Integrating waste-to-energy with low-temperature geothermal systems in Iceland



Low-temperature geothermal field at Hveragerðisbær, Iceland — Solberg (2024)

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WHY THIS RESEARCH MATTERS

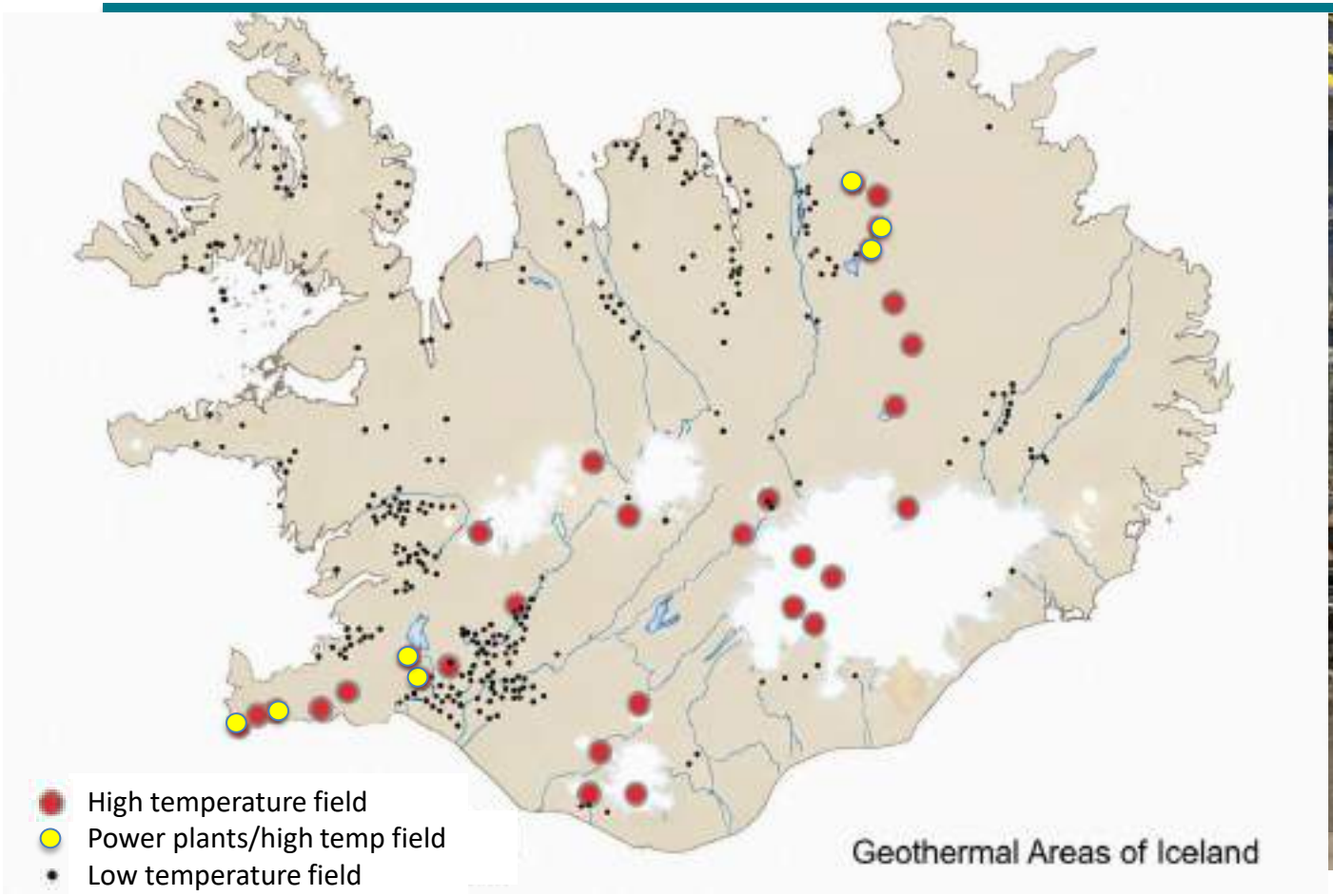
Iceland is facing growing electricity supply shortfalls while:

- **Waste-management challenges are increasing**
- **Low-temperature geothermal resources remain underutilized for power generation**



Transmission lines, Iceland.Photo by Carlos Zinato on Unsplash

Two local renewable resources, one energy opportunity





LOW-TEMPERATURE GEOTHERMAL (80–150 °C at 1 km)

Primarily used for direct heat applications

(i.e.- district heating, pools, spas, greenhouses)

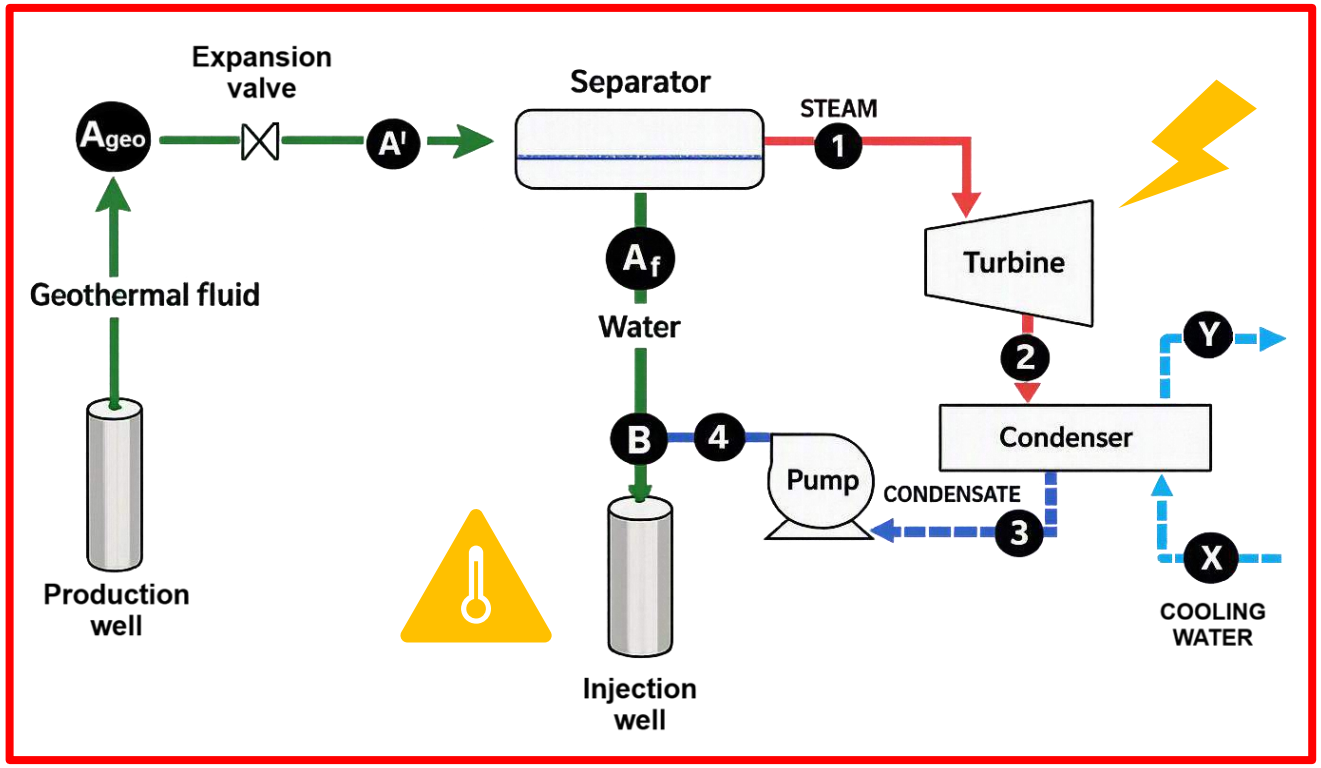
Map: Jóhannesson & ÍSOR (2014), modified by author.

RESIDUAL WASTE –
currently exported to EU for incineration

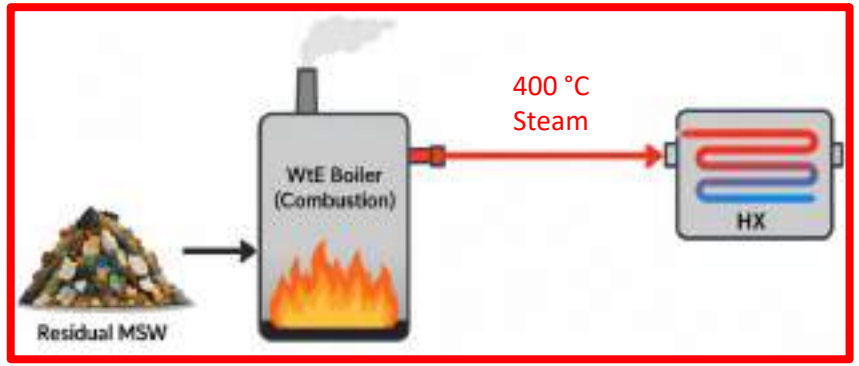
Potential domestic source of recoverable heat

Photo: SORPA facility, Solberg (2024).

Combining two systems with local renewable resources



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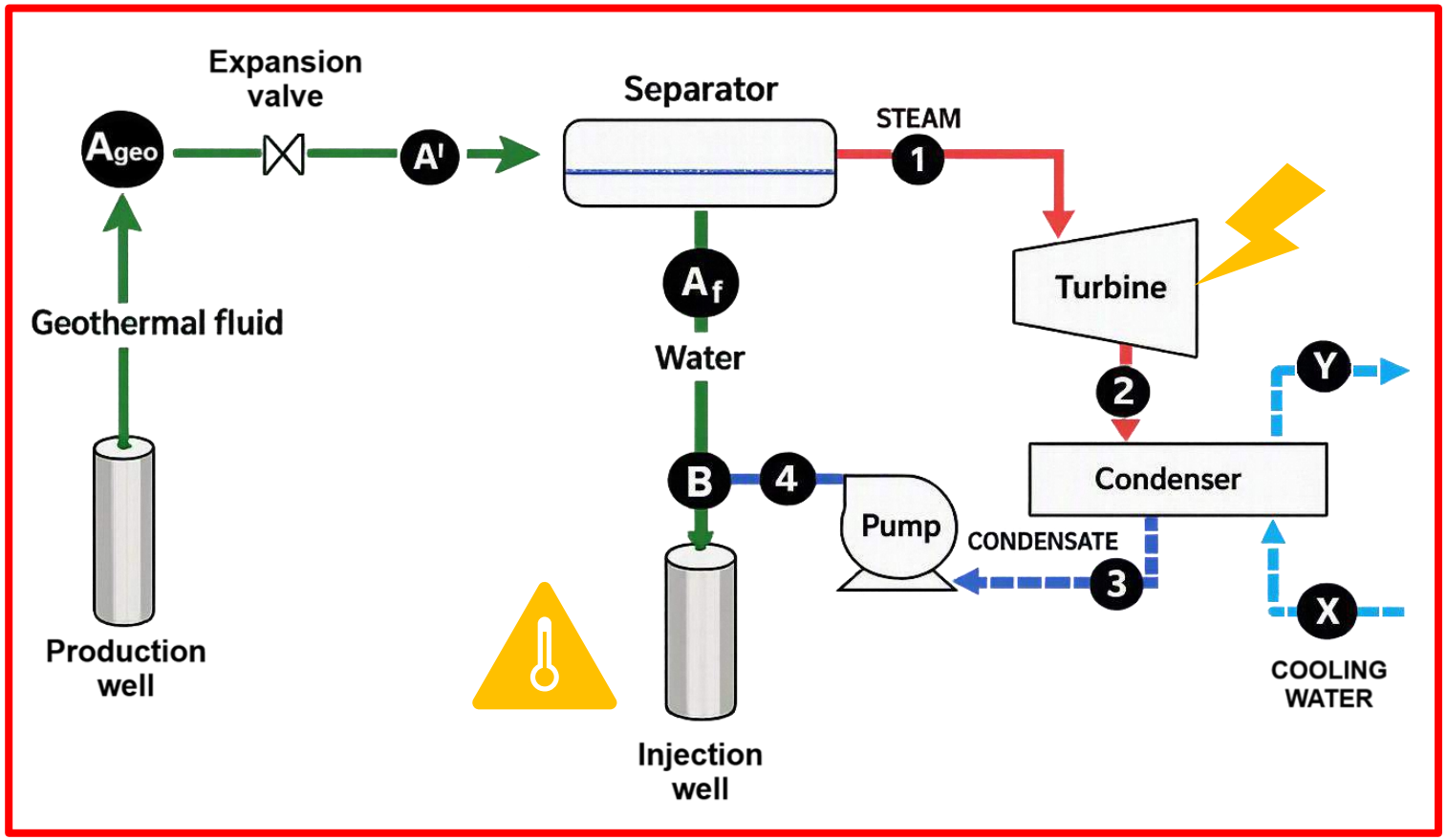


Purchased WtE heat (€15/MWth) provided via a heat exchanger with no fluid mixing.

Geothermal Single Flash Steam

Waste-to-Energy (WtE)

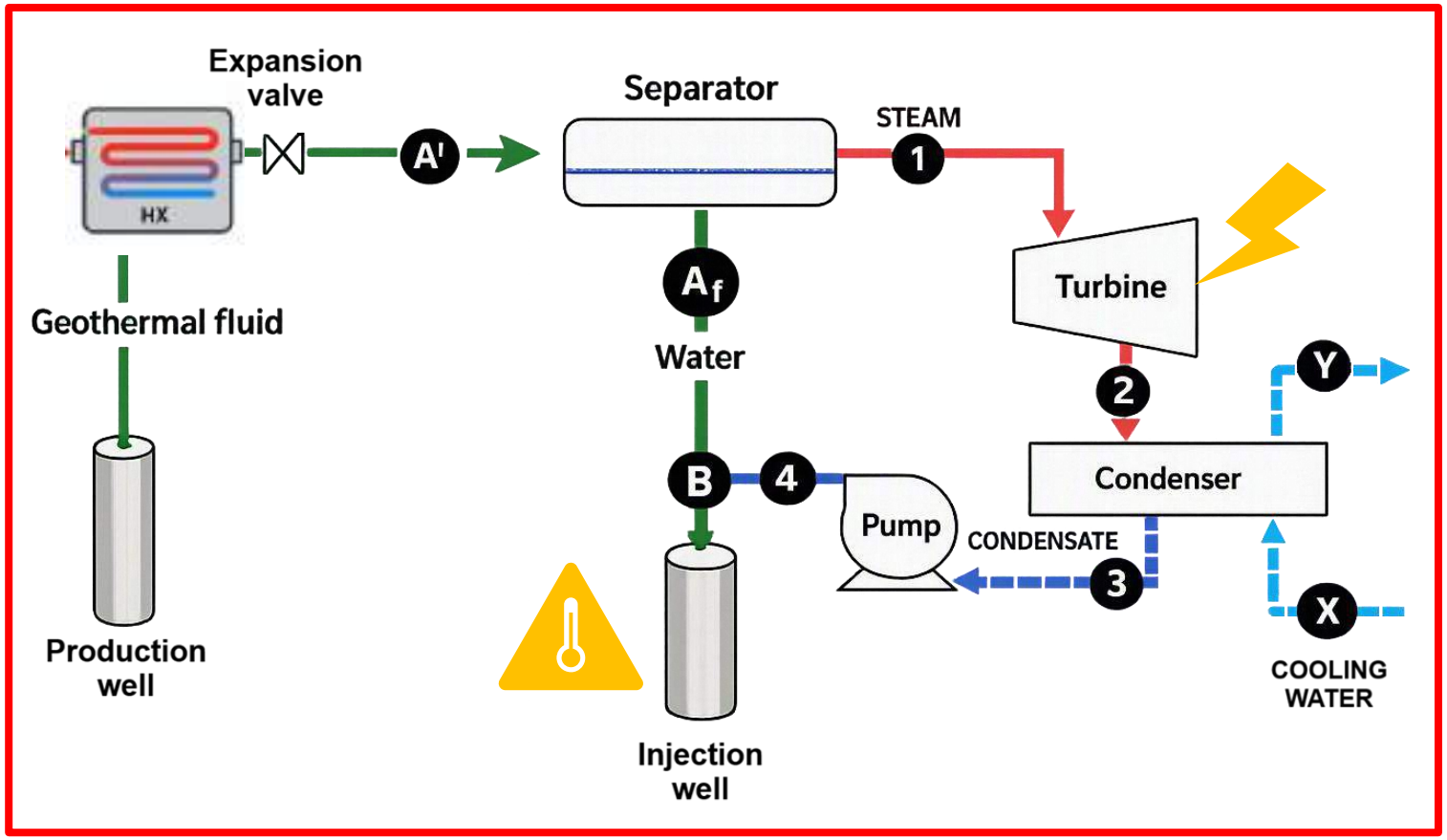
Base case - No waste heat



Geothermal Single Flash Steam

Scenario 1

Waste heat added to geothermal fluid

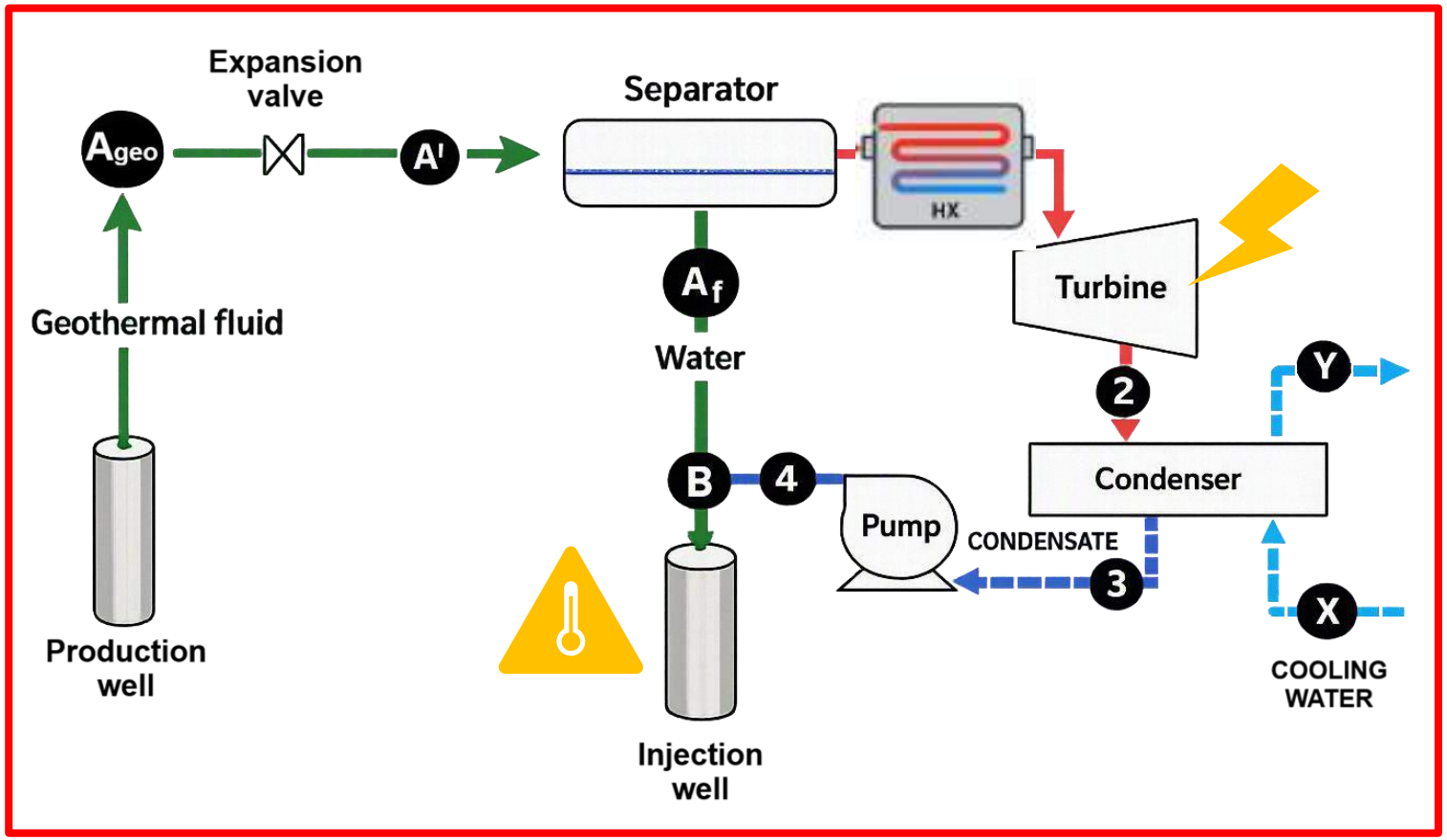


Scenario 2

Geothermal Single Flash Steam

WtE and geothermal streams do not mix.

Waste heat added to steam at turbine inlet



Scenario 3

Geothermal Single Flash Steam

WtE and geothermal streams do not mix.

Three Steady State Scenarios

Scenario 1 **Baseline Single Flash Steam**	Geothermal water → Flash → Steam → Turbine
Scenario 2 **Heat geofluid before flashing**	WtE heat raises geofluid enthalpy,
Scenario 3 **Heat the separated steam**	WtE heat superheats the available steam after flashing,

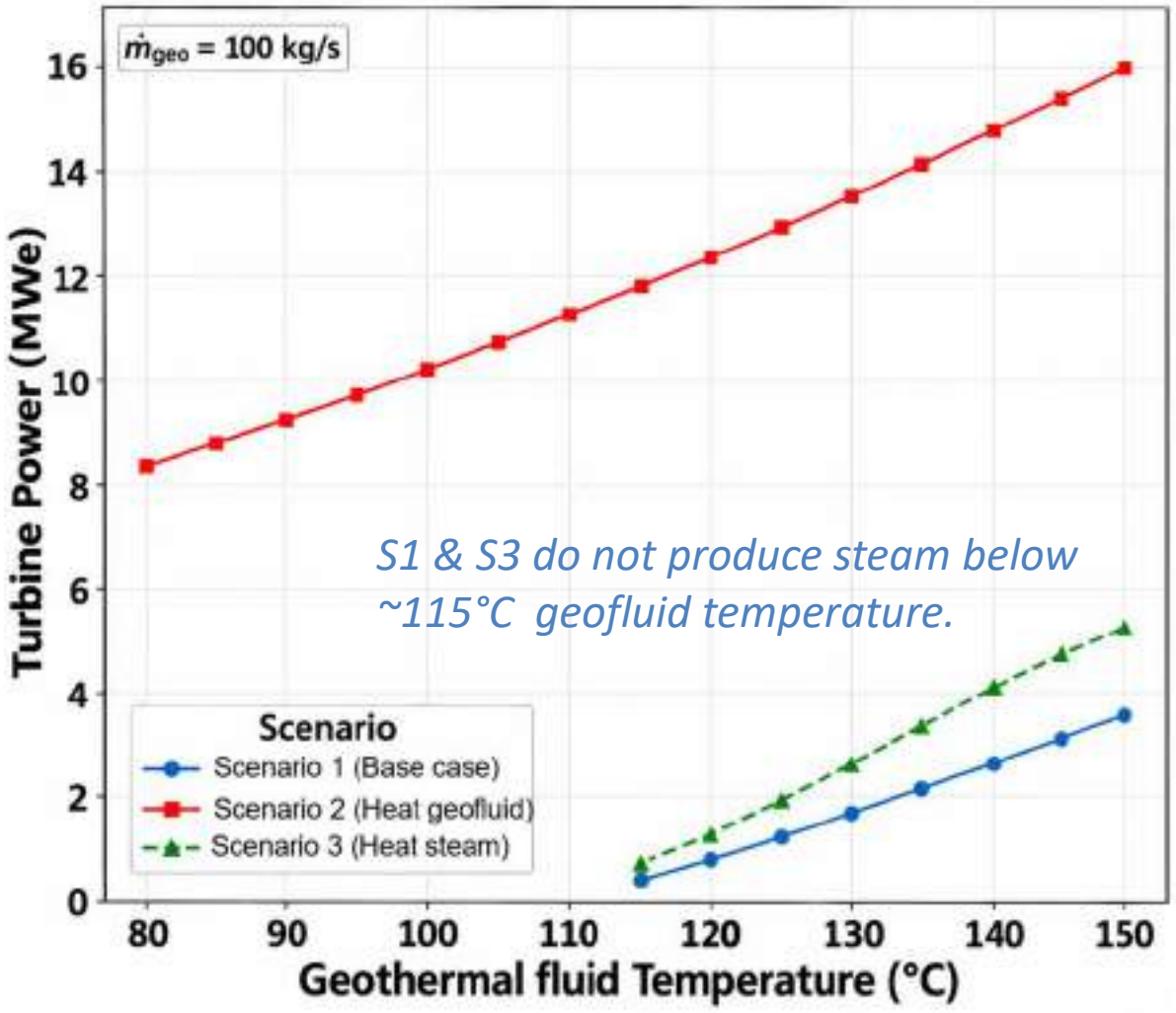
Consistent model boundaries across idealized scenarios

Geothermal inlet conditions	80–150 °C; 100 kg/s; water at 60 bar_a (single phase liquid)
External WtE heat	Maximum available 52 MWth; 400 °C steam
Flash pressure	1,5–15 bar_a; Selected for maximum turbine power
Evaluation metrics	First and second laws; subcritical conditions, turbine power/electricity: LCOE; District heating (DH) potential

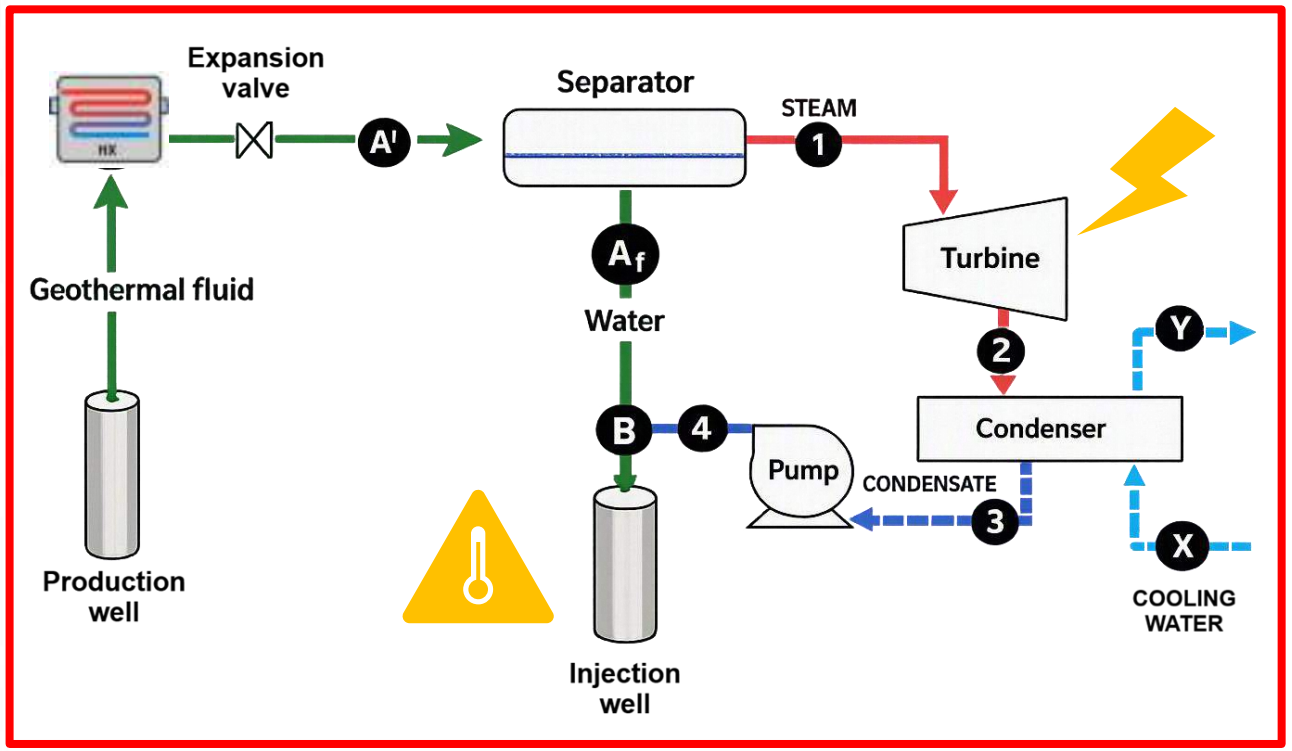
Source: Solberg (2026), MSc thesis

Python model verified with hand calculations.

Heating geothermal fluid before flashing produces maximum power



Scenario 2

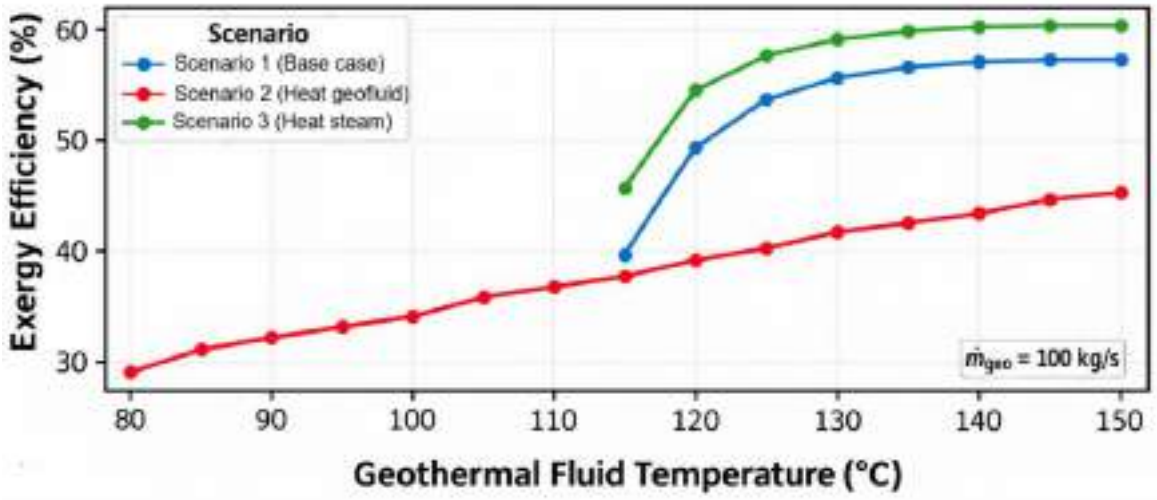


Scenario 2 increases steam **quantity** through the turbine.

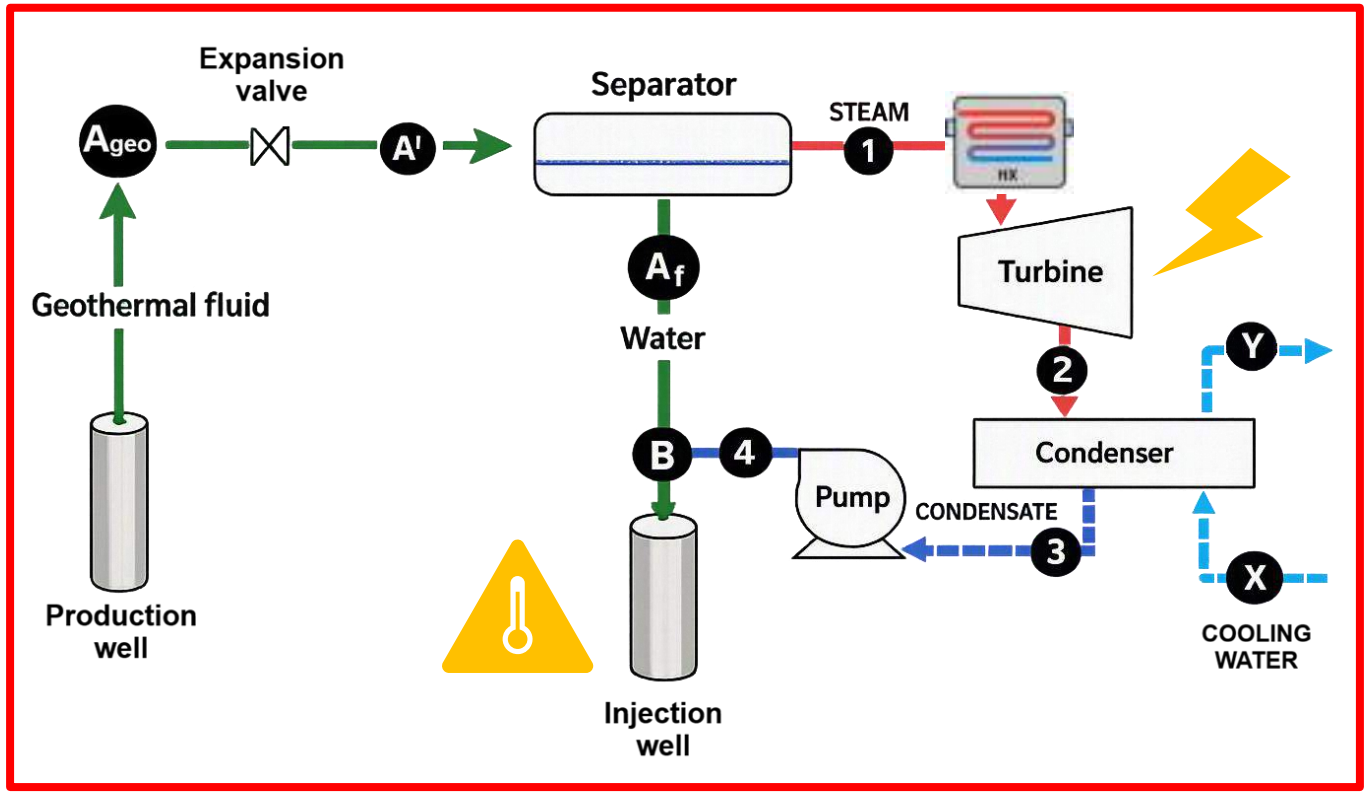
Source: Solberg (2026), MSc thesis

The exergy results tell a different story

Highest power ≠ highest exergy efficiency



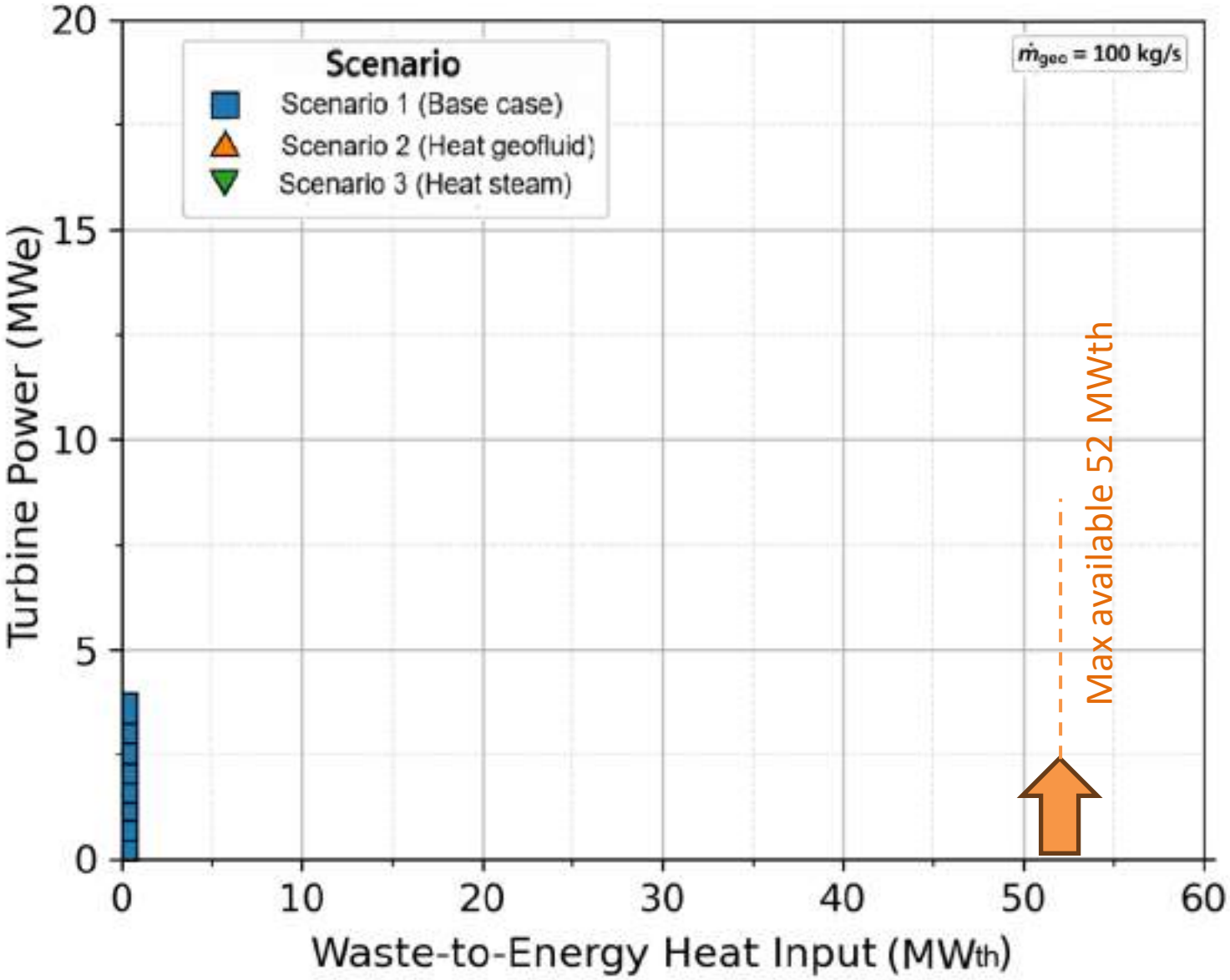
Scenario 3



Scenario 3 increases the **work potential** of the steam entering the turbine.

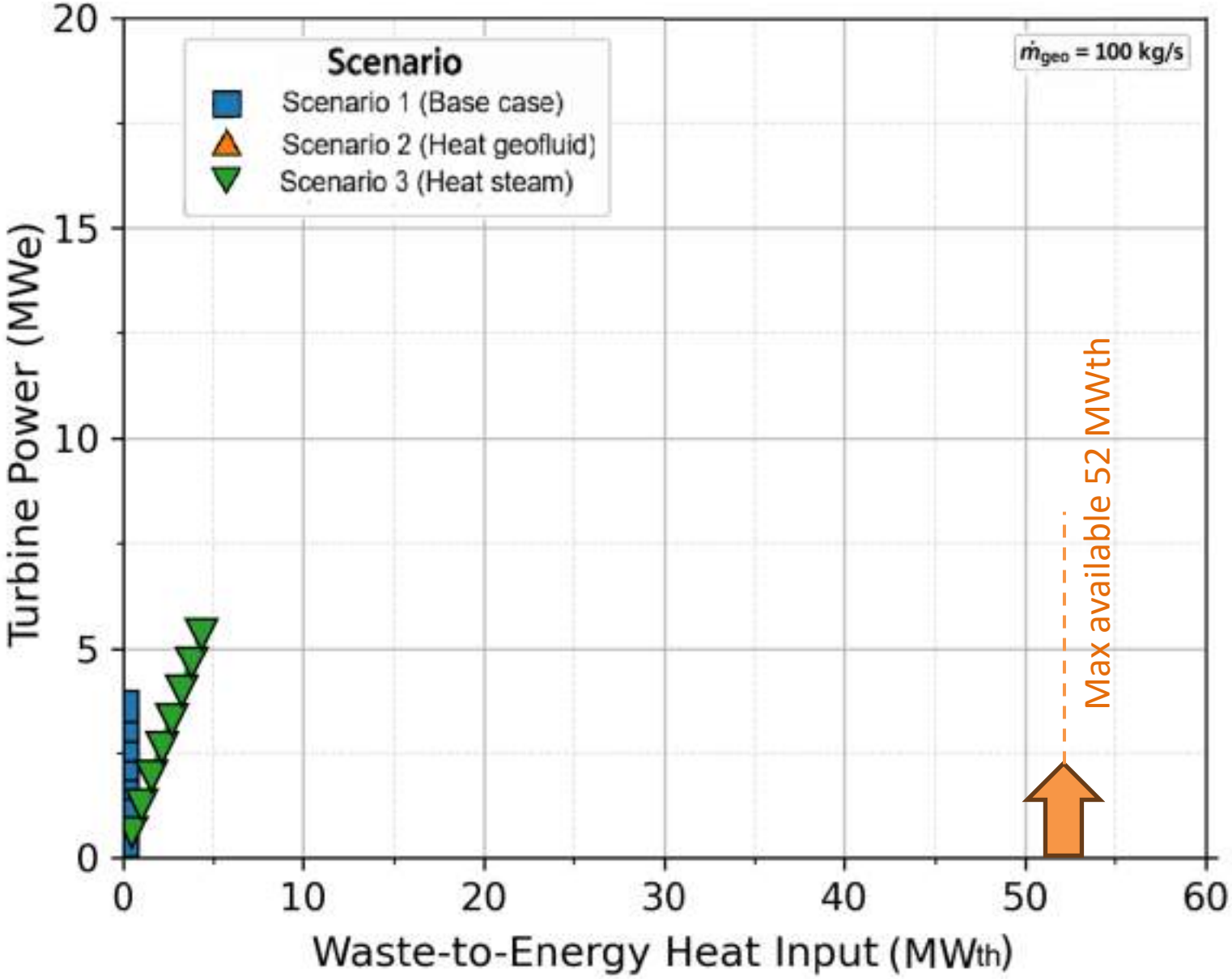
Source: Solberg (2026), MSc thesis

WtE heat usage varies by Scenario



Scenario 1 uses **NO** WtE heat

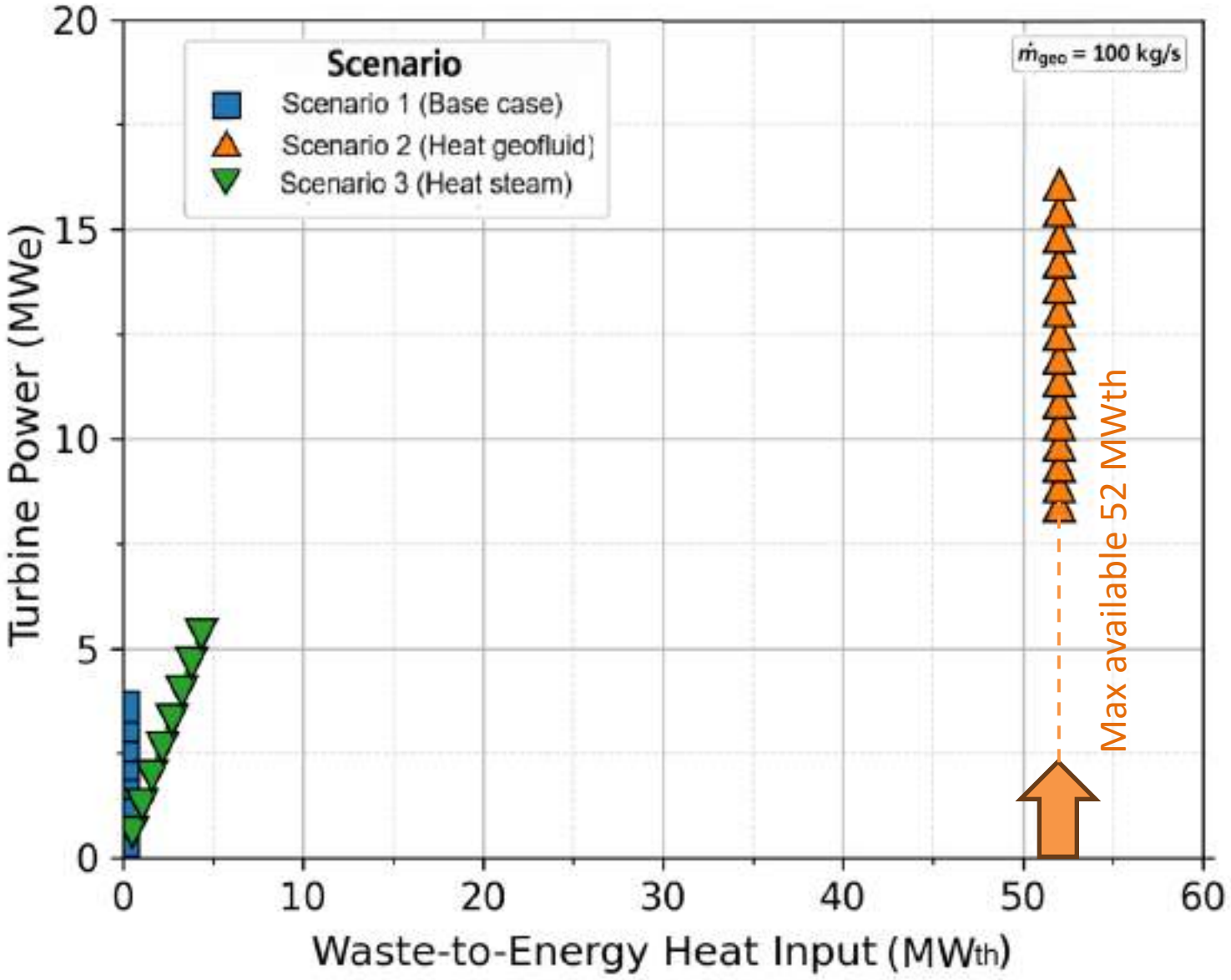
WtE heat usage varies by Scenario



Scenario 1 uses **NO** WtE heat

Scenario 3 uses a **FRACTION** of the WtE heat
(the steam is a fraction of the total geofluid mass flow)

WtE heat usage varies by Scenario

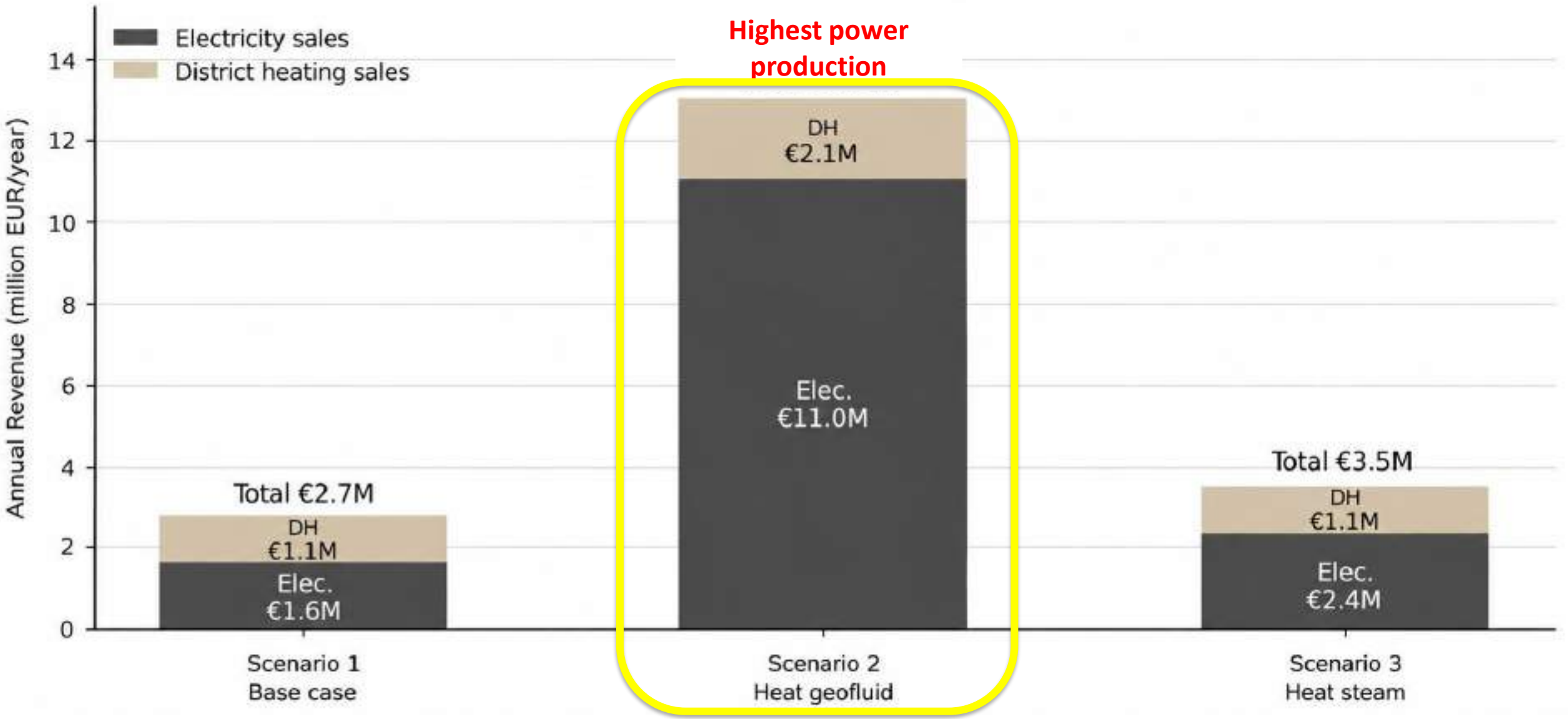


Scenario 1 uses **NO** WtE heat

Scenario 2 uses the **MAXIMUM** WtE available (heat is added to the full geofluid mass flow)

Scenario 3 uses a **FRACTION** of the WtE heat
(the steam is a fraction of the total geofluid mass flow)

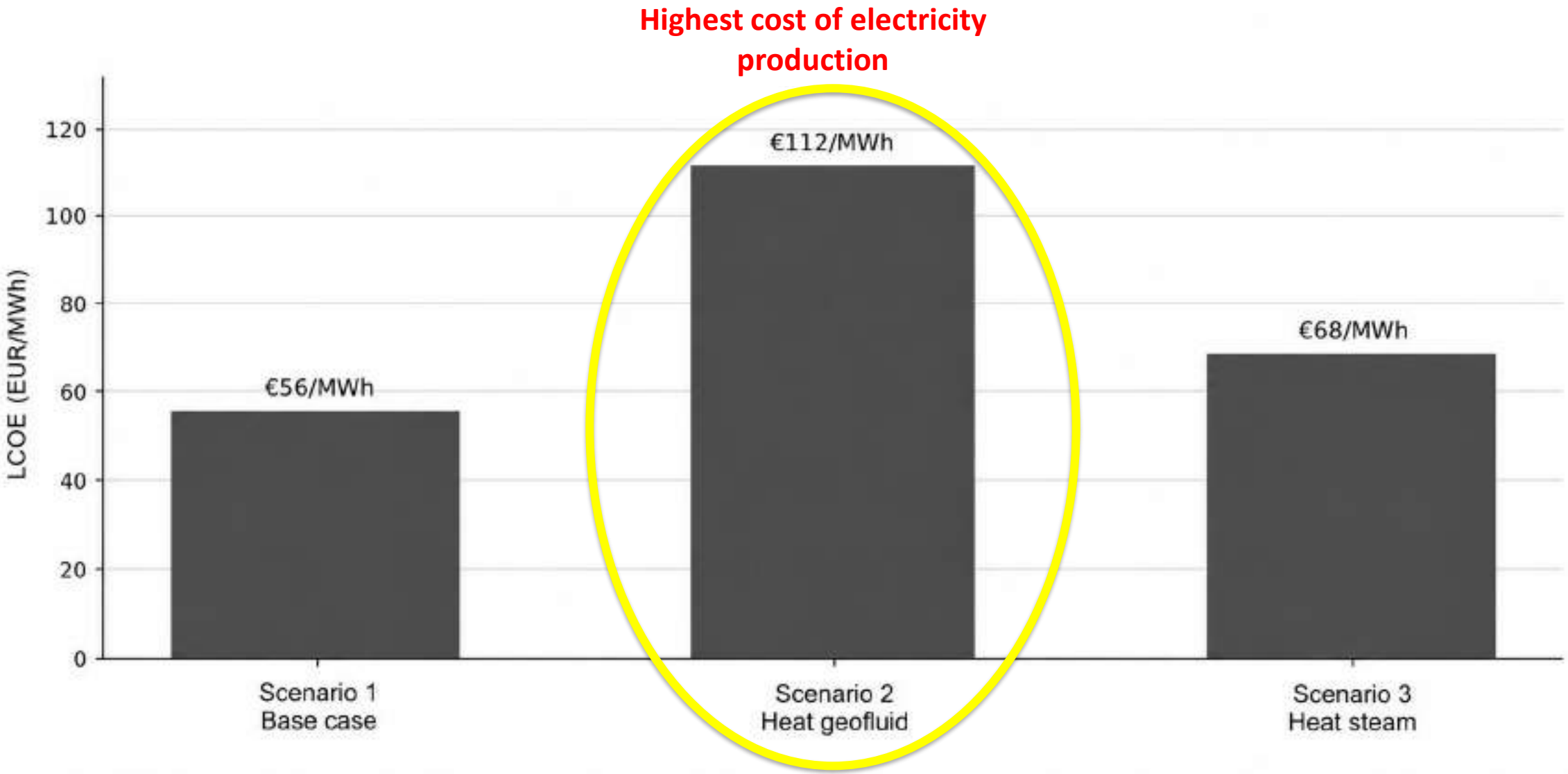
↑ Power Output = ↑ Revenue



Electricity sale price assumed at €100/MWh$_e$; district-heating sale price assumed at €15/MWh$_{th}$.

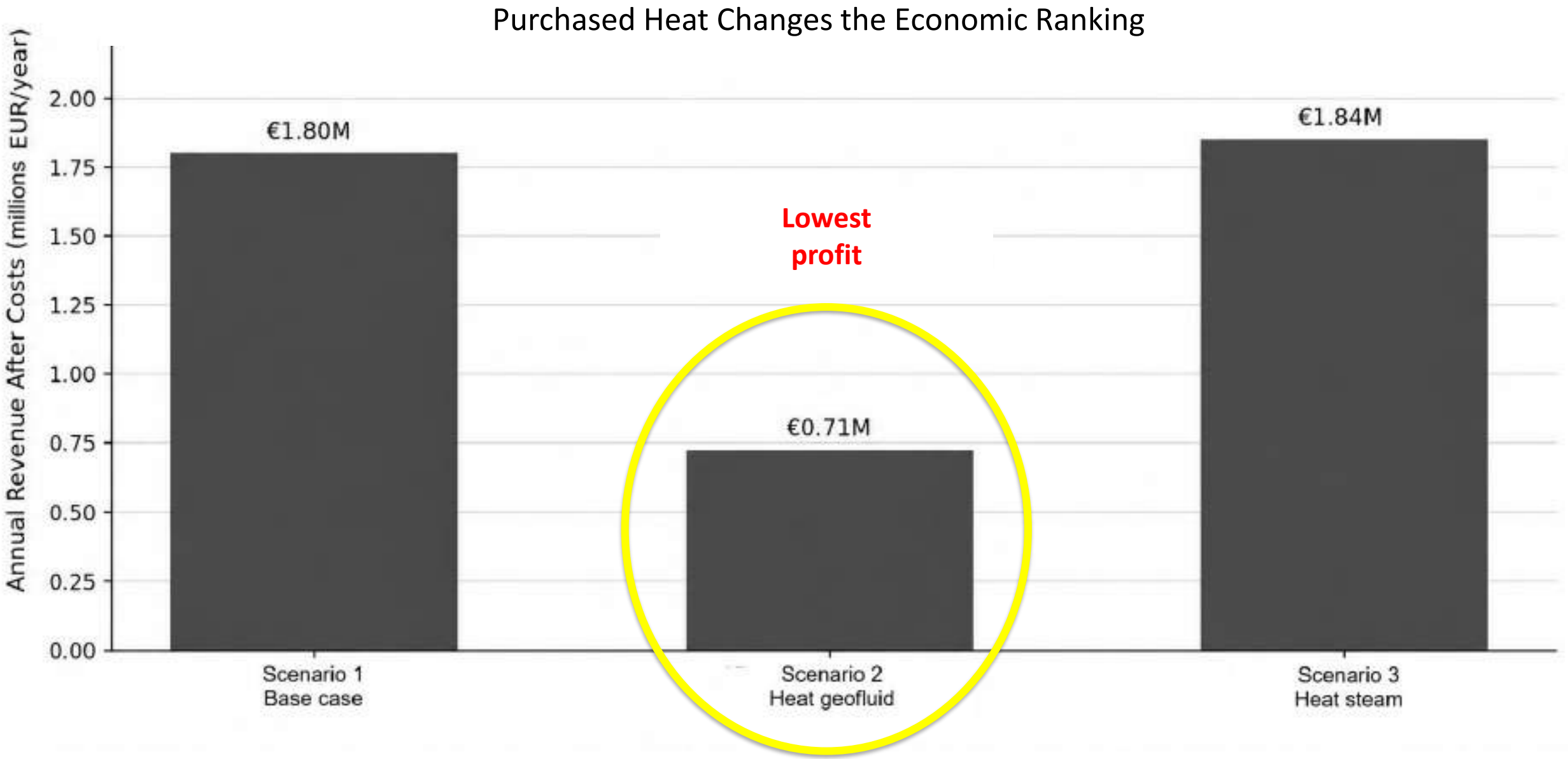
Levelized Cost of Electricity (LCOE) by Scenario

Generating more electricity isn't the same as lowering the cost of producing it.



Externally supplied WtE heat purchase price assumed at €15/MWh_{th}.

Net Revenue by Scenario



Electricity sales price assumed at €100/MWh_e; district-heating sales price assumed at €15/MWh_{th}.

Key takeaways for hybrid low-temperature geothermal / WtE design

1. Flash cycles can be steam-limited.
2. Heat placement shifts steam quantity vs. steam work potential
3. Best system design depends on preference for steam quantity or steam work potential
4. WtE heat price impacts the business model, and including district heating sales can offset some of the cost.

Hveragerði geothermal area, *Iceland – Solberg (2025)*.



Flúðir geothermal area, *Iceland – Solberg (2025)*.

Future Research

- Model real-world equipment + operating constraints
- Test split-heat strategies
- Assess ORC integration for low-T hybrid systems
- Evaluate alternative uses for recoverable heat in addition to district heating
- Refine the economic model
- Evaluate resources beyond Iceland



Thank you - Questions

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Hveragerði at sunrise. Photograph: Gerjan Wolterink. Source: Flickr (Creative Commons License).