra.com/sites/default/files/assets/pdf/powerhouse-hybrid-whitepaper.pdf)

Report by: Dr. Chad Walker and Ignacio Lopez (Dalhousie University)

Key facts

Location (town + country)	Markham, Ontario, Canada
Duration (start/end dates)	*Five years (2018-2023)*
Funding source	*Natural Resources Canada (Smart Grid Program), Project partners (including Alectra)*
Project lead (organisation)	*Alectra*
Project partners	*Natural Resources Canada, Enbridge, City of Markham, Toronto Metropolitan University (Centre for Urban Energy)*
No. of participants	*10 (homes)*
Case study type	*Technical demonstration/User-acceptance demonstration*

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Case study statistics

Parameter	As designed	As built
No. of participants	10 (homeowners)	10 (homeowners)
Generation (kWp)	33kWp (3.3kW x 10 homes)	33kWp (3.3kW x 10 homes)
Storage (kWh)	114 kWh (11.4kWh x 10 homes)	114 kWh (11.4kWh x 10 homes)
Unit price ($/kWh)	Not available	Not available
Project cost ($)	$3,384,655 CAD	$3,384,655 CAD

Summary of case (~200 words)

Alectra's Power.House Hybrid (PHH) pilot project aimed to empower 10 households in Markham, Ontario, Canada to generate, store, and manage clean energy and encourage local residents toward moves to net-zero. The project was partially funded by Natural Resources Canada's Smart Grid program, receiving $1,669,000 million over the project's lifespan. The PHH project created a local Virtual Power Plant (VPP), made up of several components: rooftop solar, battery storage, hybrid natural gas/electric heating, micro combined heat and power, and electric vehicle chargers. All of this was coordinated through software and controllable electrical and thermal equipment. The project has allowed local residents to lower their greenhouse gas emissions, have greater control, save money, and increase comfort.

Impact highlights (~4*50 words)

As found in both the Power.House Hybrid whitepaper (presented by the City of Markham, Alectra, Enbridge, Natural Resources Canada, and researchers from Toronto Metropolitan University; see here) and our own research (Lopez and Walker), the major impacts of the project included:

- Reduced GHG emissions by 29.7 tCO2e per household annually (on average); (
- Increased net annual electricity consumption by 9.5 MWh
- Decreased annual gas consumption by 9,140 m3 (96 MWh)
- Decreased total annual energy consumption by 85 MWh
- Saved homeowners about $15,000 in annual operational costs (approximately $1,500 per house)
- Improved efficiency of HVAC systems, leading to lower costs of and GHG emissions
- Participants received a new HVAC system, including an air handler, tankless water heater, air source heat pump, and controller – all installed free of charge
- Improved grid flexibility
- Increased the sense of pride and self-reliance of homeowners
- Increase participants environmental awareness and this sometimes led to spreading of information and the promotion of these technologies amongst the wider public
- The broader community benefited from reduced grid demand (i.e. via energy demand shifting via the participants)
- Local reinvestment in hybrid heating technology, sparking initiatives like Enbridge's Clean Home Heating Initiative and the Canadian Greener Homes Program. These initiatives, influenced by lessons from the pilot, expanded hybrid heating installations, benefiting communities and promoting energy-efficient solutions

Project aims and objectives (~250 words)

- What problem(s) does the case study aim to resolve?
    - In Ontario, the reliance on increasingly expensive forms of mainly fossil-fuel based energy is contributing to climate change and energy poverty amongst residents. The Power.House Hybrid pilot project aimed to increase grid flexibility, increase renewable energy generation, and lower emissions associated with electricity generation, home heating, and transport
- What were the social objectives (if any)?
    - The social objectives of the project included reducing costs for participating households, and increasing feelings of comfort, pride, and independence
- What were the environmental objectives (if any)?
    - The environmental objectives were to lower emissions across electricity generation, home heating, and transport
- To what degree were participants actively involved in design or operation?
    - Participants were largely excluded from project design. In terms of operation, levels of participation varied. For some, participation included managing and curtailing their energy consumption based on the state of the system (as shown via an interactive dashboard available to participants)
- Was participation financially or socially incentivised or both?
    - Participation was incentivized through both financial (i.e. cost savings) and social (i.e. sense of pride, environmental stewardship, comfort and independence) means.
- What degree of demand response flexibility was provided?
    - Demand response flexibility was provided mainly through tiered time-of-use pricing
- Provide images of, and participant quotes from the case study.

“The financial saving was not the primary motivation for me, but the fact that **you could help make the grid greener.** And more importantly this notion that it’s a pilot, with all the partners and government **taking the learnings from the experience in our homes to help the next generation of homes, to help with global warming...”** (PHH Participant)

Figure 1 - Rooftop solar panels (taken from PHH whitepaper)

Description of case (≤ 6 pages)

- Market value proposition and key activities
    - The main value proposition was a local energy system project that created a VPP and in doing so, helped to increase grid flexibility and integration and lower costs and emissions and increase comfort levels associated with 10 participating households' use of electricity, home heating, and transport
    - The key activities included the installation and operation of new rooftop solar panels, battery storage, gas/electric heating systems, micro combined heat and power, and electric vehicle chargers. This was all controlled via new electrical and thermal equipment.
- Financing/funding (who contributed funding and under what terms)
    - The project received funding from the Government of Canada through Natural Resources Canada's Smart Grid Program. According to the 2018 call for proposals under this program, funding was designed to "support larger-scale demonstrations of promising near-commercial smart grid technologies and the deployment of proven smart grid integrated systems to reduce greenhouse gas emissions, which will better utilize existing electricity assets while fostering innovation and creating clean jobs." (see here).
    - Other funding came from the project partners themselves.
- Legal structure (co-operative; partnership; social enterprise; etc)
    - Partnership
- Timeframes including for project initiation; funding cycles; detailed design; legals and contracts; participant recruitment; trial duration; decommissioning; etc
    - Funding was awarded in 2018, which is when the pilot project also began. According to the PHH whitepaper, the project started with "site selection and recruitment. Installation of pilot equipment and controls began in 2020". The project's operation and outreach phases occurred from 2020 to 2023. 2023 was also the end of the funded project. This means that the overall project timeline was five years.
- Stakeholders/project partners involved (organogram)
    - The project partners of PHH are: Alectra Utilities Corporation, Enbridge Gas, the City of Markham, and researchers from Toronto Metropolitan University. The project received funding from the Government of Canada through Natural Resources Canada.
    - Other stakeholders involved include the 10 participating households in Markham, Ontario.
- Participant types and characteristics: residents (social housing, private rented, private ownership; socioeconomic status); SMEs (types and loads); social institutions (schools, etc). What were the inclusion/exclusion criteria for participating in the case?
    - Participants were those living in single family, and detached homes in the City of Markham, Ontario. The 10 homes were selected based on readiness to adopt the technology installation, limited to Markham, Ontario. The participants were mainly homeowners, married or partnered, with varied ages

ranging from mid-30s to 70s. Slightly more males participated than females. Participants were also generally of higher levels of household income compared to the overall population.

- Participant recruitment methods, incentives and protection (opt-in or opt-out; were participants paid to participate; were they exposed to financial losses or other risks; etc)
    - Homeowners were selected based on a number of criteria including: the requirement for them to own an electric vehicle, size of home, suitability of roof to host solar panels, type of home heating and cooling system, willingness of to share data and allow occasional site visits for monitoring and servicing the equipment. They were not paid to participate. They were not exposed to financial losses or other apparent risks. Installed equipment that made up the PHH project was installed free of charge.
- Participants' role in co-creation of project and objectives (if any)
    - There was no indication that the project participants (i.e. the 10 homeowners) were involved in the co-creation of the project and/or its objectives
- Case study functional requirements.
    - Regulatory structure and requirements (beyond compliance with existing law), e.g. constraints imposed by regulatory sandboxes.
        - Outside of compliance with existing [energy] law, there were no other apparent constraints imposed by regulation.
    - Stakeholder requirements (trial design requirements)
        - Smart Grid funding was available to several groups including: "legal entities formed in Canada, including: electricity and gas utilities, electricity system operators, transmission system owners and operators (including provincial Crown corporations, agencies, co-operatives, Indigenous and municipally owned) and local distribution companies as direct or ultimate recipients; provincial, territorial, regional and municipal governments and their departments and agencies where applicable as initial recipients.
    - Technical architecture (representation of assets: generation; storage; control; load types (electric vehicles (EVs); heating, ventilation and air conditioning (HVAC); small and medium-sized enterprises (SMEs); etc)
    - Data architecture (including data ontology/standards where used)
        - Data was managed through a Virtual Power Plant design
    - Financial model (representation of financial flows and markets)
        - The financial model was that of a private utility (Alectra) embedded within the traditional financial incentives and disincentives associated with tiered, time-of-use pricing.
- Geographical scale
    - The City of Markham, Ontario, Canada (single family homes)
- Governance structure (organogram)
    - The project is a collaboration between: Alectra Utilities Corporation, Enbridge Gas, the City of Markham, and researchers from Toronto Metropolitan

University. The project received funding from the Government of Canada through Natural Resources Canada.

- Electricity network ownership (public or private)
    - Private
- Management of changes in case study over time (i.e. participants leaving; assets failing; data losses; etc)
    - We are not aware of any changes in terms of project partners, participants leaving, assets failing, data losses, or the like.

Key takeaways

The Power.House Hybrid pilot project aimed to lower costs and emissions, and increase participating householders' sense of comfort and pride in their use of local electricity, home heating, and transport

The PHH received funding from Natural Resources Canada's Smart Grid program, which ran from 2018-2023.

By all available metrics and indicators, PHH was a success in terms of accomplishing its initial major objectives as well as providing additional benefits for participants such as increasing environmental awareness amongst the general (local) public

Outcomes and achievements (~1 page)

What outcomes are anticipated from the pilot?

- The outcomes that were anticipated from the PHH pilot project were: increased grid flexibility and integration, and lower costs and emissions and increase comfort levels associated with 10 participating households' use of electricity, home heating, and transport

What outcomes were delivered by the pilot?

- Yes, the outcomes listed above were delivered by the pilot.

What was the primary goal of the project? (please tick one) *

☒ **Grid integration** - e.g. management of grid constraints; balancing of demand and supply; promote/include distributed energy resources (DER) generation; optimisation of energy behaviour to benefit system; aggregation of participant energy loads.

☐ **Environmental benefits** - e.g. promote or include renewable energy (RES) generation.

☐ **Empowering individuals** - e.g. participants have greater control over preferences; self-sufficiency (autarky); autonomy.

☐ **Local benefits** - e.g. improvement to local economy (job creation etc); independence from other regions; community as focal point for engagement; shared benefits across the community.

☐ **Creating market value** - e.g. economic incentives for participants; access wholesale, balancing and ancillary service markets.

Were there any secondary goals of the project? (please tick as many as apply) *

☐ **Grid integration** - same description as above

☒ **Environmental benefits** - same description as above

☒ **Empowering individuals** - same description as above

☐ **Local benefits** - same description as above

☐ **Creating market value** - same description as above

☐ If other, please give a brief description

Key takeaways

The objectives of the PHH project were increased grid flexibility and integration, and lower costs and emissions and increase comfort levels associated with 10 participating households' use of electricity, home heating, and transport

Based on our analysis, these objectives were delivered by the project

Obstacles encountered when conducting the pilot (~1 page)

Highlight the obstacles you came across when conducting the pilot. A few examples are mentioned below:

The obstacles that the project team came across while conducting the pilot project included:

- A lack of reliable indicators around how participation affected social relations – either with other participants or the wider (local) public
- A limited empirical understanding around how participants' initial expectations may or may not have been met
- Participation was limited by household characteristics and this led to higher income families being able to participate in the pilot
- Participants had limited direct control over their energy consumption preferences; the system was largely managed by Alectra
- Participants were not generally well-informed about the source of their energy
- The project lead, Alectra, had to hire specialized staff with expertise in blockchain software development, end to end solution architecture, cloud computing and data engineering - which increased salary spending. These expertise and backgrounds were not previously in-house.
- Benefits were largely centred around participating households rather than the broader public.

> '"I don't think a lot of [participants] **understood the full source of where their energy was coming from. They were more focused on the technologies** in their homes." – Project partner #4 (interview)

> "I would say from a control perspective, **the actual, like day-to-day control wasn't really in the hands of the homeowners.** It was more on the automation side." **-** Project partner #5 (interview)

Key learnings for other pilots (~250 words)

Key takeaways
With the right set of project partners and participating households, a local energy system project like PHH can result in a host of tangible benefits.

Success in this project was likely due to a combination of factors such as participant selection/recruitment and the unique energy context of Markham, Ontario

Pilot projects interested in mirroring the successful elements of the PHH project should ensure that there is a range of energy system and participant benefits

If you were repeating the pilot project: what would you have done differently, what are your key lessons learned and key takeaways?

Key takeaways
The project may have been more successful in terms of creating local and participants value if these people were involved in initial project design or co-creation activities

In terms of assessment, there should me more focus on the broader societal impact of local energy system projects such as PHH

After determining the scope of the project, make sure that there is appropriately trained staff with expertise and experience in relevant areas

Recommendations for policymakers (~400 words)

Please fill in the table below, by including recommendations for policymakers based on your experience of conducting the pilot (in particular obstacles encountered).

What?	Who?	Why- Example from case study?	How?	When?
Ensuring that policy and programs encourage clean and local energy through in multiple ways	Governments responsible for the regulation of electricity generation, management, and use. In our case study, this is the Provincial Government of Ontario.	The success of the PHH project was due in large part because of the range of benefits (financial, environmental, social)	Writing policies and programs that, for example, lower emissions while saving participating households money across all of their energy expenditures (electricity, heating, transport)	As soon as possible
Creating policy and programs that increase social acceptance and encourage participation and engagement among a wide, diverse segment of society	Governments responsible for the regulation of electricity generation, management, and use. In our case study, this is the Provincial Government of Ontario.	Despite being a project that was largely successful, PHH mostly delivered tangible benefits toward a small number of participating households.	Writing policies and programs that expand participation and benefits across less-affluent communities and households.	As soon as possible

Further information

- Natural Resources Canada Project Website: https://natural-resources.canada.ca/science-and-data/funding-partnerships/opportunities/current-investments/power-house-hybrid-minimizing-ghgs-maximizing-grid-benefits/22139

- Project whitepaper: https://www.alectra.com/sites/default/files/assets/pdf/powerhouse-hybrid-whitepaper.pdf

- List of all Smart Grid-funded projects: https://natural-resources.canada.ca/sites/nrcan/files/environment/Smart-Grid-2020-eng.pdf

- City of Markham's 2021 press release: https://www.markham.ca/wps/portal/home/news/alectra-enbridge-gas-and-city-of-markham-team-up-to-minimize-ghg-emissions-maximize-grid-benefits

- To learn more about the project and our analysis, contact Dr Chad Walker (Assistant Professor of Low-carbon transitions, School of Planning, Dalhousie University) at chad.walker@dal.ca