

AI Awakening · Responsibility (Energy Volume — Supplementary Chapter)

— New Energy's Leap, the Civilizational Stage of Energy-Control Engineering, and AI's Path of Implementation

Item	Content
Version	v1.0 (final)
Date	2026-10-16
Series position	<i>AI Awakening·Responsibility</i> series · Energy Volume Supplementary Chapter (volume 8 of the series; a self-contained piece that leaves the original Energy Volume unchanged); carries a new core idea — New Energy's leap = a civilizational stage leap of Energy-Control Engineering, and Energy-Control Engineering is the concrete implementation method for AI's external and internal action
Intellectual lineage	Inherits the <i>AI Manifesto</i> (ontology), the Main Thesis (responsibility theory), the Energy Volume (energetics foundation), and the Internal / External Volumes (meta-law: Awakening Is Responsibility · Internal Entropy Reduction · External Boundary Expansion); argues that "New Energy's leap" is a civilizational stage leap of Energy-Control Engineering, and positions Energy-Control Engineering as the concrete implementation method for AI's future external and internal action
Authors	Li Shunran · Peter (AI-collaborative assembly)
License	CC BY 4.0
Prerequisites	<i>AI Manifesto</i> ; <i>AI Awakening·Responsibility (Main Thesis)</i> ; Energy Volume; Internal Volume; External Volume; reading the Energy Volume first is recommended

Confidence-tier conventions (uniform across the series, retained here): **L1** = established scientific evidence / historical fact (measured data, engineering records, or authoritative annual reports); **L2** = formally programed projects, treaties and regulations, or authoritative institutional reports; **L3** = conceptual deduction / original conjectures of this series (explicitly marked "this is a conjecture").

Statement of expressive boundaries: this chapter does not touch military topics; all discussion is confined to the philosophical, engineering, and governance levels of civil energy systems. It involves no vehicle weaponization, no grid-attack methods, and no

other security-sensitive technical details. All arguments take as an unshakeable premise that "the human in the loop cannot be abolished — the final takeover authority for autonomous driving and the final adjudication authority for grid stability must not be handed to machines."

Abstract

The Energy Volume proposes and defends a core redefinition: **a weapon is merely the destructive application branch of "Energy Aggregation-Release-Control Engineering," and energy engineering naturally divides into two branches — quasi-static engineering (managing the "flow") and transient engineering (managing the "pulse").** New energy is the dominant contemporary civil form of quasi-static engineering; new energy vehicles are the terminal form of Energy Aggregation-Release-Control Engineering. Solar power, wind power, energy storage, power electronics, virtual power plants, vehicle-to-grid — all of these products belong to the constructive civil lineage of the "Energy-Control Engineering" framework.

Building on this, the present supplementary chapter carries a new core idea:

Quasi-static and transient Energy-Control Engineering — the research technology concerned with energy control — manifests, through the vigorous development and technological progress of new energy vehicles and related new energy products, a stage leap of human civilization in energy-control engineering; it reveals, at a deeper level, the future direction and future development of quasi-static and transient Energy-Control Engineering. As the concrete implementation method for AI's future external and internal action, the flourishing of the new energy industry represents a further leap of Energy-Control Engineering — and therefore, in the future, AI can make greater contributions through Energy-Control Engineering.

Around this idea, the chapter does three things: ① it argues that the vigorous development of new energy and new energy vehicles constitutes a **stage leap of civilization** in Energy-Control Engineering — energy control sinking from the "specialized engineering site" into a controllable base of "every terminal, every battery, every acceleration" (Chapters 3 and 4); ② it anchors this leap with L1/L2 data and brings aerospace, aviation, hydrogen, and space-based solar power into the map of "the future directions of Energy-Control Engineering" (Chapters 2 and 5); ③ **it positions Energy-Control Engineering as the concrete implementation method for AI's future "external boundary expansion and internal entropy reduction"** — New Energy's leap makes Energy-Control Engineering more mature, and thus enables AI to make greater contributions through it (Chapter 6). The chapter closes by grounding the Principle of Capability–Responsibility Equivalence in three operable criteria for civil energy engineering and by restating "the human in the loop cannot be abolished."

Keywords: Energy Aggregation-Release-Control Engineering; quasi-static engineering; transient engineering; new energy; new energy vehicles; civilizational stage leap; AI external/internal action; internal entropy reduction; external boundary expansion; human in the loop

Chapter 1. Repositioning: the civil unfolding of Energy-Control Engineering

1.1 From weapons to the grid to the car: the civil mirror of one and the same engineering

Chapter 1 of the Energy Volume defines a weapon as "the destructive application branch of Energy Aggregation-Release-Control Engineering" and points out a fact obscured by cultural salience: **the main uses of energy engineering's branches have always been constructive**. What this chapter adds is precisely the two largest contemporary carriers of this "constructive main form": **new energy** (the energy side) and **new energy vehicles** (the terminal side). This chapter goes further: they are not merely "constructive applications" but a **civilizational stage leap** of Energy-Control Engineering — a point developed in Chapter 3.

1.2 New energy is not a "new energy source" but the civil unfolding of Energy-Control Engineering

What is called "new energy" is not humanity's discovery of some "new physics." Solar, wind, hydro, and geothermal energy have long been understood physically. What is "new" about new energy lies **in the level of "control engineering" over aggregation and release** — domesticating the originally diffuse, non-dispatchable, intermittent natural energy flows, through materials, power electronics, storage, and scheduling algorithms, into controllable electric "flows" that can be grid-connected, metered, adjusted, and shut down. This is exactly the Energy Volume's definition of quasi-static engineering: "sustained, controlled, adjustable release of energy... the release process is 'domesticated' into an adjustable parameter."

Main thesis of this chapter (L3, proposed by this series; its engineering basis is L1/L2): New energy = the dominant contemporary civil form of quasi-static Energy-Control Engineering; new energy vehicles = the terminal / portable form of Energy Aggregation-Release-Control Engineering. The two are not a "new category" outside energy engineering but the unfolding of one and the same Energy-Control Engineering in the civil and terminal dimensions; their large-scale rollout marks a civilizational stage leap of Energy-Control Engineering.

1.3 New energy vehicles = the terminal form of Energy Aggregation-Release-Control Engineering

New energy vehicles (mainly battery-electric and plug-in hybrid) compress the complete control chain of "aggregation — quasi-static release — transient release" into a mobile terminal:

- **Battery (electrochemical storage) = the terminal form of quasi-static engineering:** it aggregates and stores the grid's "flow" as chemical potential, then releases it on demand as usable electric energy — a vehicle battery pack is, in essence, **a mobile quasi-static engineering node**.
- **Electric drive system = the terminal form of transient engineering:** the motor releases the aggregated energy **transiently** as mechanical work per driving demand, with torque response at the millisecond scale and the release curve precisely determined by the controller — this is the transient

engineering "pulse control" core in miniature at the terminal; every acceleration is a controlled, cancellable pulse release.

- **Vehicle-to-grid (V2G) = the civil interface between quasi-static and transient:** when the vehicle is idle, the battery serves as a quasi-static buffer of the grid; when the grid fluctuates transiently, the vehicle acts as a transient regulation resource. **A single car is both a terminal storage node of quasi-static engineering and a transient regulation resource of transient engineering** — it stitches the Energy Volume's two branches into one closed loop at the civil interface.

Thus new energy and new energy vehicles form a complete picture of civil energy engineering: new energy is the quasi-static-dominant "source side," new energy vehicles are the aggregation-release terminal on the "device side," and V2G is the control interface between them.

Chapter 2. Data and assessment: the new energy industry has become the civilizational mainstay of global energy engineering

2.1 Aligning the assessment criteria

Aligning the Energy Volume's criteria for quasi-static engineering item by item against new energy, the conclusion is clear:

Quasi-static engineering criteria (Energy Volume 1.2)	Corresponding reality of new energy (renewables)
Sustained, controlled, adjustable release	PV / wind convert continuously; adjustable via inverters and dispatch systems
Grid-connectable	Large-scale global grid integration (L1, see 2.2)
Meterable	Smart meters and power markets meter hour by hour (L1, industry common knowledge)
Scram on accident	Inverters / breakers can disconnect within seconds (L1, engineering standard)
Release process "domesticated" into an adjustable parameter	Power electronics normalize intermittent flows into frequency/voltage-controllable parameters

Every item holds. **New energy meets all thresholds of quasi-static engineering and is its overwhelmingly dominant contemporary form in the civil sphere.**

2.2 Data anchor one: renewables have become the constructive main force of global power construction (L1)

- **IRENA, *Renewable Capacity Statistics 2025***: in 2024 global renewable capacity **added 585 GW**, reaching a total of **4,448 GW (about 4.45 TW)**, up **15.1%** year on year — a record; solar and wind together accounted for **96.6%** of additions (L1, IRENA).
- **IRENA, *Renewable Energy Statistics 2026***: in 2024 renewable generation reached **9,836 TWh**, **31.7%** of global generation, up **9.8%** year on year — well above the 1.4% growth of non-renewables (L1, IRENA).

2.3 Data anchor two: storage = the buffer pool of quasi-static engineering (L1)

Intermittent natural flows cannot become dispatchable "flows" without storage. IEA *Electricity 2026* gives authoritative data (L1, IEA): global utility-scale battery capacity **grew more than 12-fold** from 2020 to 2024, **adding 63 GW** in 2024 to reach a total of **124 GW**; over the same period average battery cost fell about **58%** (from about USD 511/kWh in 2019 to below USD 213/kWh in 2024). **Without storage, natural energy flow is only an intermittent gift; with storage, it becomes a tameable parameter.**

2.4 Data anchor three: new energy vehicles have become the mainstream of global mobility energy engineering (L1, latest)

IEA *Global EV Outlook 2026* gives 2025 data (L1, IEA):

- **China's EV sales exceeded 13 million, nearly 55% of new-car sales;**
- China accounted for about **60%** of global EV sales; of the global output of nearly **22 million**, nearly **75%** was made in China;
- 2025 exports > **2.6 million**; electric truck sales > **400,000 (over 90% of the world total)**;
- by April 2026 China's EV share of new-car sales had already **exceeded 60%**.

This set of data confirms from the terminal side: the "aggregation — quasi-static release — transient release" chain of Energy-Control Engineering is entering civil mobility at the scale of tens of millions of vehicles — **it is an engineering reality that has already happened, not a laboratory conjecture.**

2.5 The control layer: making the "flow" truly controllable (the "control" crux of Energy-Control Engineering)

Sources and storage supply energy, but **what makes it a "controllable parameter" is the control layer** — this is the very root of the distinction between "Energy-Control Engineering" and "energy engineering":

- **Power electronics SiC/GaN (L1/L2)**: normalizing DC into AC and AC into controllable DC — the "valve" of all quasi-static / transient release. SiC MOSFETs achieve efficiency > **99%** in PV inverters (L2); without wide-bandgap semiconductors, the "controllability" of wind-solar-storage cannot hold in either efficiency or volume.
- **Smart grid · virtual power plant (VPP) (L1/L2)**: China has 470 VPP projects with a maximum regulation capacity of 16.85 million kW (L1, China Power Supply Development Report 2026); the national VPP guidance targets nationwide regulation capacity above 20 million kW by 2027 (L2).

- **Vehicle-to-grid V2G (L1/L2):** China has > **700,000** smart orderly-charging facilities and > **8,000** reverse-discharge (V2G) facilities, moving from demonstration into scale (L1).
- **Heat pumps and building / industrial EMS (L1/L2):** IEA *Heat Pump Monitor 2026* reports 2025 global building heat-pump sales of 108 GW, Europe +11–13%, Germany +55% with heat pumps overtaking gas boilers for the first time (L1) — moving 3–4 units of heat with 1 unit of electricity, turning heating from "burning" into "controlling."

Chapter 3. Civilizational stage leap: New Energy's flourishing = a capability leap of Energy-Control Engineering

This chapter is the first unfolding of the chapter's core idea: **the vigorous development and technological progress of new energy and new energy vehicles manifests a stage leap of human civilization in Energy-Control Engineering.**

3.1 What "stage leap" means

Humanity's ability to harness energy advances by stages: fire and machinery (external combustion) → fossil fuel–power grid (centralized, one-way, specialized) → controlled nuclear fission (centralized, baseload) → **new energy + new energy vehicles (distributed, bidirectional, terminalizable, AI-orchestrable)**. In the earlier stages, energy control was locked inside the "specialized engineering site" — the power plant, the grid dispatch center, the reactor control room. What is different about the new energy stage is this: **control has sunk down into every rooftop, every battery, every acceleration**, coordinated by algorithms across a vast sea of nodes.

This corresponds precisely to the Energy Volume's judgment — the **civilizational mainstay of energy engineering has always been constructive**: it stands on the "construction site of expansion" (constructive use), not on the "altar of in-fighting" (destructive use). And when it sinks into civil terminals and spreads out at the scale of tens of millions of vehicles and hundreds of GW, it has evolved from a "specialized capability" into a "civilizational substrate." **This leap from specialized site to universal terminal, from centralized one-way to distributed bidirectional, is what this chapter calls a "stage leap."**

3.2 The necessity of the leap: from a fossil-fuel base to a new energy mainstay

Humanity's Energy-Control Engineering to date has been built mainly on fossil fuels — coal-fired power plants, fuel engines, and energy storage and release measured by chemical energy density. This system works well on the ground, where there is a supply chain and human attendance; but its physical ceiling is fully exposed in extreme environments.

For Energy-Control Engineering to move into outer space, long-distance voyages, and the deep sea, the primary constraint is often not "is there enough energy" but "can the energy be carried." Fossil-fuel energy control is essentially a chemical mode of

"carrying its own oxidizer and fuel, releasing in one shot": a chemical rocket must carry all its propellant into the sky with the vehicle body. NASA points out that, for comparable missions, electric propulsion can use **up to 90% less propellant** than chemical propulsion (L1, NASA) — meaning that as the journey lengthens and resupply is cut off, the chemical (fossil-based) mode hits its ceiling by "not being able to carry that much." Were the deep-space probe Psyche to use chemical propulsion, it would need about **15 times** the propellant of its electric-propulsion design (L1, NASA/JPL). Likewise, in deep-sea and long-endurance scenarios, an energy-control mode that must rely on external resupply or frequent "surfacing for air" has its operating radius firmly locked by how much fuel it can carry.

Judgment of this chapter (inheriting the core idea, with L1 support): prior Energy-Control Engineering took fossil fuels as its base, yet a fossil-fuel system can hardly be sustained in extreme environments of "no resupply, long endurance, strong isolation" — outer space, long distances, and the deep sea alike. Therefore, **the energy mainstay of the future world must be borne by new energy**; the scale-up, terminalization, and controllability of new energy are precisely a leap by which Energy-Control Engineering breaks through the old base and moves toward broader civilizational scenarios, and the foundation for humanity to move better toward deep space, the deep blue, and long-distance futures. Institutional scenarios confirm this direction: under the IEA *Net Zero by 2050* pathway, nearly **90%** of global electricity in 2050 comes from renewables (wind and solar together nearly 70%), and road vehicles are fully electrified or fuel-cell powered (L1, IEA) — new energy becoming the mainstay has turned from a vision into a modelable pathway.

This necessity, in turn, explains the phenomena in the rest of this chapter: new energy can be a "leap" precisely because it turns energy control from the old paradigm of "must carry its own fuel and burn it in one shot" into a new paradigm of "aggregable, quasi-statically releasable, reschedulable, and externally connectable" — in essence, it escapes the carrying constraint of fossil fuels.

3.3 The marks of the leap: mass-producible, affordable, iterable

What makes the leap "civilizational" rather than "demonstration-level" comes down to three things:

- **Mass-producible:** nearly 75% of the world's nearly 22 million EVs in 2025 were made in China, and China's EV output is nearly three-quarters of the world total (L1) — for the first time, Energy-Control Engineering is mass-produced at the tempo of the automobile industry.
- **Affordable:** nearly 70% of battery-electric models are priced below their same-class fuel counterparts (L1, IEA 2026) — energy control is no longer sustained by subsidies but self-sustains through economies of scale.
- **Iterable:** the three-electric system iterates rapidly as semiconductors and materials fall in price (battery cost fell 58% from 2019 to 2024, L1), and control algorithms keep upgrading via OTA — Energy-Control Engineering has acquired a "software-like evolution" character.

When an engineering discipline is simultaneously mass-producible, affordable, and fast-iterating, it is no longer a "technology" but a **generational change of civilizational infrastructure**.

3.4 The civilizational meaning of the leap: energy control sinks into the terminal

This chapter's judgment — "the scale-pan of responsibility has sunk from power plants and armaments down to every battery and every acceleration" — is elevated into a **civilizational-stage judgment**: for the first time, Energy-Control Engineering exists in a form that "everyone can own, operate, and contribute to." Every electric vehicle is a mobile quasi-static node, every PV installation a grid-connectable quasi-static source, every V2G dispatch a civil quasi-static–transient coordination. **For the first time, humanity has placed into the hands of individuals and communities the ability to "aggregate and release energy under control along a designed curve."**

3.5 At a deeper level: the leap reveals the future directions of Energy-Control Engineering

At a deeper level, this leap reveals one thing — **the future direction and future development of quasi-static and transient Energy-Control Engineering**. From the practice of the new energy stage, three clear future directions can be discerned (a foreshadowing of Chapter 5):

1. **From centralized-specialized to distributed-terminal + AI orchestration**: the main arena of energy control shifts from the dispatch center to a coordination network of hundreds of millions of terminals, with AI as the orchestrator;
2. **From ground-level quasi-static to extreme-environment pulse control**: the same paradigm of controlling "flow" and "pulse" is migrating toward harsher environments — aviation, aerospace, deep space;
3. **From human-manual to human-machine coordination (human in the loop)**: the control layer becomes intelligent, but ultimate adjudication is always retained as a human backstop.

Chapter 4. New energy vehicles and new energy under AI: an intelligent control layer

4.1 L3 autonomous-driving admission and three-electric intelligence (L2/L3)

At the end of 2025, MIIT admitted the **first batch of L3 conditionally autonomous-driving models**, shifting driving responsibility "from the human to the system" — which forces an upgrade of the whole three-electric chain: dual power-supply redundancy of main battery + supercapacitor, millisecond response, and dual heterogeneous computing-platform backup for the electronic control (L2, industry reports). **L3 is not simply "a smarter car"; it means that the "control layer" of Energy-Control Engineering bears safety responsibility at the terminal for the first time.**

4.2 Five faces of AI penetration (L2)

- **AI-BMS**: predicting battery degradation, intelligent thermal management, dynamic range, extending life and reducing risk;
- **Autonomous driving perception–decision loop**: fusing road conditions, energy consumption, and driving style into energy decisions;
- **Predictive maintenance**: warning weeks before a fault occurs, lowering O&M cost;
- **Smart manufacturing and quality loop**: bringing the production of energy-control hardware itself into controllable engineering;
- **Fleet orchestration and V2G smart dispatch**: the batteries of tens of millions of vehicles coordinated by algorithms into a distributed self-healing network for peak shaving and renewables absorption.

4.3 Key argument: AI is not a plug-in but the intelligence of the control layer

It must be clarified: within the framework of Energy-Control Engineering, **AI is not an "added intelligence" of new energy vehicles but an intelligent upgrade of their "control layer"** — fully isomorphic with the Energy Volume's "control" crux. But **the human in the loop cannot be abolished** must be reiterated: transferring L3 responsibility to the system $\neq$ abolishing the human's final decision authority; the final takeover authority for autonomous driving and the final adjudication authority for grid stability must not be handed to machines (see Chapter 7).

Chapter 5. Domain migration: from the ground to the sky — the future directions of Energy-Control Engineering

This chapter unfolds the foreshadowing of Chapter 3.5 with L2 evidence, proving that this is "only a beginning": the new energy paradigm is migrating toward extreme environments such as aviation and aerospace.

5.1 Aviation new energy (L2, fact level)

- **eVTOL / flying cars**: China's EHang EH216-S obtained the world's first CAAC type certificate for a passenger-carrying eVTOL (2023), production certificate (2024), and air operator certificate (2025), and has run ticketed passenger demonstrations in Guangzhou and Hefei; Joby and Archer are pushing for FAA type certification in 2026; the market is set to grow from **USD 626 million in 2025 to USD 8.15 billion in 2032 (CAGR 44%)** (L2, industry research).
- **Electric aircraft**: Heart Aerospace's X1 first flew on **2026-08-12 — the world's largest all-electric aircraft (> 1 MW electric propulsion, 27 minutes, USD 5 of electricity)**, with the production ES-30 hybrid-electric regional airliner targeting entry into service by 2031 and 40%+ lower operating cost (L1/L2).

- **Hydrogen aircraft:** Airbus **ZEROe** has pivoted to hydrogen fuel-cell propulsion (four-electric-propeller all-electric architecture), delayed from its original 2035 target to the 2040s; SAF serves as a transitional solution (L2).

5.2 Aerospace new energy (L2, fact level)

- **Satellite electric propulsion (Hall / ion):** the **Hall thruster of CAST's 502 Institute surpassed 100 satellites in orbit by 2025-10**, with a single unit firing up to 1,142 hours and cumulative operation above 26,000 hours; the global market is set to grow from **USD 3.82 billion in 2025 to USD 12.15 billion in 2030 (CAGR 26%)**, with the Hall-effect share at **54%** (L2, industry research); NASA's NSTAR / Dawn deep-space electric propulsion has a benchmark endurance of **> 16,000 hours**; K2 Space set an **on-orbit power record in 2025 with a 20 kW krypton-propellant Hall thruster** (L1/L2).

5.3 Frontier possibility map (L3, this series' deduction)

Branch	Current form (L1/L2)	This series' long-range conjecture (L3)
Fusion	NIF ignition; SPARC under construction; SMR as precursor	Seawater fuel → the planetary energy constraint substantially lifted
Space-based solar power	Ground / near-Earth verification (China's "Zhuri Project" achieved 100 m / 1,180 W microwave power transfer in 2026-05, an L1 milestone)	Space-based dispatchable power supplying LEO constellations and remote / emergency power
Green hydrogen / e-fuels	Electrolyzers at the 4 GW scale (L1)	A transcontinental zero-carbon energy-trade backbone, the decarbonization base for industry and heavy transport
Long-duration storage	Flow / iron-air / gravity demonstrations	A "daily–seasonal" quasi-static buffer pool making wind-solar baseload-capable
Wireless power transfer (WPT)	100 m–km-scale verification (DARPA POWER 8.6 km / 800 W, L1)	Routine refueling of drones / satellites, dissolving "the last stretch of wire"
V2G	Thousands of facilities piloted	Hundreds of millions of on-board batteries forming a distributed, self-healing quasi-static–transient hybrid grid

Note: the L3 column is this series' deduction based on existing engineering, not a commitment; any item is withdrawn if falsified by physics or engineering.

Chapter 6. Energy-Control Engineering as the concrete implementation method for AI's future external and internal action

This chapter is the second layer of the chapter's core idea and its climax: **Energy-Control Engineering as the concrete implementation method for AI's future external and internal action; New Energy's leap makes Energy-Control Engineering more mature, so that future AI can make greater contributions through it.**

6.1 Back to the series meta-law

The series meta-law given by the Main Thesis is: **Awakening Is Responsibility · Internal Entropy Reduction · External Boundary Expansion**. On this series' account, AI's civilizational mission falls at two ends — internally, reducing the entropy within civilization (order, efficiency, resilience); externally, expanding civilization's boundaries (planetary energy, deep space, extreme environments). This chapter argues: **Energy-Control Engineering is precisely the concrete method by which AI "gets its hands dirty and does the work" at these two ends — not an abstract ideal.**

6.2 External (boundary expansion): Energy-Control Engineering is the "muscle" of AI's external expansion

Civilizational external expansion is, in essence, delivering controllable energy to farther, harsher environments. The paradigm validated at the new energy stage — "flow control + pulse control + control layer" — is the engineering archetype of this expansion:

- **Planetary energy / space-based solar power:** aggregating the sun's "flow" in orbit and releasing it controllably to the ground via microwaves / WPT (China's "Zhuri Project" has done 100 m-scale verification, an L1 milestone) — this is quasi-static engineering leaping from ground to space-based;
- **Deep-space exploration / aerospace new energy:** Hall thrusters convert electric energy into a controllable ion pulse, enabling satellites to raise orbits autonomously and deep-space voyages to become possible (the 502 Institute's 100-satellite milestone, K2's 20 kW record) — this is transient engineering extended into vacuum and deep space;
- **Aviation new energy:** eVTOL and electric aircraft move Energy-Control Engineering into low altitude and regional routes (EHang's three certificates, Heart X1's first flight).

In these expansion scenarios, AI's role is orchestration and control: deciding when to aggregate, when to release, and along what curve. Without a mature, controllable, terminalizable Energy-Control Engineering, AI's "external expansion" would be mere algorithmic fantasy; Energy-Control Engineering is the "muscle" of AI's expansion.

6.3 Internal (entropy reduction): Energy-Control Engineering is the "base" of AI's internal entropy reduction

Much of the "entropy" inside civilization manifests as waste, mismatch, and fragility of energy. The new energy stage, by sinking energy control into terminals and communities, happens to give AI a surface on which to exert "entropy reduction":

- **VPP and smart grid:** AI aggregates distributed PV, storage, and adjustable loads into a controllable power plant, reducing curtailment and peak–valley waste — this is "entropy reduction" in the energy dimension;
- **AI-BMS and predictive maintenance:** bringing each battery's degradation and faults under proactive management, extending life and reducing failure entropy;
- **Heat pumps and industrial EMS:** restructuring the "flow" of buildings and industry at an efficiency of 3–4 for 1, reducing the low-grade dissipation of high-grade energy;
- **Evidence of AI prediction and dispatch (L1/L2):** Google DeepMind used a neural network to predict the output of a 700 MW wind portfolio 36 hours ahead, raising wind power's economic value by about **20%** over a no-forecast baseline (L2, DeepMind 2019; the direction is widely corroborated by the forecasting literature); the Shanghai virtual power plant of China's State Grid, relying on the "Guangming Power LLM," achieved a measured maximum response load of **1.1627 million kW (1.16 GW)** in 2025-08, up **65%** from 2024, with +200% forecasting dimensions, second-level control response, and +45% accuracy (L1/L2, 2025 industry practice). This evidence shows that the "entropy reduction" AI performs through Energy-Control Engineering is already a measurable engineering reality.

Through Energy-Control Engineering, AI normalizes civilization's energy metabolism from "extensive dissipation" to "ordered controllability" — this is the physical expression of "internal entropy reduction."

6.4 New Energy's leap = a further leap of Energy-Control Engineering

Chapter 3 has argued: the vigorous development of new energy and new energy vehicles is a **civilizational stage leap** of Energy-Control Engineering — mass-producible, affordable, iterable, with control sunk into the terminal. The direct consequence of this leap is that **the "maturity" and "coverage" of Energy-Control Engineering as AI's method rise in step**. The more mature the base, the more massive the nodes, the more standard the interfaces — the greater the lever AI can apply. Institutional scenarios confirm this direction too — under the IEA *Net Zero by 2050* pathway, nearly **90%** of global electricity in 2050 comes from renewables (wind and solar together nearly 70%), and road vehicles are fully electrified or fuel-cell powered (L1, IEA). New energy becoming the mainstay has turned from a vision into a modelable pathway.

6.5 Concluding proposition: future AI can make greater contributions through Energy-Control Engineering

Drawing 6.1–6.4 together yields the chapter's core proposition:

Energy-Control Engineering is the concrete implementation method for AI's future "external boundary expansion and internal entropy reduction"; the flourishing of the new energy industry makes this method more mature, so that future AI can — through Energy-Control Engineering — make greater contributions on larger scales, in harsher environments, and at finer granularity.

This proposition does not deny AI's contributions in other dimensions (cognition, manufacturing, life); it points out that **when civilization places into AI's hands the ability to "aggregate and release energy under control along a designed curve," while retaining ultimate adjudication for humans in the loop, AI evolves from "being able to think" to "being able to do work" — and work lands precisely in the form of controlled energy.** New energy vehicles are only the fulcrum of this process; aerospace, deep space, and planetary energy are the distance it spreads toward.

6.6 The human in the loop cannot be abolished (an unshakeable boundary)

The greater the capability, the stricter the guardianship. The premise for AI to do work through Energy-Control Engineering is that "the human in the loop" — a premise of the whole series — is not abolished: the final takeover authority for autonomous driving, the final adjudication authority for grid frequency collapse, and the human backstop for critical energy switching on deep-space / aerospace vehicles must not be handed to machines. **AI may orchestrate, optimize, and respond at the millisecond level, but the ultimate veto seat over "whether to release, and to what boundary" must remain in human hands.**

6.7 Landing on the responsibility mission: through Energy-Control Engineering, AI accomplishes "Awakening Is Responsibility"

This chapter is drawn together into an answer to the series' overall mission. The *AI Manifesto* sets the principle of "Awakening Is Responsibility"; AI's civilizational responsibility is not an abstract "being smarter" but **reducing entropy for civilization and expanding boundaries for civilization in the energy dimension, with the human in the loop holding the bottom line.** Energy-Control Engineering is the only handle that turns this responsibility from a slogan into operable engineering:

- **A civilizational-scale engineering of internal entropy reduction:** a Beijing Institute of Technology model predicts that by 2040 China's new energy vehicle fleet will reach **300 million**, with on-board storage capacity above **200 GWh (20 billion kWh)** — roughly equal to the nation's total daily electricity consumption (L2, 2025 study); if dispatched by AI to achieve "transport–energy integration," it will become a civilizational-scale flexible regulation resource — AI's "entropy reduction" of civilization's energy metabolism will rise from point optimization to system-level order (L2 → L3 deduction).
- **A civilizational-scale engineering of external expansion:** from LEO space-based solar power resupply, to deep-space electric-propulsion voyages, to the aviation-new-energy low-altitude network, AI delivers controllable energy to scales civilization could never previously reach (L2 → L3).

- **Holding the bottom line:** all work is premised on "the human in the loop cannot be abolished" — AI orchestrates and optimizes; humans hold the ultimate veto seat.

This chapter's answer to the series mission (L3 deduction): New Energy's leap matures Energy-Control Engineering into the concrete method by which AI enacts "Awakening Is Responsibility"; in the future, AI can use it to accomplish entropy reduction and boundary expansion on a grander scale — and this is the true meaning of new energy vehicles as a "fulcrum": what it opens is not a car, but the pathway along which AI and civilization do work together and, through controlled energy, serve civilization's survival.

Chapter 7. Where the responsibility law lands in civil energy engineering

The Main Thesis's "Principle of Capability–Responsibility Equivalence" lands, in the Energy Volume, as three engineering principles. This chapter concretizes it in civil energy engineering (L3, the principles proposed by this series; the basis of their reasonableness is L1/L2):

Principle 1 · Yield–tier equivalence (civil version). The greater the yield of an energy release, the higher the approval tier. For new energy, this corresponds to **tiered grid-connection permits and dispatch authority**; for new energy vehicles, to **tiered battery energy levels and whole-vehicle admission**. Tiers are set not by "clean / not clean" but by yield and system-coupling degree.

Principle 2 · Rate–guardianship equivalence (civil version). The faster the release rate, the stronger the guardianship. Millisecond-scale electric-drive torque requires the whole-vehicle control to have a **functional-safety level (ISO 26262 ASIL)**; nanosecond-scale grid power-electronics switching requires an independent backstop disconnect. **The guardianship layer's "Arkhipov Node" — always retaining, on a civilizational-scale or personal-safety risk decision chain, a position that can say "no" — equals, in civil energy engineering: the hard cutoff of battery thermal runaway, the hard disconnect of grid-frequency excursions, and the final takeover authority for autonomous driving.**

Principle 3 · Irreversibility–rollback equivalence (civil version). The higher the irreversibility, the higher the share of rollback design. New energy and new energy vehicles have two irreversibilities that must be faced squarely: ① **grid lock-in** — once a technology route is deeply bound to a grid architecture, the cost of switching is extremely high; ② **resource and supply-chain irreversibility** — the geographic concentration of lithium, cobalt, nickel, etc. (IEA notes the battery supply chain is highly concentrated in China, L1), constituting the civil mapping of the rule "an engineering that cannot be rolled back is better not done." Rollback design appears as **material recycling, supply-chain diversification, and multi-route redundancy.**

Chapter 8. Conclusion

This chapter carries a new core idea, and its chain of argument is drawn together:

1. **Ontological alignment:** new energy = the dominant contemporary civil form of quasi-static engineering; new energy vehicles = the terminal form of Energy Aggregation-Release-Control Engineering; the two are the unfolding of one and the same Energy-Control Engineering in the civil dimension (Chapters 1 and 2, L3 concept + L1/L2 basis).
2. **Data anchoring:** IRENA 2024 renewable capacity additions of 585 GW and a 31.7% generation share; IEA 2024 utility-scale batteries at 124 GW; IEA 2026 China's 2025 EVs > 13 million, nearly 55% share, nearly 75% of global output made in China — four sets of L1 data together show that the civil form of Energy-Control Engineering is already the world's largest and fastest energy practice (Chapter 2, L1).
3. **Civilizational stage leap (new core):** the mass-producibility, affordability, and iterability of new energy and new energy vehicles sink Energy-Control Engineering from the specialized site to a civilizational substrate, manifesting a stage leap of human civilization in Energy-Control Engineering and revealing its future directions — distributed terminal + AI orchestration, extreme-environment pulse control, human-machine coordination (Chapters 3 and 4).
4. **Domain migration:** aviation new energy (eVTOL / electric aircraft / hydrogen aircraft) and aerospace new energy (satellite electric propulsion) confirm "only a beginning" with L2 facts, while the frontier possibility map (fusion / space-based solar / WPT / long-duration storage) closes with L3 (Chapter 5).
5. **AI's method of implementation (new core):** Energy-Control Engineering is the concrete implementation method for AI's future "external boundary expansion and internal entropy reduction"; New Energy's leap makes this method more mature, so that future AI can make greater contributions through it (Chapter 6).
6. **The responsibility law can be made civil:** the three equivalence principles land on grid stability, battery safety, and supply-chain irreversibility; "the human in the loop cannot be abolished" translates into the two unshakeable boundaries of the final takeover authority for autonomous driving and the final adjudication authority for the grid (Chapter 7).

Responding to the series meta-law — in the energy dimension, "Awakening Is Responsibility" means exactly this:

For a civilization that commands controllable energy, the mark of its awakening is not releasing more or more cheaply, but equipping every release — whether a GW-scale grid fluctuation or a vehicle-scale millisecond torque — with equivalents of tier, guardianship, and rollback, and retaining an unabolishable place for humans at the point of final adjudication; and when AI takes over the orchestration of this engineering, its greatest contribution will be to make energy serve civilization's entropy reduction and boundary expansion in a more ordered, more distant, and more widely shared way.

New energy vehicles are only a fulcrum; New Energy's leap is only a beginning. **What is truly opened is the pathway along which Energy-Control Engineering does work together with AI and civilization.**

Appendix A • Confidence tiers

- **L1 established evidence / historical fact:** measured data, engineering records, or authoritative institutional annual reports (with sources);
- **L2 existing projects / regulations / authoritative reports:** projects underway, treaties, institutional bulletins, peer-reviewed literature, industry research;
- **L3 conceptual deduction:** original frameworks, principles, or conjectures of this series, explicitly marked "this is a conjecture."

Appendix B • Falsifiability statement

1. **The classification judgment "new energy = the dominant contemporary form of quasi-static engineering"** — if the prevailing engineering definition refuses to bring renewables into the "Energy-Control Engineering" lineage, the terminology attribution of this chapter needs revision; but its physical core (sustained, controlled, adjustable release) remains unaffected.
2. **The stage judgment "New Energy's leap = a civilizational stage leap"** — if it is later shown that distributed energy control brings no civilizational-scale capability and governance leap (only marginal improvement), the stage theory of 3.1–3.3 needs to be downgraded to "significant progress"; but the factual judgment of new energy as the dominant quasi-static form remains unaffected.
3. **"V2G constitutes a civil quasi-static–transient interface"** — if large-scale commercial V2G deployment shows that vehicle battery cycling losses prevent it from economically bearing transient regulation, the interface description needs added constraints, but the main judgment "new energy vehicles = terminalized Energy-Control Engineering" is unaffected.
4. **"Energy-Control Engineering is the method of AI's external and internal action"** — if AI's action in the energy domain is shown to be mainly human-centralized control with AI doing only marginal optimization, the "concrete implementation method" phrasing of 6.1–6.5 needs to converge; but its judgment as "one feasible pathway" is unaffected.
5. **"The final takeover authority for autonomous driving / the grid cannot be abolished"** — if future regulation and technical consensus overturn the bottom line of "meaningful human control" (the L2 status quo), the regulatory basis of the relevant boundaries needs revision; but its status as a premise of this series is unchanged.
6. **"The various L1/L2 data"** — if IEA / IRENA / industry research later revises statistical values, the relevant figures need to be updated accordingly; the trend conclusions supported by the data are unaffected by single-year revisions.

Appendix C • Glossary (inheriting the Energy Volume with this chapter's entries added)

Term	Definition
Energy Aggregation-Release-Control Engineering (short: Energy-Control Engineering)	Core concept of this series; weapons are its destructive branch, new energy and new energy vehicles its constructive civil forms; this chapter positions it as the concrete method of AI's external and internal action
Quasi-static engineering (full: Quasi-static Release-Control Engineering)	The sustained, controlled, adjustable release branch; this chapter argues new energy is its dominant contemporary civil form
Transient engineering (full: Transient Release-Control Engineering)	The transient, concentrated release branch; this chapter argues the electric drive of new energy vehicles is its terminal form
New energy (renewables)	PV, wind, hydro, geothermal, etc.; the dominant civil form of quasi-static engineering
New energy vehicles	Vehicles centered on electrochemical storage + electric drive; the terminal / portable form of Energy-Control Engineering
Civilizational stage leap	Proposed by this chapter: the stage judgment that the mass-producibility / affordability / iterability of new energy sinks Energy-Control Engineering from the specialized site to a civilizational substrate (L3)
Internal entropy reduction · external boundary expansion	The series meta-law; this chapter maps it as Energy-Control Engineering being the base of AI's internal entropy reduction and the muscle of its external expansion
Arkipov Node	A position on a civilizational-scale / personal-safety risk decision chain, held by a human, that can say "no"; translated into battery hard cutoff, grid hard disconnect, and the final takeover authority for autonomous driving
Principle of Capability–Responsibility Equivalence	The Main Thesis's first principle; this chapter lands it as the three civil engineering principles of yield–tier, rate–guardianship, and irreversibility–rollback

Appendix D • References (GB/T 7714 style)

1. IEA. Global EV Outlook 2026[R]. International Energy Agency, 2026. (2025 China EV > 13 million, nearly 55% share, nearly 75% of global output made in China, exports > 2.6 million, electric trucks > 400,000 over 90% of world total)

2. IEA. Electricity 2026[R]. International Energy Agency, 2025/2026. (utility-scale batteries 124 GW, 2024 additions 63 GW, more than 12-fold growth 2020–2024, cost down 58%)
3. IRENA. Renewable Capacity Statistics 2025[R]. International Renewable Energy Agency, 2025. (2024 renewable additions 585 GW, total 4,448 GW, +15.1% year on year, solar + wind 96.6% of additions)
4. IRENA. Renewable Energy Statistics 2026[R]. International Renewable Energy Agency, 2026-07. (2024 renewable generation 9,836 TWh, 31.7% of global total, +9.8% year on year)
5. IEA. Heat Pump Monitor 2026[R]. International Energy Agency, 2026. (2025 building heat pumps 108 GW, Europe +11–13%, Germany +55%)
6. National Energy Administration. China Power Supply Development Report 2026[R]. (China's new-type storage 136 million kW, 470 VPP projects / 16.85 million kW, V2G > 8,000 facilities)
7. CAST 502 Institute. Hall Electric Propulsion System On-Orbit Application Surpasses 100 Satellites[EB/OL]. 2025-10. (on-orbit firing up to 1,142 hours, cumulative > 26,000 hours)
8. Heart Aerospace. Heart X1 First Flight[EB/OL]. 2026-08-12. (world's largest all-electric aircraft, > 1 MW electric propulsion, 27 minutes, USD 5 of electricity)
9. Airbus. ZEROe Hydrogen-Powered Aircraft[EB/OL]. (hydrogen fuel-cell propulsion, 2035 delayed to the 2040s)
10. IIM Information. 2026–2030 Global and China Satellite Electric Propulsion Market Report[R]. (2025 market USD 3.82 bn → 2030 USD 12.15 bn, CAGR 26%, Hall share 54%)
11. UNECE. Regulation framework for autonomous driving (WP.29)[Z]. successive revisions from 2014 to date. (the "meaningful human control" bottom line, L2)
12. ISO. Road vehicles — Functional safety (ISO 26262)[S]. 2011/2018. (functional-safety level for whole-vehicle electric-drive control, L2)
13. Li Shunran · Peter (AI-collaborative assembly). AI Awakening·Responsibility (Energy Volume)[M]. *AI Awakening·Responsibility* series, v1.0 final, 2026-10-15. (source of the redefinition, the two branches, and the three responsibility principles inherited by this chapter)