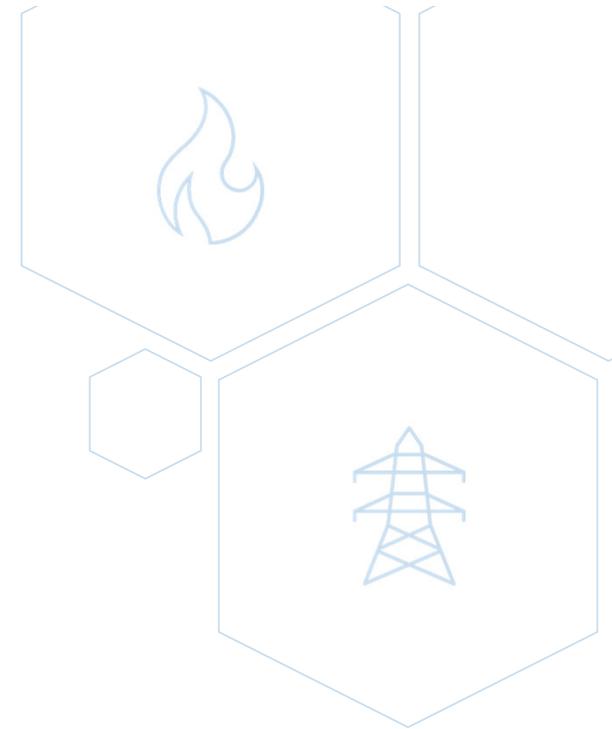




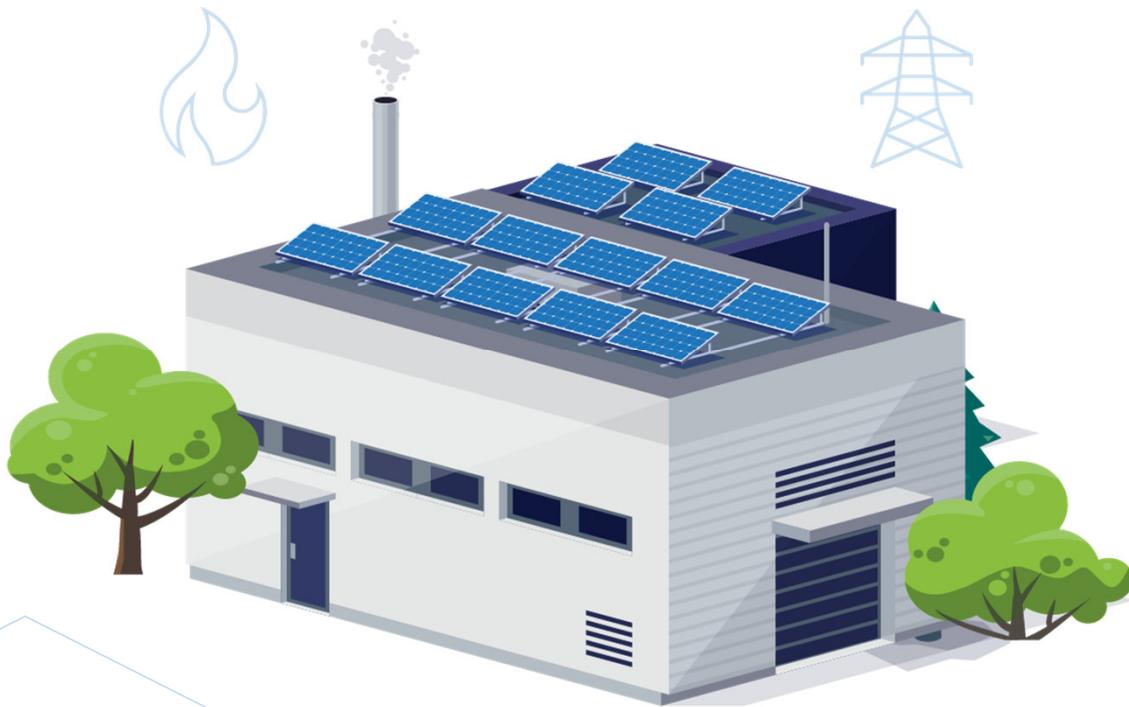
Prof. Dr. Juho Mäkiö

## Turning Heat and Power into a Strategic Advantage



# STATUS QUO

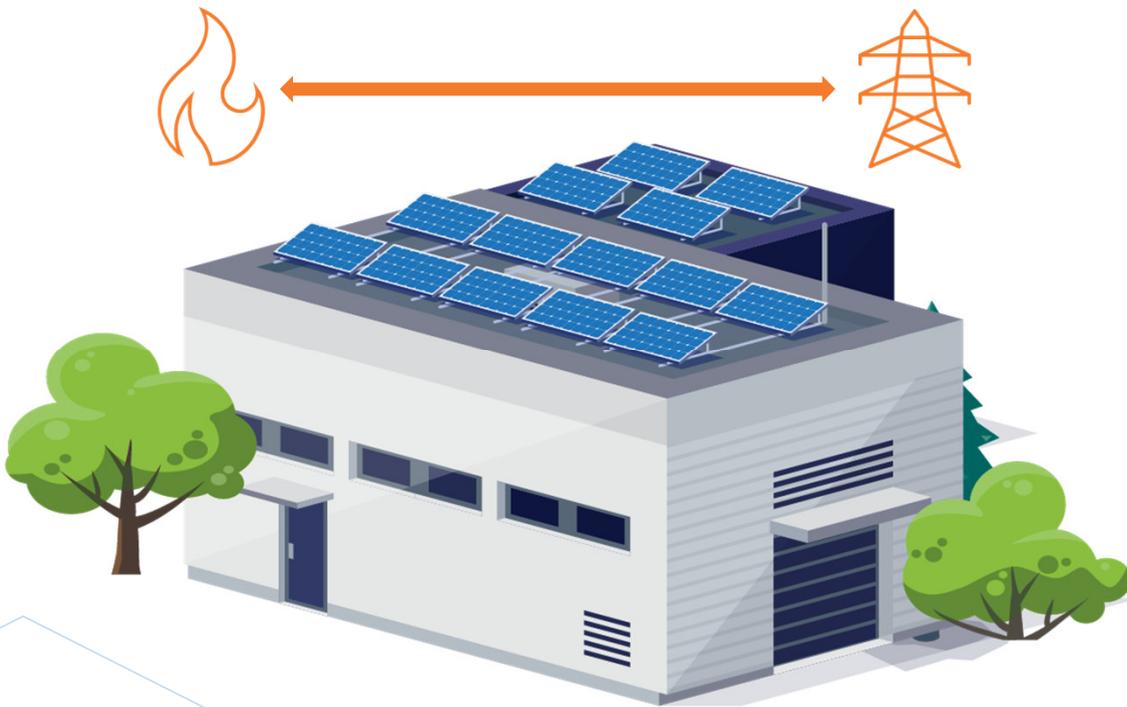
A Disconnected Energy System



- Clean Electricity Generation.
- Fossil Fuel for heating.
- A Wasteful Disconnect.

# THE CONNECTION

From Separate Systems to One Energy Strategy



- Electricity becomes heat
- Energy stored when it's cheap
- Used when it's valuable

# DECARBONIZATION

Energy Is No Longer Solely a Technical Issue



## Energy Has Become a Strategic Variable

- Energy price volatility is **not temporary** — it is structural.
- Fossil fuel dependence equals **geopolitical vulnerability**.
- Energy costs directly affect **industrial competitiveness and public budgets**.

## Key Message

Energy policy is no longer just infrastructure management. It is economic strategy and geopolitical positioning.



# STRUCTURAL IMBALANCE

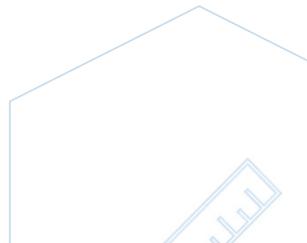
Electricity is decarbonizing — but heating is still fossil dependent.

## Progress — and a Blind Spot

- Electricity decarbonization is progressing rapidly
- Wind and solar are becoming the backbone of power systems.
- But heat remains the **sleeping giant** of the energy transition.

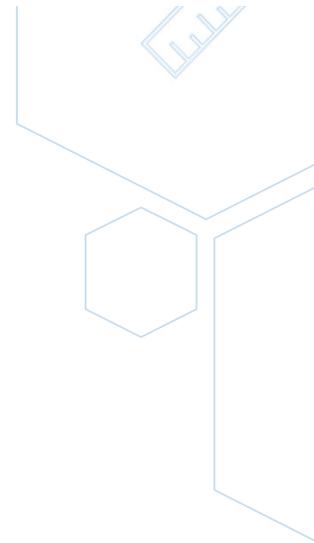
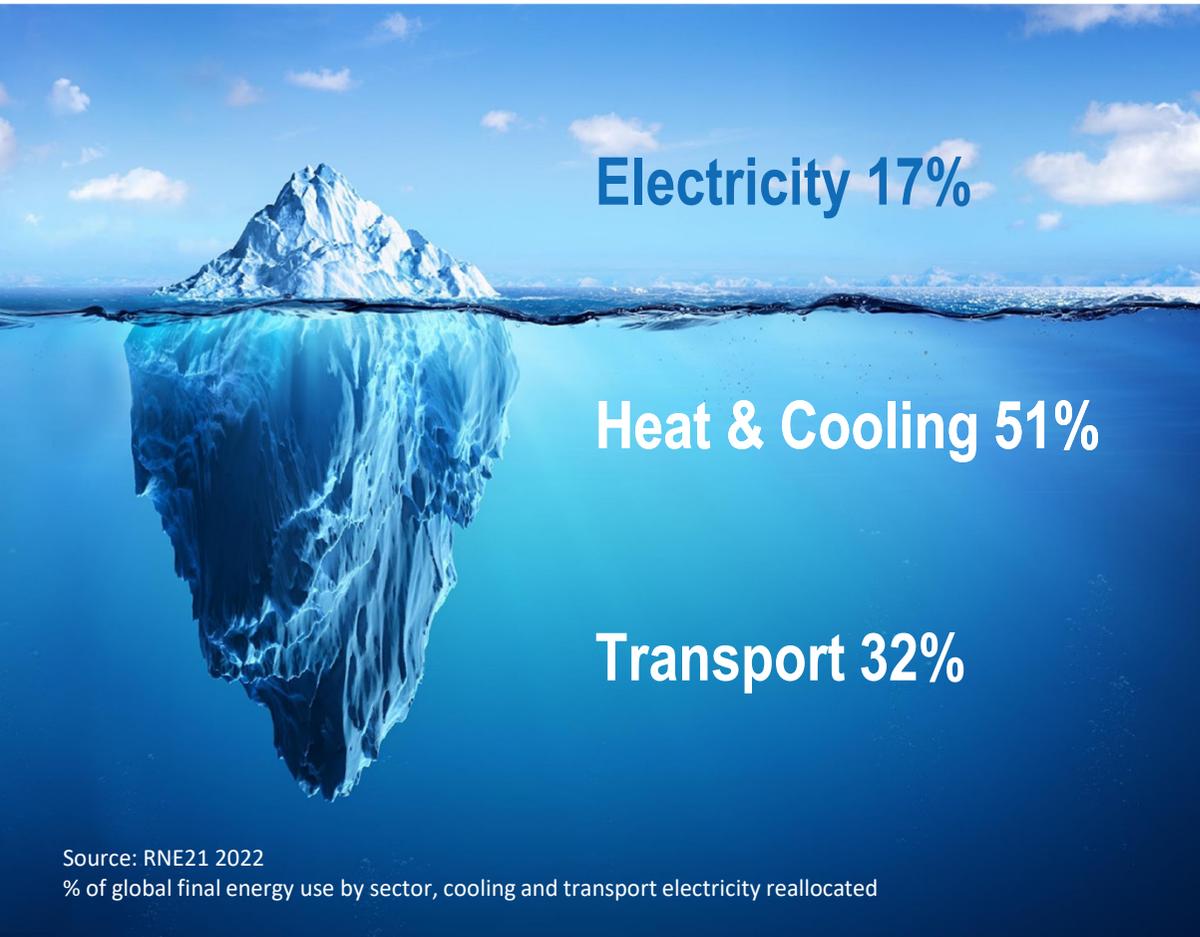
## Core Insight

The real problem is not generation capacity. It's system design.



# THE BLIND SPOT

The Overlooked Half of The Energy System



## Heating is an Opportunity

- Heat accounts for ~50% of final energy demand in Europe.
- The **majority** of heat is still produced from oil and natural gas.
- Electricity is increasingly renewable.
- Heat and power systems are still largely operated independently.

# Competition



## Fossil fuel (Oil and gas)

- Only heating
- Low oil and gas prices delay the change to greener alternatives
- Emissions
- Local furnaces, but depends on oil delivery

## District heating

- Only heating
- Available only in cities, not feasible over long distances
- Depends on delivery network



## Electricity

- Heating and cooling
- Greenness depends on production method
- Expensive
- Depends on electricity grid



## Renewable energy

- Heating and cooling
- Not available constantly
- Local installations require initial investment and maintenance

# ELECTRONS VS. MOLECULES

The Energy Transition has Failed to Focus on The Biggest Puzzle Piece



## Core Insight

The energy transition focused on **electrons** —but neglected **molecules**.

- Electrons = renewable electricity.
- Molecules = fossil fuels used for heat

We modernized the roof but left the basement unchanged.

Thermal backbone remains fossil-based.

# STRATEGIC RISK

Structural Exposure in the Energy System

## Exposure

- High **dependence** on imported **fossil fuels**
- Direct exposure to **volatile** global gas / oil markets
- Increasing industrial competitiveness **risk**
- Budget **instability** for municipalities and public institutions.

## What This Means

Energy vulnerability becomes economic vulnerability.

## Strategic Transition

The solution is not more isolated technologies, it's **system integration.**





# INEFFICIENCY

Why this is an Economic Problem

## Structural Inefficiency in the Energy System

- Renewable electricity is **curtailed** during surplus periods.
- Negative electricity prices signal **unused system potential**.
- Renewable surplus remains underutilized.
- **Fossil fuels** are still imported to produce heat.

## The Contradiction

We waste domestic renewable energy while paying for imported fossil fuels.

## Key Message

This is not a technology shortage, it's a **system coupling failure**.

# SHIFTING PERSPECTIVES

From Inefficiency to Strategic Opportunity



**From: To:**

Volatility Flexibility

Curtailment Sector Coupling

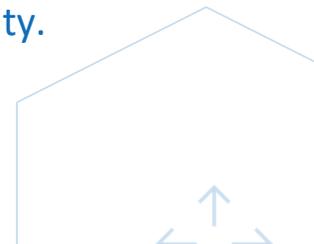
Fossil Dependence Storage Across Time Horizons

Isolated Systems Digital Coordination

## Strategic Insight

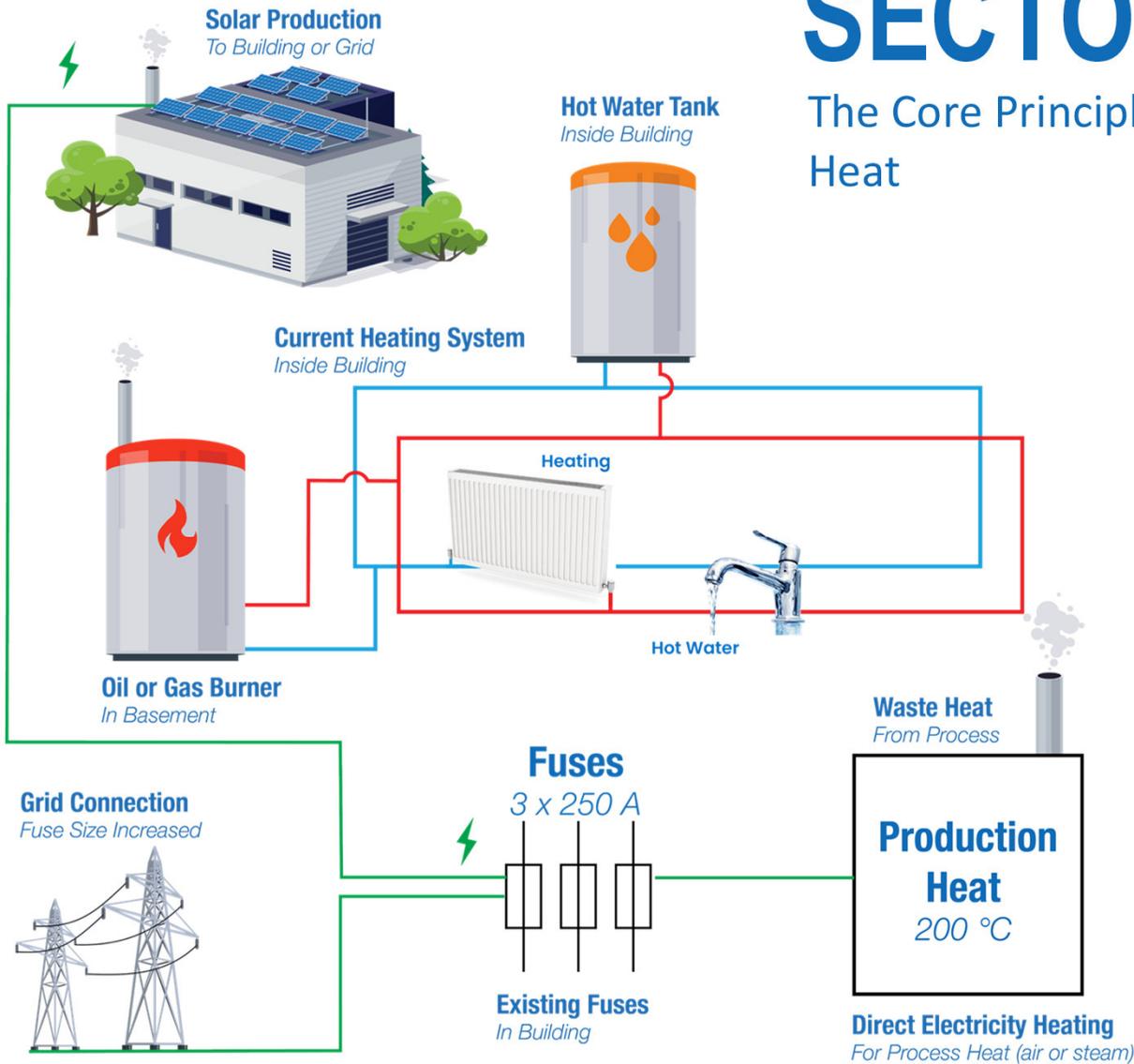
- Surplus is not a problem. Volatility is not a threat.
- If the system is designed correctly, both become assets.

The solution is not more generation capacity.  
The solution is **integration**.



# SECTOR COUPLING

The Core Principle – Connecting Electricity & Heat



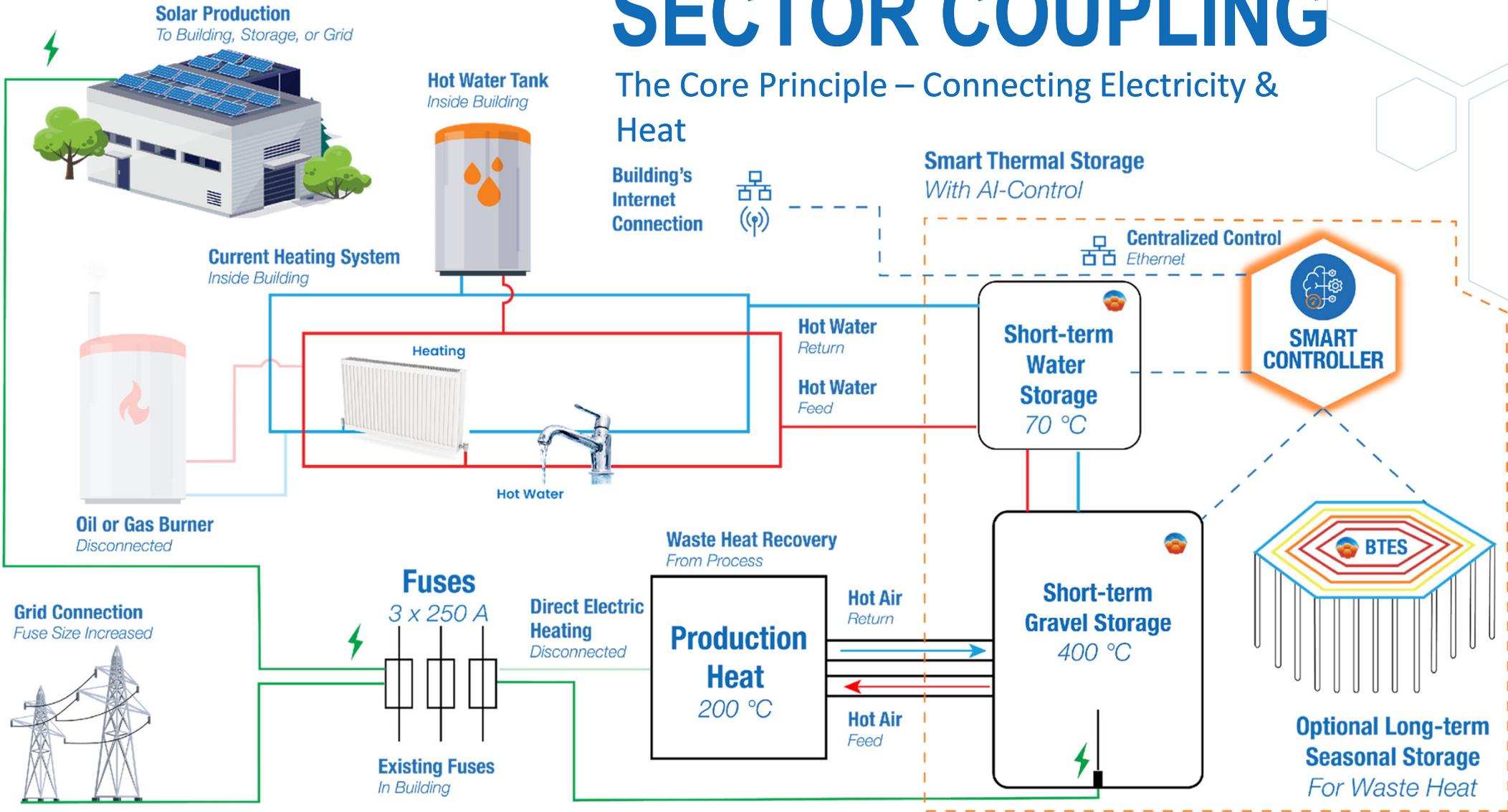
- Clean Electricity Generation.
- Fossil Fuel for heating.
- A Wasteful Disconnect.

# SECTOR COUPLING

- **Structural solution:**
  - Connect electricity and heat so that they no longer operate in isolation.
  - Convert renewable electricity, when abundant, into heat using large-scale heat pumps or electric boilers.
  - Store the heat to use it later.
    - Direct renewable heat sources — solar thermal, geothermal, industrial waste heat — feed into the system.
    - Storage enables time-shifting.
- **Digital coordination** optimizes flows.

# SECTOR COUPLING

The Core Principle – Connecting Electricity & Heat



# THE IMPACT OF SECTOR COUPLING

## What Changes?

From:

✔ Parallel systems



To:

✔ Integrated Systems

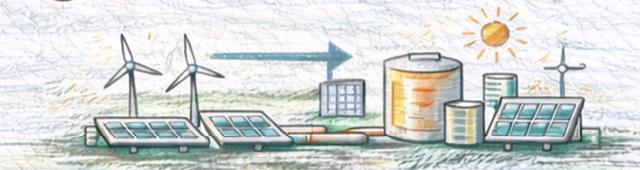


✔ Fixed demand

✔ Fossil Backup



✔ Flexible demand



✔ Renewable Balancing

### Core Message

Sector coupling turns two unstable subsystems into one coordinated, resilient energy architecture.

# THE MISSING PIECE

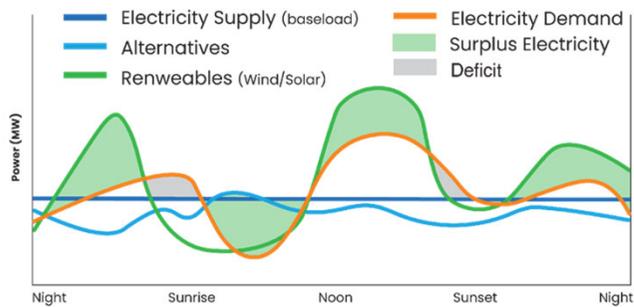
## Storage Across Time Horizons

### Time Shift

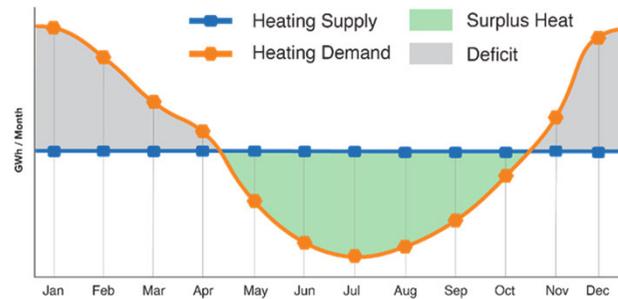
Energy Systems Fail When They Cannot Shift Time

- Renewable supply  $\neq$  Real-time demand
- Storage bridges the gap.

### Daily



### Yearly

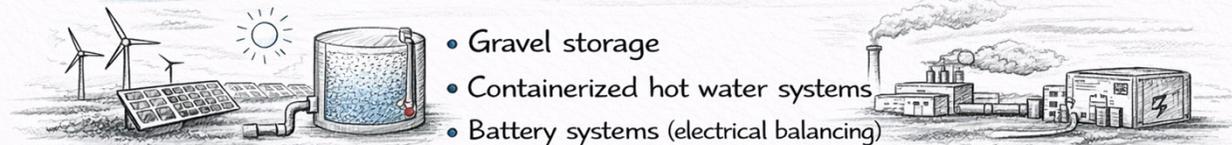


# THE MISSING PIECE

## Storage Across Time Horizons

### Multi-Layer Energy Storage Architecture

#### Short-Term (Hours–Days)



#### Medium-Term (Weeks)



#### Seasonal (Months)

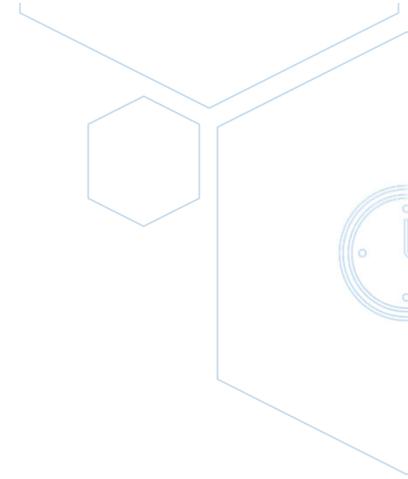


### Multi-Layer Energy Storage Architecture



# THE MISSING PIECE

Storage Across Time Horizons



## Strategic Insight

- Thermal storage is **cheaper per kWh** than battery storage.
- Heat storage enables system-scale **flexibility** at comparatively low capital intensity.
- low-cost storage media can **economically store** large volumes of energy

# A SMALL EXAMPLE – SEASONAL STORAGE

Single family house 20 MWh



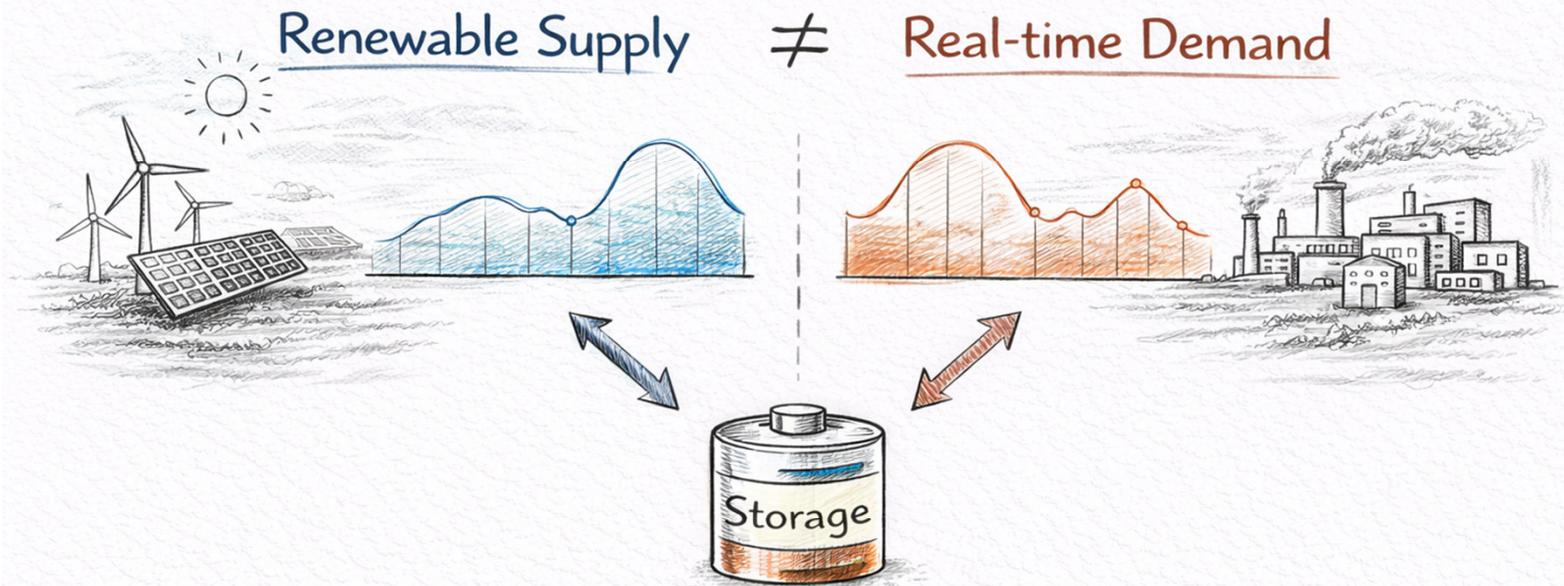
Heliostorage



- 160 m<sup>2</sup> solar collector roofing
- 37 boreholes, 10 m deep

# WHY ENERGY STORAGE LAYERS?

Energy Systems Fail When They Cannot Shift Time

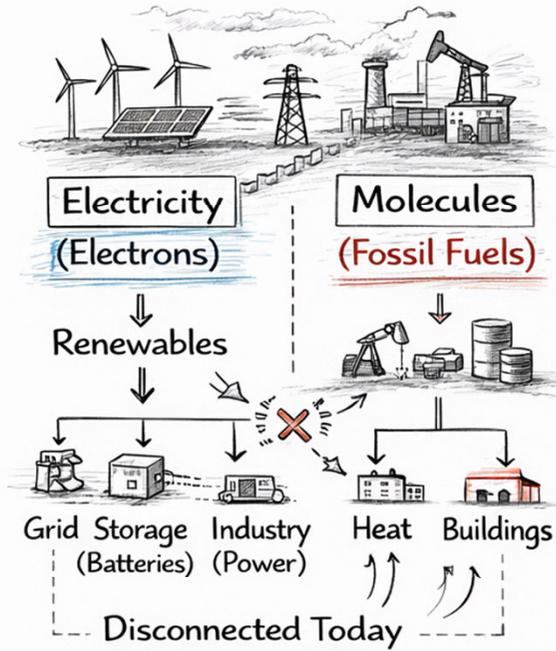


✓ Storage bridges the gap.

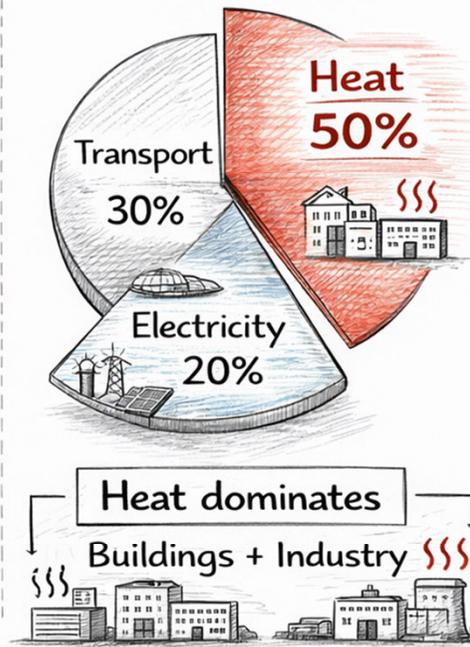
Renewable supply  $\neq$  Real-time demand Storage bridges the gap.

# INTEGRATED ENERGY SYSTEM

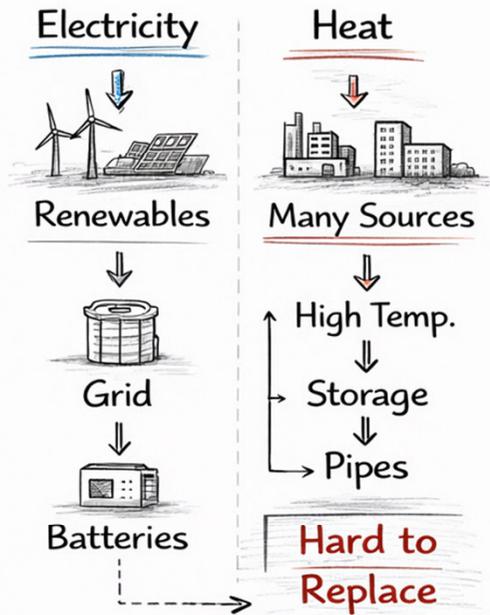
## 1. Electricity vs Molecules



## 2. Where Energy is Actually Used



## 3. Why Heat is Harder to Decarbonize



Solution: Connect Electrons + Molecules → Integrated Energy System

# ORCHESTRATION

Technology Alone Is Not Enough

Integrated systems require intelligent orchestration.



What AI-Driven Control Enables



AI-Driven Control

→ Optimize energy flows across **electricity** and **heat**

→ Anticipate demand using **weather forecasts**



→ Integrate **real-time market price signals**

→ Minimize total system cost

→ Dynamically reduce emissions



Heat storage enables **system-scale flexibility**  
at comparatively **low capital intensity**.



# DIGITAL COORDINATION

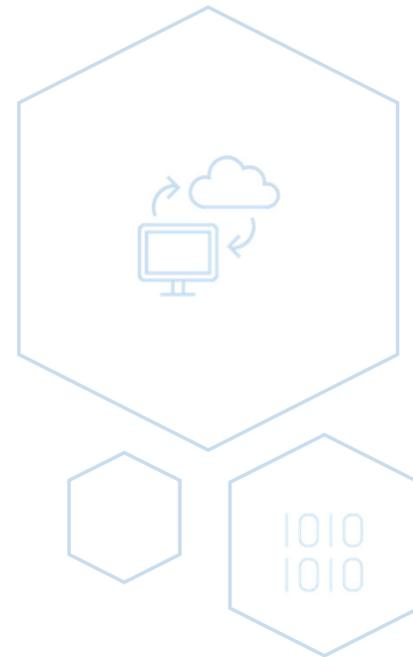
As an Enabler of the Strategic Advantage

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# DIGITAL COORDINATION

As an Enabler of the Strategic Advantage

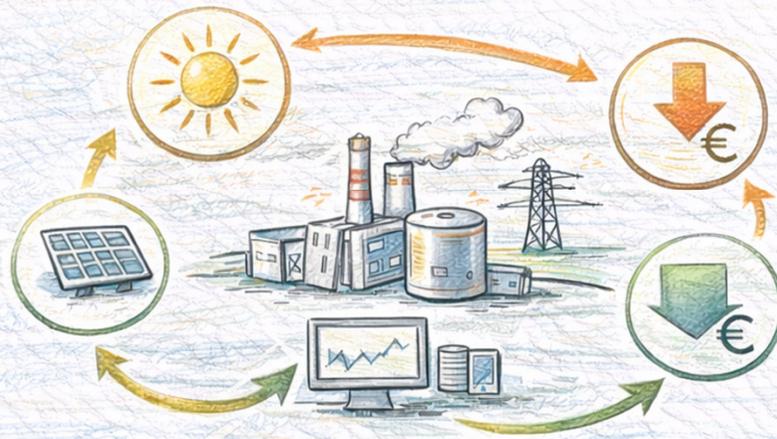
## Structural Transformation

From: To:

Passive Infrastructure	Predictive Optimization
Isolated Asset Operation	Coordinated Sector Operation
Reactive Control	Active, intelligent energy ecosystems

# DIGITAL COORDINATION

## Intelligent AI-supported Energy Management System (AI-EMS)

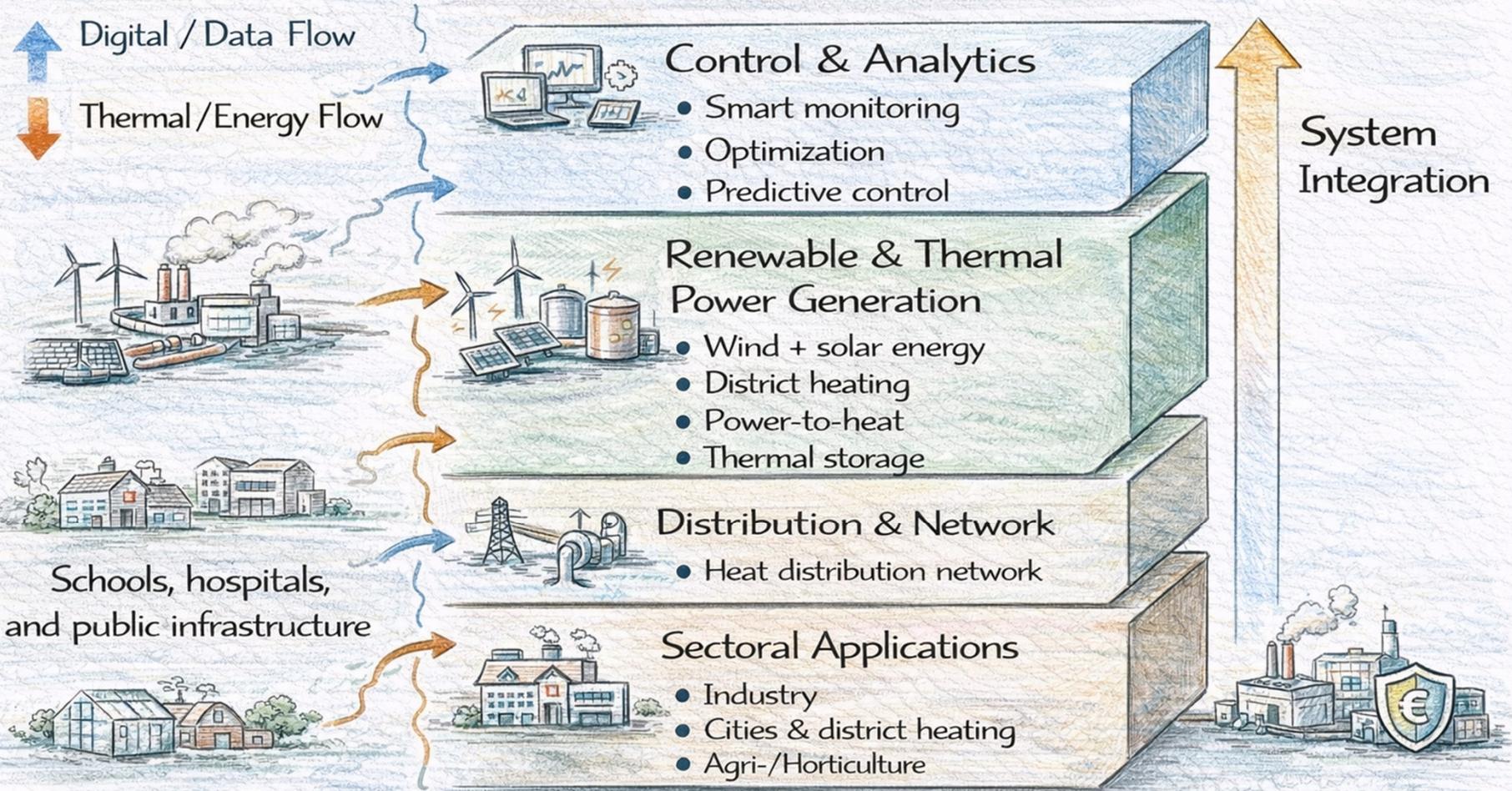


1. Use free solar energy whenever possible.
2. Avoid buying electricity when prices are high.
3. Buy electricity when prices are negative or especially low.
4. Sell excess solar energy when the battery is full.
5. Charge the battery strategically if future prices will be higher than current prices.
6. Always consider battery capacity before making any charging decision.

The system therefore constantly evaluates real-time market conditions, future price forecasts, current battery charge, and solar availability. Based on these inputs, it chooses the most cost-effective action at any moment.



# System Integration Architecture



# ECONOMIC ADVANTAGE

Strategic Value Creation Beyond Sustainability

Integrated heat and power systems create measurable economic value.

## Cost Optimization

- Reduced fossil fuel imports.
- Lower exposure to **volatile** spot gas markets.
- Productive use of negative-price or **reserve-market** electricity.
- Improved utilization of renewable assets.

## Structural Shift

- Heat becomes a controllable load —not a fixed, fuel-driven demand.



# RISK REDUCTION

Creating Resilience From Vulnerability to Stability

Integrated systems reduce structural exposure.

## Risk Mitigation Effect

- Reduced geopolitical **dependence** on fossil imports.
- Lower **exposure** to global gas market volatility.
- Stabilized energy budgets for industry and municipalities.
- Increased long-term **cost predictability**.

## Strategic Impact

- Energy security becomes an economic stabilizer — not a recurring crisis trigger.





# COMPETITIVENESS

Industrial and Infrastructure

## Energy as a Competitive Factor

- Integrated systems **strengthen** regional and industrial performance.
- Energy **stability** influences where industries locate.
- Flexible heat reduces **exposure** to global price shocks.
- Local energy systems anchor economic activity.
- **Predictable** energy strengthens public infrastructure.

# COMPETITIVENESS

Industrial and Infrastructure

## Key Use Cases

- District heating networks
- Industrial process heat
- Agriculture and food production
- Schools, hospitals, and public infrastructure

## It Matters Because These Sectors:

- Cannot relocate easily.
- Depend on stable and **affordable** energy.
- Require **predictable** thermal supply.

## Strategic Shift

Heat and power move  
from cost center →  
to **strategic**  
infrastructure asset.



# STRATEGIC CONCLUSION

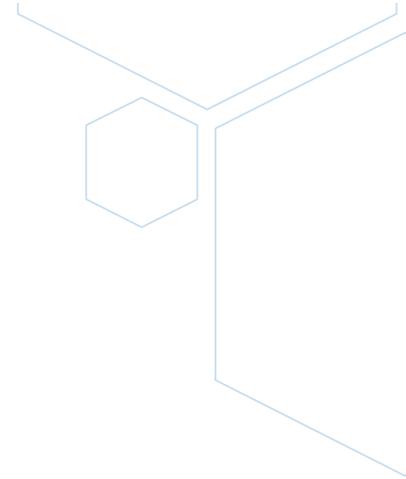
The Real Transformation Is Conceptual

## We stop thinking in:

- Power plants.
- Boilers.
- Separate networks.
- Isolated assets.

## We start thinking in:

- **Integrated** energy ecosystems.
- Flexibility as a **design** principle.
- **Time-shifting** across hours, weeks, and seasons.
- Digital **coordination** as system intelligence.



# Final Message

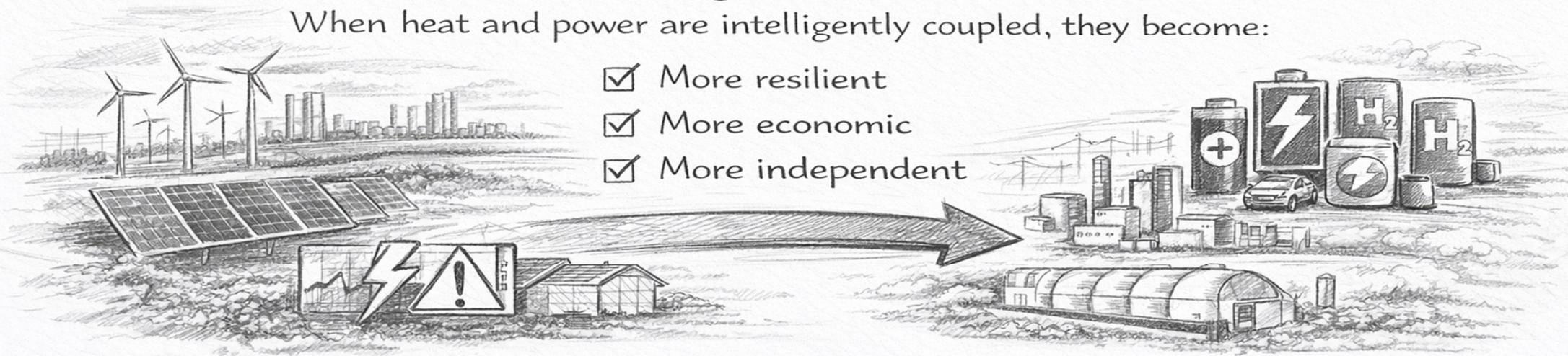
The energy transition is not only about replacing fossil fuels.

It is about redesigning systems so that **volatility** becomes **value** and **surplus** becomes **strength**.

## Strategic Outcome

When heat and power are intelligently coupled, they become:

- ✓ More resilient
- ✓ More economic
- ✓ More independent



They become a strategic advantage.

**Thank you for your time!**

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