COALITION FOR INNOVATION

CleanTech
Blueprint for the Future

Coalition for Innovation, supported by LG NOVA

Jami Diaz, Director Ecosystem Community & Startup Experience
William Barkis, Head of Grand Challenges & Ecosystem Development
Sokwoo Rhee, Ph.D., Executive Vice President, LG Electronics, Head, LG NOVA

Blueprint Chairs

Alex Fang, CleanTech Chair
Sarah Ennis, AI Chair
Alfred Poor, HealthTech Chair

Authors

Sayeed Ahmed, John Barton, Irene Chen, Darlene Damm, Alex Fang, Aman Johar, Ram Krishnan, Tin Hang Liu, Winston Morton, Jiri Skopek, Julia Yan

Senior Editor, Alfred Poor

October 2025

Preamble

The Coalition for Innovation is an initiative hosted by LG NOVA that creates the opportunity for innovators, entrepreneurs, and business leaders across sectors to come together to collaborate on important topics in technology to drive impact. The end goal: together we can leverage our collective knowledge to advance important work that drives positive impact in our communities and the world. The simple vision is that we can be stronger together and increase our individual and collective impact on the world through collaboration.

This "Blueprint for the Future" document (henceforth: "Blueprint") defines a vision for the future through which technology innovation can improve the lives of people, their communities, and the planet. The goal is to lay out a vision and potentially provide the framework to start taking action in the areas of interest for the members of the Coalition. The chapters in this Blueprint are intended to be a "Big Tent" in which many diverse perspectives and interests and different approaches to impact can come together. Hence, the structure of the Blueprint is intended to be as inclusive as possible in which different chapters of the Blueprint focus on different topic areas, written by different authors with individual perspectives that may be less widely supported by the group.

Participation in the Coalition at large and authorship of the overall Blueprint document does not imply endorsement of the ideas of any specific chapter but rather acknowledges a contribution to the discussion and general engagement in the Coalition process that led to the publication of this Blueprint.

All contributors will be listed as "Authors" of the Blueprint in alphabetical order. The Co-Chairs for each Coalition will be listed as "Editors" also in alphabetical order. Authorship will include each individual author's name along with optional title and optional organization at the author's discretion. Each chapter will list only the subset of participants that meaningfully contributed to that chapter. Authorship for chapters will be in rank order based on contribution: the first author(s) will have contributed the most, second author(s) second most, and so on. Equal contributions at each level will be listed as "Co-Authors"; if two or more authors contributed the most and contributed equally, they will be noted with an asterisk as "Co-First Authors". If two authors contributed second-most and equally, they will be listed as "Co-Second Authors" and so on.

The Blueprint document itself, as the work of the group, is licensed under the Creative Commons Attribution 4.0 (aka "BY") International License: https://creativecommons.org/licenses/by/4.0/. Because of our commitment to openness, you are free to share and adapt the Blueprint with attribution (as more fully described in the CC BY 4.0 license).

The Coalition is intended to be a community-driven activity and where possible governance will be by majority vote of each domain group. Specifically, each Coalition will decide which topics are included as chapters by majority vote of the group. The approach is intended to be inclusive so we will ask that topics be included unless they are considered by the majority to be significantly out of scope.

We intend for the document to reach a broad, international audience, including:

- People involved in the three technology domains: CleanTech, AI, and HealthTech
- Researchers from academic and private institutions
- Investors
- Students
- Policy creators at the corporate level and all levels of government

Appendix:
DC Demonstration Home- Design Intent Document

Author: Jiri Skopek

Project Title: DC Demonstration Home

Location: Toronto, Ontario

Prepared By: MODULINK (Jiri Skopek Architect)

Date: May 23, 2025

Executive Summary

The DC Demonstration Home is a pioneering initiative designed to showcase the feasibility and benefits of low-voltage direct current (DC) microgrids in residential construction. This project will integrate a 48V DC backbone to directly power lighting, HVAC, appliances, and optional waste management systems using energy from an on-site solar PV array and battery storage. By eliminating unnecessary AC/DC conversions and optimizing for off-grid resilience, the project aims to significantly reduce energy losses, operational costs, and carbon emissions. It is designed as a replicable model to inform policy, advance market adoption of DC infrastructure, and empower homeowners seeking resilient, efficient living environments.

Design Intent Document (DID)

1. Project Overview

- Client: Demonstration DC Living Showcase
- Project Type: New Construction –DC house
- Gross Floor Area: 60 m² (640 ft²)
- Target Performance: Energy, DC-native infrastructure
- Anticipated Construction Start: September 2025
- Completion Date: March 2026

2. Project Vision and Objectives

- Create a showcase residential unit that operates on direct current (DC) for core systems to demonstrate energy efficiency, resilience, and compatibility with renewable energy sources.
- Integrate solar photovoltaics (PV), battery storage, and DC appliances to reduce conversion losses and operational costs.
- Provide a replicable and scalable blueprint for future residential electrification in Canada.

3. Functional Program

Zone	Area (m^2)	Features
Living / Dining / Kitchen	55	Open plan, daylight-maximized, passive ventilation
Bedrooms (x3)	45	One primary, two secondary bedrooms
Bathrooms (x2)	12	Low-flow fixtures, DC heat pump water heater
Mechanical / Utility	10	Battery storage, inverters, controls
Garage / Storage	18	EV charging-ready, DC distribution hub
Circulation & Closets	20	Barrier-free access

4. Architectural Design Intent

- Form & Orientation: Compact form with south-facing roof slope optimized for PV production.
- Envelope: High-R-value triple-glazed windows (for northern climates), continuous exterior insulation, airtight construction (target ≤ 0.6 ACH@50Pa).
- Materiality: Low-embodied carbon finishes (wood cladding, cork flooring, recycled drywall).
- Layout Efficiency: Centralized wet wall alignment; minimized internal heat loss paths.

5. DC Power System Design Intent

- Core Concept: Establish a low-voltage DC microgrid (nominal 48V DC) to power lighting, ventilation, appliances, and electronics.

- Renewables:
    - Rooftop PV array (7.5 kW) – DC-coupled
    - 15 kWh lithium battery storage – DC-native with battery management system (BMS) integration
- Loads (DC-native where possible):
    - LED lighting with 48V fixtures
    - Mini-split heat pump (DC inverter compressor)
    - DC refrigerator, DC induction cooktop
    - USB-C wall ports and 12V/48V receptacles for electronics
- Inverter Use (AC fallback): Limited to laundry and oven (critical AC appliances) via high-efficiency inverter

6. Building Systems and Controls

- HVAC: High-efficiency, variable-speed DC mini-split system with heat recovery ventilation (HRV).
- Water Heating: DC heat pump water heater with smart scheduling.
- Controls: Home Energy Management System (HEMS) optimized for DC load balancing, peak shaving, and demand response.
- Monitoring: Integrated dashboard (web/app) showing DC system performance, energy flow, and carbon footprint.

7. Visual System Diagrams

The following diagrams illustrate the structure and integration of the 48V DC microgrid, highlighting the flow of energy from renewable generation through storage and distribution to end-use devices, including DC-native lighting, HVAC, and water/waste systems.

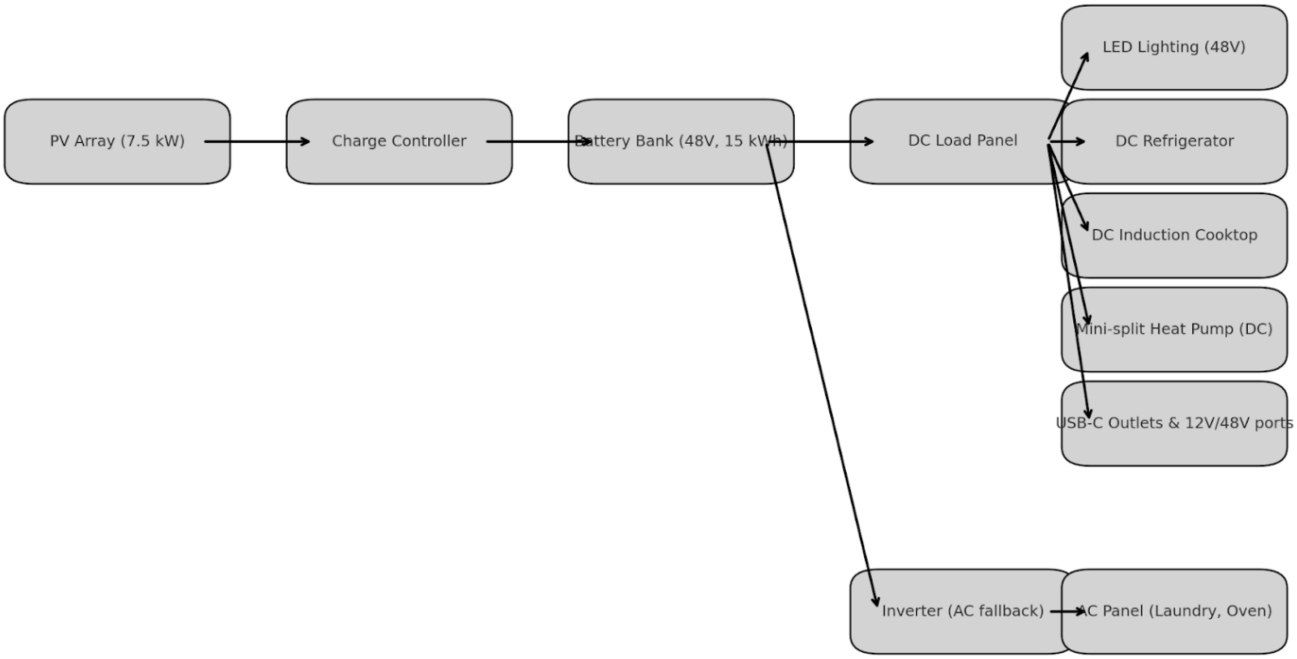

Figure 1: 48V DC Microgrid Architecture

Note: Laundry and/or Oven could be eliminated.

8. Detailed Bill of Materials for DC Microgrid

The following table presents a detailed bill of materials (BOM) for the 48V DC residential microgrid, including specifications, estimated costs, and recommended suppliers. This BOM supports the implementation of a fully DC-integrated, net-zero energy home.

Component	**Qty**	**Specification / Description**	**Est. Cost (CAD)**	**Recommended Suppliers / Brands**
PV Array	1 set	7.5 kW (18–20 monocrystalline panels, ~400W each)	$12,000	Canadian Solar, Trina Solar, REC Solar
Charge Controller	1	MPPT, 150V input, 48V output, 80A	$700	LG Victron SmartSolar, OutBack FlexMax

Battery Bank	1	48V, 15 kWh $LiFePO_4$ with integrated BMS	$10,000	LG Simpliphi, LG, Discover AES- to be discontinued, Fortress Power
Inverter (AC Fallback)	1	5 kW, 48V input, pure sine wave, split phase 120/240V	$1,500	LG Victron MultiPlus-II, Schneider Conext SW to be discontinued
DC LED Lighting	20+	48V DC dimmable fixtures	$1,200	LG Lighting DC Flex Lighting, Mean Well, Luxtech
Mini-Split Heat Pump	2	DC inverter compressor, SEER > 20, 9k/12k BTU	$4,500	LG Electronics Mitsubishi Hyper Heat, LG, Gree Vireo+, Fujitsu Halcyon, Senville,
DC Refrigerator	1	48V or 12V DC (upconverted), ~8 cu ft, 1 kWh/day	$1,200	SunDanzer, Dometic, Unique Appliances
DC Induction Cooktop	1	48V or 24V DC (via converter), ~2 kW peak	$1,000	LG Electronics Eco Hotplate (custom), Off-grid DIY kits, Stella
USB-C / 12V / 48V Outlets	15+	Flush-mount DC receptacles	$300	Blue Sea Systems, Powerwerx, Victron
Wiring & Conduits	-	4 AWG–10 AWG DC-rated, connectors, fuses, breakers	$2,000	ABB, Victron, Blue Sea, Siemens

Total Estimated Cost: ≈ $34,400 CAD

Budget Justification

- PV Array ($12,000): Offsets annual consumption; sized for full autonomy.

- Battery Storage ($10,000): Provides 3-day autonomy; supports peak shaving.
- Power Electronics ($2,800): Matched for performance in Canadian conditions.
- DC Appliances & HVAC ($7,900): Enables inverter-free, efficient operation.
- Install Materials & Safety ($2,000): Ensures compliance and protection.

These costs align with project goals of demonstrating energy efficiency, resilience, and replicability through DC-native infrastructure.

9. Alternative Water, Wastewater & Toilet Systems Integration

This section outlines the integration of DC-compatible wastewater and toilet systems into the 48V DC home microgrid. These systems operate on low-voltage direct current (typically 12V or 24V) and align with off-grid and net-zero objectives by minimizing energy consumption and eliminating the need for water-intensive sewage infrastructure.

The following diagram illustrates the placement of toilets, composting toilets, macerating toilets, greywater filtration, and sewage pumping within the existing DC microgrid system.

DC-Compatible Water Systems

1. Water

- **How they work:** Applies cutting-edge graphene materials and innovations in nanotechnology to manufacture and distribute robust and effective water filtration and recyclation systems for commercial and residential use
- **DC Relevance:** run on 12V/24V DC
- **Examples:**
  - **Purafy** https://purafy.com/

DC-Compatible Waste Systems

a. DC-Powered incinerating Toilets

- **How they work:** No water or minimal water. The produced ash remains are completely sterile and contain nutrients like potassium and phosphorus, ideal for fertilizing your garden.
- **DC Relevance:** run on 12V/24V DC
- **Examples:**
  - **Cinderella Comfort – Electric with 12 V DC supply** https://incineratingtoilets.com/ca/product/cinderella-comfort/
  - **Incinolet Electric**

- **Power use:** ~ Electric unit designed for off-grid use; runs on 12 V DC power
- **Best for:** Good option if you have a strong DC system

b. DC-Powered Composting Toilets

- **How they work:** No water or minimal water; uses a small DC fan (12V–24V) for ventilation and decomposition acceleration
- **DC Relevance:** Fans and heaters (if any) run on 12V/24V DC
- **Examples:**
    - **Nature's Head Composting Toilet**
    - **Separett Villa** (12V model) Cabin Depot
- **Power use:** ~2–3W continuous (vent fan); optional heating elements consume more
- **Best for:** Remote, off-grid, or net-zero homes with limited water supply

c. DC-Powered Macerating or Pump Toilets

- **How they work:** Electric pumps grind and move waste upward or to remote tanks.
- **DC Relevance:** Pumps available in 12V or 24V DC versions
- **Examples:**
    - **Superflo**
    - **Jabsco Quiet Flush Electric Toilet (12V/24V DC)**
    - **Saniflo marine/RV models**
- **Power use:** Short bursts of 150–300W, typically <1 min per use
- **Best for:** Homes without gravity-fed sewage lines (e.g., basement toilets or mobile units)

d. Greywater Pumps and Treatment Systems (DC-compatible)

- **Applications:** Shower, sink, and laundry water reuse for irrigation or toilet flushing
- **DC Systems Available:** Pumps and treatment units (filters, UV disinfection) in 12V/24V
- **Examples:**
    - **Flojet and** Shurflo **diaphragm pumps** (widely used in RV and off-grid systems)
    - Solviva-inspired wetland biofilters with low-voltage aeration

f. DC Sewage or Sump Pumps

- **For:** Moving blackwater or greywater to septic or treatment units
- **DC Options:** 12V–48V submersible or surface-mounted sewage pumps
- **Examples:**
  - **Whale Gulper 220** (grey/blackwater, 12V/24V)
  - **Rule Industries 12V sewage pumps**

Integration with DC Home Microgrid

Component	DC Voltage	Power Rating	Integration Notes
Composting toilet fan	12V/24V	~2–5W	Direct connect to DC panel or USB port
Macerator pump toilet	12V/24V	150–300W	Requires surge-capable DC circuit
Greywater pump/filter	12V/24V	30–100W	Pair with rainwater reuse systems
UV/ozone disinfection	12V/24V	10–20W	Can run on DC battery with smart switch
Sewage sump pump	12V/24V	100–500W	Controlled via float switch + DC relay

System Design Tips

- Use **DC-rated breakers** and fuses for safety.
- For surge loads (e.g., macerators), ensure **battery/inverter can handle inrush current**.
- Pair low-flow DC systems with **water-saving fixtures** and **real-time monitoring** for resilience and efficiency.

10. Bill of Materials – DC Wastewater Systems

Component	Quantity	Est. Cost (CAD)	Supplier/Brand
Composting Toilet (12V Fan)	1	$1,400	Nature's Head, Separett
Macerating Toilet (12V/24V)	1	$1,200	Jabsco Quiet Flush, Superflo, Sanimarin
Greywater Pump & Filter	1	$800	Shurflo, Solviva-style system
Sewage Pump (12V/24V)	1	$600	Whale Gulper, Rule Industries

11. Next Stage- Schematic Design (SD)

- **Goal:** Translate design intent into conceptual plans.
- **Outputs:**
  - Preliminary floor plans, site plans, elevations
  - Massing studies and building orientation
  - Initial system diagrams (HVAC, structure, power)
  - Basic cost estimate and material palette

Author (In order of contribution)

Jiri Skopek, Architect and Smart Community Planner, 2030 Districts-vice chair, NIST-GCTC chair, smart building cluster
Jiri Skopek is Architect, Smart Community Planner and Advisor for smart, green buildings and resilient and sustainable communities. He is best known for creating the GBI /ANSI Green Globes green building assessment standard. His current focus is on deployment of technologies to enhance communities' economic development, resiliency, energy transition and decarbonization.

For more information about the Coalition for Innovation, including how you can get involved, please visit coalitionforinnovation.com.