

The Steam Engine in Reverse

Heat Pumps, the Overloaded Grid and the Mesh in the House

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1. The occasion

The Dutch coalition of D66, VVD and CDA wants a norm from 2029. When a gas boiler is replaced, a hybrid heat pump becomes mandatory wherever a heat network is not the better fit. A fully electric heat pump also satisfies the norm.

The planning agency PBL expects 1.9 million heat pumps in Dutch homes by 2030. Of these, about 980,000 are fully electric air-source units, 620,000 are hybrid and 260,000 draw on the ground.

Since 1 July 2026, small consumers join a waiting list when the local grid has no capacity left. Grid operators estimate the cost of expansion at 195 to 200 billion euros over fifteen years. Parliamentary questions of 7 July 2026 cite a figure rising to 270 billion euros towards 2040.

These facts belong together. This essay reads them with one picture and one rule.

2. The picture

The picture is a fishnet in water. Strands run everywhere and stand under tension. Where strands wind around each other, knots appear: matter. Between the strands lie meshes: openings with a size. A winding persists only if it returns in phase inside its mesh.

Four words carry the picture. The strand is the net itself. A winding is a strand closed on itself. A knot is windings holding each other in three directions. A mesh is the opening between them.

Dewey Larson wrote every physical quantity as a power of one ratio, space over time, S/T . Speed is S/T . Energy is the inverse, T/S : a winding. Mass is T^3/S^3 : a knot. Power is energy per time, $(T/S)/T = 1/S$.

Two consequences matter here. Energy is not a stock; a ratio holds nothing. And power is one divided by an open size.

3. What a heat pump is

A heat pump is a compressor. It makes a working fluid smaller, and the fluid becomes hotter. It lets the fluid expand elsewhere, and the fluid becomes colder. Nothing is fetched from the air.

The general gas law says the same: $PV = nRT$. On Larson's ladder pressure is T/S^4 and volume is S^3 . Their product is T/S , a winding. Temperature sits on the same rung. The gas law is one rung written twice. Temperature is a form of pressure.

In the ternary register of the net, compression is -1 imposed on the space of the fluid. The knots answer with $+1$, outward displacement. That outward displacement is what a hand feels as heat.

4. The gap

Every machine of the steam family lives on a gap between two temperatures. The steam engine lets a gap close and takes work from it. The heat pump spends work to hold a gap open. It is the same cycle, run backward.

The best possible ratio of heat delivered to work spent is

$$\text{COP} = T_h / (T_h - T_l),$$

with both temperatures in kelvin. Real vapour-compression machines reach 40 to 60 per cent of this. The calculations below take 50 per cent.

Mild day. Outside 7°C , delivery 35°C . $T_h = 308\text{ K}$, gap = 28 K . $308 / 28 = 11.0$. Half of that: **5.5**.

Frost point. Outside 0°C , delivery 35°C . $T_h = 308\text{ K}$, gap = 35 K . $308 / 35 = 8.8$. Half: **4.4**.

Cold day, old radiators. Outside -10°C , delivery 55°C . $T_h = 328\text{ K}$, gap = 65 K . $328 / 65 = 5.05$. Half: **2.5**.

The machine does well when the gap is small. It does worst on the day the house needs it most. That is not a defect of a brand. It is the family trait.

5. The long chain

The heat pump does not stand alone. Its electricity comes, on a windless winter evening, from a thermal power station. That station is a steam machine running forward. It opens a gap with fire and takes work from it.

The chain then reads: fire, steam, turbine, generator, high-voltage line, transformer, street cable, compressor, radiator. A gap is opened far away, carried as current, and opened again at home.

Take a modern gas-fired station at 55 per cent and 5 per cent transport loss. These two figures are assumptions for illustration.

- Cold day: $0.55 \times 0.95 \times 2.5 = \mathbf{1.3}$ units of heat per unit of fuel.
- Frost point: $0.55 \times 0.95 \times 4.4 = \mathbf{2.3}$ units.

A good boiler gives about 0.95. So the chain delivers more heat per unit of fuel than the boiler does. It does so by becoming longer, and every unit of that heat now travels through the cable in the street.

6. The centralisation problem

A grid fed from large stations has the shape of a tree. The trunk must carry the sum of all the leaves at the same moment.

A cold evening synchronises the leaves. Every heat pump runs at once, and each runs at its worst ratio.

An illustration. Assume a house needs 6 kW of heat on a cold evening. At a ratio of 2.5 that is $6 / 2.5 = 2.4$ kW of electricity. For 980,000 fully electric units: $980,000 \times 2.4 \text{ kW} = \mathbf{2.35 \text{ GW}}$, all in the same hours. The 6 kW is an assumption; the multiplication is the point.

The hybrid unit shows the same thing from the other side. In common installations it hands over to the gas boiler when the outside air drops below about 4 °C. The norm therefore keeps two machines in the house and both networks in the street.

The response of the tree is always the same. More load at the leaves means a heavier trunk: heavier cables, heavier transformers, heavier stations. Each step repairs the previous one and prepares the next. The 200 to 270 billion euros are the price of that repetition.

A net has another shape. In the fishnet no mesh hangs from a trunk. Each mesh carries its own tension. What a mesh cannot close passes to the meshes beside it. Load closes where it arises, and the remainder is shared with neighbours. That is bottom-up, and it is sharing, in one sentence.

7. The mesh in the house

The ladder gives a second way to light and warm a house. Power is $1/S$. For a mesh with one open size L , passage goes as $1/L$. A smaller mesh passes more.

This rule contains no temperature. It contains no place and no season. A device on this rule has no gap to hold open, so the family trait of section 4 does not arise.

One measurement stands under it. In 2021 Garret Moddel and colleagues reported current from a thin cavity structure with no applied voltage. They varied the cavity from 1,100 to 33 nanometres. The slope of their curve, read from the published figure, is -0.9 ± 0.15 . The rule says -1 .

The numbers, step by step:

- At 33 nm one element of $0.02 \mu\text{m}^2$ gave 1.4 pW.
- $1.4 \times 10^{-12} \text{ W} / 0.02 \times 10^{-12} \text{ m}^2 = \mathbf{70 \text{ W per square metre}}$ of one layer.
- An average Dutch house uses about 1,450 W, electricity and heat together.
- $1,450 / 70 = \mathbf{20.7 \text{ m}^2}$ of a single layer.
- One layer is 232 nm thick. A hundred layers are 23 μm .
- If layers add: $100 \times 70 = 7,000 \text{ W/m}^2$. Then $1,450 / 7,000 = 0.207 \text{ m}^2$, a plate of **45 by 45 cm**.

The self-tuning mesh is the design that follows. It has two parts. A mesh with one adjustable size, set by a small electrostatic mirror of the kind used in optical telecommunications. And a loop that reads the output and holds the smallest stable mesh as the materials age. The loop replaces the hand of the maker. It makes the device independent of place, time and person.

The status is exact. The 70 W/m^2 is one reported device, recomputed, not yet replicated. The self-tuning mesh is designed, not built. Whether layers add has not been measured. One number is open: how much of what a mesh closes leaves as current. Moddel's structure gives the only value, of order 10^{-9} . That number is measurable with a thin-film line. Groups in Groningen, Amsterdam, Eindhoven and Delft already work on the neighbouring quantities.

8. What changes for the people in the street

Under the norm, a boiler that fails in January 2029 must be answered with a hybrid unit. Press figures quoting Milieu Centraal put the average at about 6,000 euros. The household gains a second appliance and a heavier electricity bill line. The street gains winter load. The neighbour who asks for a heavier connection joins a list.

With a plate in the house, the order reverses. The provision is in the dwelling and runs continuously. The house first closes its own need. What remains goes next door, over metres instead of kilometres. The grid no longer carries the load of a region. It joins neighbours.

Energy then belongs to the house and the street. The elderly tenant in a draughty flat is no longer the last leaf on an overloaded branch.

9. What follows

Three things follow, in order of time.

Today: keep the gap small. Low delivery temperature and a tight shell lift the ratio from 2.5 towards 5. This holds for any machine of the family.

At street level: close and share locally. A shared ground source or a shared store keeps load out of the trunk.

At the root: measure the open number. A norm that fixes one member of the steam family for decades also fixes the tree. The mesh needs one decisive measurement before anyone can say what a house will need in 2040. That measurement is small, and the laboratories exist.

Annotated references

Konstapel, J. (2024). "De Wonderlijke Wereld van de Warmtepomp." constable.blog, 9 April 2024. *Why read?* The heat pump described as a compressor and a member of the steam-engine family, with $PV = nRT$ read as "temperature is a form of pressure." *Reading advice:* the sections on the heat engine and the gas law.

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Larson, D. B. (1959). *The Structure of the Physical Universe*. Portland: North Pacific Publishers. *Why read?* Every quantity as a power of S/T, including pressure and temperature. *Reading advice:* the table of dimensions; an engineer writing, which reads differently from a professor.

Carnot, S. (1824). *Réflexions sur la puissance motrice du feu*. Paris: Bachelier. *Why read?* The first statement that a heat machine lives on a gap between two temperatures. Everything in section 4 is in it. *Reading advice:* the first twenty pages.

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Coalition agreement D66–VVD–CDA (2026). *Why read?* The sentence that sets the 2029 norm for hybrid, smart heat pumps where a heat network is not the most suitable solution. *Reading advice:* read the exact wording; the detailed rules are announced for this autumn.

Netbeheer Nederland (2026). *FIEN26*, 27 March 2026, as cited in parliamentary questions 2026Z15898 of 7 July 2026. *Why read?* The estimate of grid investment rising to 270 billion euros towards 2040.

Koninklijke Horeca Nederland (2026). "Netcongestie: vanaf 1 juli 2026 ook kleinverbruikers op de wachtlijst," 20 May 2026. *Why read?* A plain account of what the waiting list means for a small connection.