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HELIOS GRID

Deterministic coordination for a fragmented national grid

A research brief on Canada's thirteen electricity grids, the generation mix they dispatch, and why auditability — not prediction — is the binding requirement for coordinating them.

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THE PROBLEM

Canada has no national electricity grid. Electricity is provincial jurisdiction under Section 92A of the Constitution, so the country operates as thirteen semi-autonomous systems — each with its own utility, regulator, market design, and planning process (CER; C.D. Howe Institute). National installed capacity is roughly 156,000 MW producing 609,000 GWh a year (2024), and the systems are far more strongly connected north–south to the United States than east–west to each other: Canada exports ~51 TWh/yr to the US, dwarfing inter-provincial exchange.

Market designs are structurally incompatible. Ontario cleared its renewed wholesale market in May 2025 with a binding day-ahead market and locational pricing across ~970 nodes (IESO). Alberta runs an energy-only market moving to locational pricing by mid-2027 (AESO). Six other provinces are vertically integrated monopolies that self-dispatch.

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WEST-EAST INTERTIES:  AB-SK (McNeill)  ~150 MW · BC-AB  designed 1,200 MW, derated ~600-735 MW · ON
    total export capability ~2,385 MW
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SOUTH-POINTING HVDC:  QC-New England ~2,000 MW · NECEC 1,200 MW (Jan 2026) · QC-NYC 1,250 MW (Jun 2026)
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The cost of fragmentation is documented. Ontario curtailed ~1.3 TWh/yr of wind (2020–2023) contracted near $151/MWh while surplus pushed prices to zero or negative (Energy Regulation Quarterly). In fiscal 2024, drought forced BC Hydro to import a record 13,600 GWh — about a quarter of provincial consumption — at roughly $1.38 billion, largely from fossil-heavy US grids and gas-heavy Alberta (Globe and Mail; CBC). Clean power is wasted in one province while its neighbour burns gas.

Ottawa is now moving: a National Electricity Strategy (May 2026), a National Energy Corridor Agreement (March 2026), and five named priority interties (June 2026), including a Regina–Winnipeg expansion of up to 2,000 MW. The wires may get built. Helios Grid asks the next question: what decides what flows across them — and can that decision be proven correct?

THE GENERATION MIX

The fleet to be coordinated is heterogeneous in ramp rate, marginal cost, carbon intensity, and failure mode.

NUCLEAR — the inflexible anchor

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Bruce Power  8 CANDU units · 6,550 MW · ~30% of Ontario supply · ~$13B refurbishment to 2030s
Darlington   4 units · 3,512 MW · $12.8B refurbishment completed Feb 2026, ~4 months early
DNNP (SMR)   4 × BWRX-300 · 1,200 MW · CAD 20.9B · first grid connection ~2030 (G7 first)
Pickering B  ~2,060 MW to end-2026 · $26.8B refurbishment restores up to 2,200 MW by mid-2030s
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Clean, constant — and the least flexible asset on the grid: a maneuvered CANDU unit takes ~72 hours to return to power (OPG; Bruce Power; Government of Ontario).

TIDAL — perfect physics, unforgiving engineering

The Bay of Fundy holds ~8,000 MW of kinetic resource, >2,500 MW considered extractable — more than Nova Scotia's entire demand (NRCan). Yet after fifteen years the bay has never sustained even 5 MW of continuous delivery: OpenHydro went bankrupt in 2018 with a 2 MW turbine abandoned on the seabed; Sustainable Marine exited in 2023 citing permitting deadlock. New 12.5 MW awards (Eauclaire, Orbital Marine, 2025) restart the attempt at the 64 MW FORCE test site.

WIND — large, lumpy, and forecast-fragile

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Canada ~19 GW installed (end-2025; +347 MW in 2025) · Prairies ~6.8 GW · Ontario ~5.9 GW · Quebec ~4.3
    GW · Atlantic ~1.3 GW
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Alberta's 2024 grid emergencies — wind collapsing ~1,350 MW to near zero around sunset, a ~1,000 MW forecast miss — illustrate the failure mode (AESO MSA).

NATURAL GAS — the balancing resource, and the audit target

Gas is ~16% of national generation; in Ontario ~30% of capacity but only ~10% of generation — peakers that ramp in minutes and emit 450–500 g CO_2e/kWh against a ~100 g national grid average (IESO; ECCC). Every hour of avoidable gas dispatch is a quantifiable coordination failure — a statement a deterministic engine can prove.

THE DETERMINISTIC CASE

Functioning electricity markets already run on deterministic optimization. Every North American ISO clears its market by solving security-constrained unit commitment (MILP, day-ahead) and security-constrained economic dispatch (LP, ~every five minutes) to tariff-defined, public formulations on commercial solvers (PJM Manual 11; CAISO Tariff §34; arXiv:2112.13469).

Prices are not estimated — they are the dual variables of the dispatch optimization itself (O'Neill et al., EJOR 2005; Hogan). Same inputs, same solve, same dispatch, same prices: market monitors re-run the case and reconcile every dollar to a named binding constraint. FERC treats this transparency as a core objective of price formation (RM15-24).

> *"Some of what is perceived as advanced is really just inscrutable and not independently verifiable… and that is part of the problem." — operator quoted in NERC's white paper on AI/ML in real-time operations (Nov 2024)*

The reliability establishment treats ML with explicit caution: NERC insists on human-in-the-loop operation and explainability; its survey found 47% of operators still only learning about AI/ML and 9% having built such systems. The academic literature concedes the gap from the other side — ML proxies predict dispatch solutions in milliseconds with sub-0.6% error but lack native feasibility guarantees (arXiv:2304.11726), and verification research exists precisely "to build the missing trust of power system operators" (arXiv:1910.01624).

Traceable dispatch has a precise meaning: every instruction and price ties back to a specific input set, a named constraint, and a re-runnable computation. Deterministic optimization delivers this by construction. Helios Grid's hypothesis: the properties required inside each market are what is missing between them. Cross-provincial coordination fails partly because there is no neutral, provable way to show all parties that a proposed exchange is correct under each province's own rules. Prediction is not the bottleneck. Proof is.

THE ARCHITECTURE

BlackGrid Labs' reasoning stack — M.A.D. (Marixous Architectural Derivation) with the Derivation Algorithmic Engine (D.A.E.) at its core — was built for problems of exactly this shape: many heterogeneous sources, one governed object model, conclusions that must survive hostile audit.

MAPPED TO THE SEAMS PROBLEM

Ingestion translates each operator's telemetry — IESO nodal data, AESO pool data, Crown-utility hydrology, intertie schedules — into a single governed structure without altering source records. The data layer is append-only: the record that produced any recommendation is immutable. D.A.E. reasons over the fused structure deterministically — finds what correlates across seams, detects what should correlate but does not, and derives every conclusion backwards to the source facts that produced it. The result is not a forecast; it is a finding with a lineage.

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DETERMINISM   bit-identical runs for identical inputs — the property regulators already rely on in
    SCED/SCUC
AUDIT TRAIL   every finding carries an immutable, hash-chained derivation record any party can re-run
TRI-CON       external parties see only encrypted composite references — never raw asset identifiers
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Tri-Con identity is what makes multi-party analysis politically feasible between utilities that are also counterparties: the engine reasons in plain IDs; the world only ever sees encrypted composites.

This is deliberately not a proposal to replace any ISO's dispatch engine. Provincial SCED stays sovereign. Helios Grid studies the layer above: a deterministic coordination and evidence engine for the seams — where today there is no optimization at all, only bilateral contracts, seasonal swaps, and disputes with no referee. In production use in another domain, the same stack fuses 19 live data sources and completes full-corpus analysis in 431 milliseconds with a complete derivation trail. The grid is a larger corpus. It is not a different problem.

NEXT STEPS

The federal moment is aligned. “Powering Canada Strong” (May 2026) commits to doubling grid capacity by 2050 — an investment on the order of $1 trillion — and names inter-provincial coordination a national priority, with five priority interties referred to the new Major Projects Office (NRCan; PMO). The Canada Electricity Advisory Council’s Recommendation 19 calls for an EU-style framework for inter-regional transmission: governance, cost allocation, funding — machinery that requires neutral, auditable analysis to function.

FUNDING ARCHITECTURE (ESTABLISHED, SPECIFIC)

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NRCan EIP      demonstration funding · typ. $0.5–4.0M/project · Smart Grids stream renewed Budget 2025
SREPs          $4.5B deployment program to 2036 · 125 projects approved as of Mar 2026
ISC            challenge stream · up to $150K proof-of-concept / $1M prototype
NRC IRAP       >$550M in 2025–26 · up to 75% of eligible costs for Canadian SMEs
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Crown partnership in practice is a milestone-based contribution agreement under the Treasury Board Directive on Transfer Payments: cost-shared, audited, and with intellectual property vesting in the recipient (TBS).

The precedent to design against is the Atlantic Loop, which collapsed in 2023 on cost allocation and ratepayer politics — the absence of a trusted, common accounting of who benefits. Its narrow, provable successor (the Wasoqonatl intertie, CIB-financed at $285M) proceeded. Inter-provincial projects live or die on whether every party can independently verify the claimed benefit.

PROGRAM PLAN

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PHASE 1   seam-level retrospective: derive the 2020–2025 curtailment-beside-combustion record from
    public data
PHASE 2   deterministic coordination model over two adjacent control areas; findings reproducible by
    both parties
PHASE 3   Crown-partnered demonstration under an EIP / Regional Tables framework
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