# The role of low-temperature geothermal resources in sustainable space-heating in Iceland

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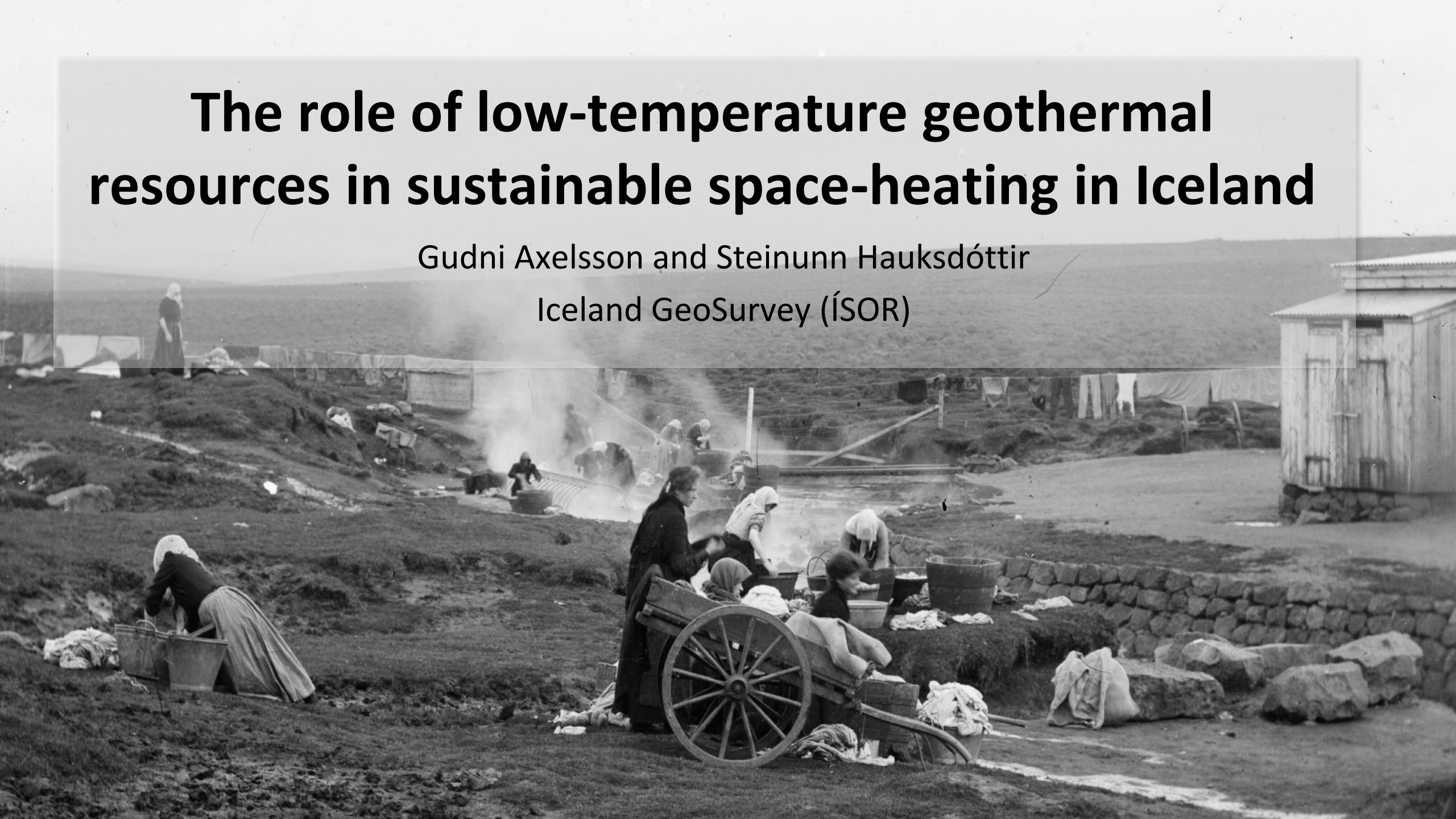

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# Geothermal resources worldwide

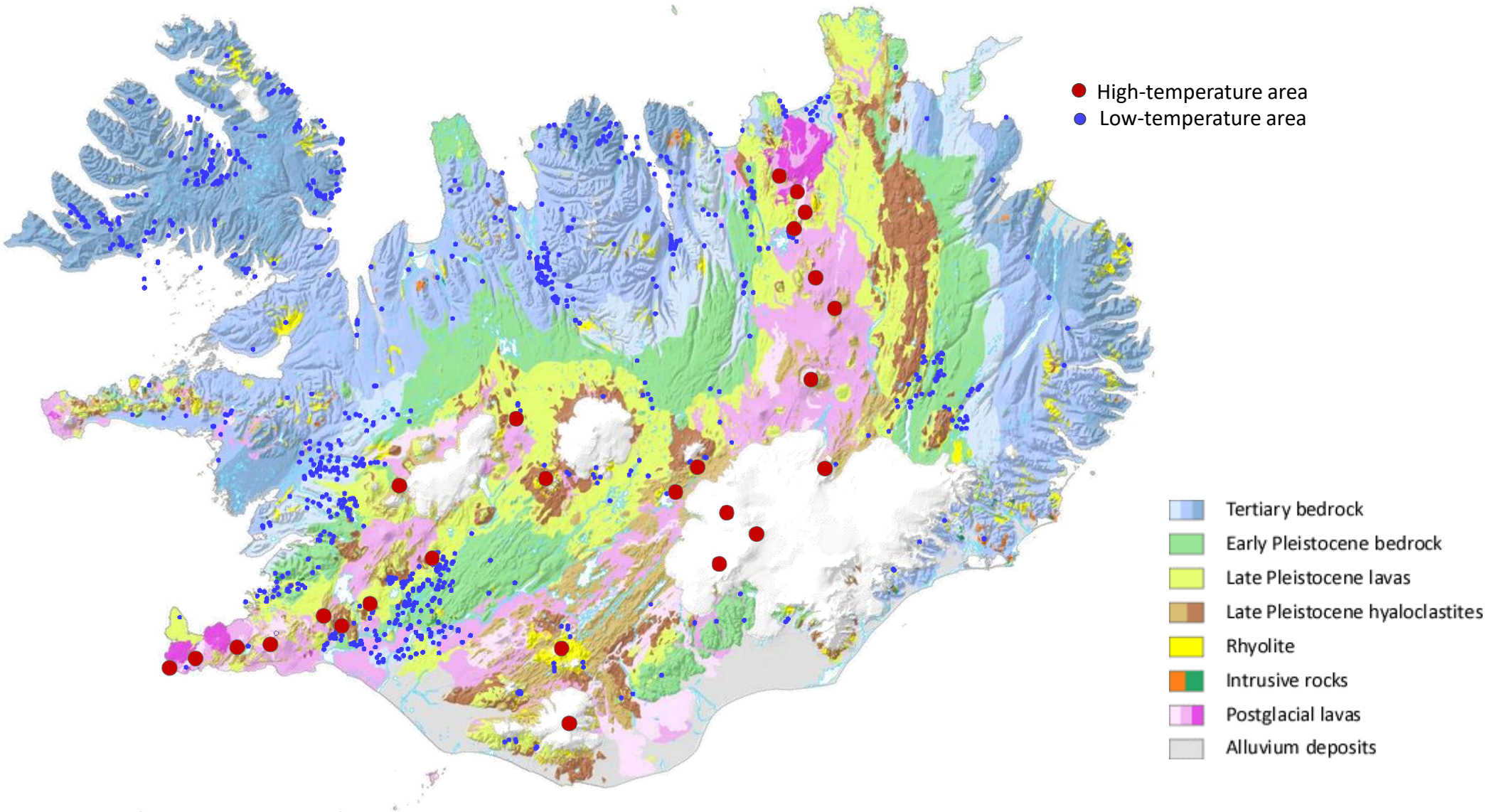
Geothermal resources can be found in most countries – Their theoretical potential is enormous

- **Volcanic systems** with hot intrusions or magma
- **Convective fracture controlled systems** with hot crust at depth in tectonically active areas
- **Sedimentary systems** with permeability at great depth – Including geo-pressured systems
- **Enhanced geothermal systems** (EGS, previously Hot Dry Rock)
- Near-surface resources used through **ground-source heat-pumps**

# Low-temperature geothermal systems in Iceland

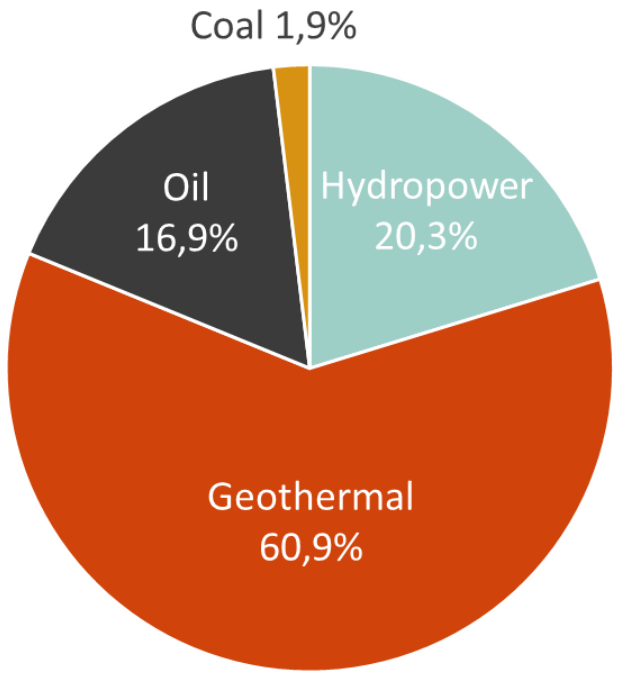
- Outside volcanic zone
- Reservoir temperature less than 150°C, liquid dominated
- Are of the “fracture controlled convective” type
- The heat-source is the abnormally hot crust with faults and fractures, which are kept open by tectonic activity, providing channels for water circulation and heat extraction
- Surface manifestations usually hot or boiling springs – no manifestations in some cases
- **Several systems utilized for more than 50 years – invaluable experience and data**

# Geothermal map of Iceland

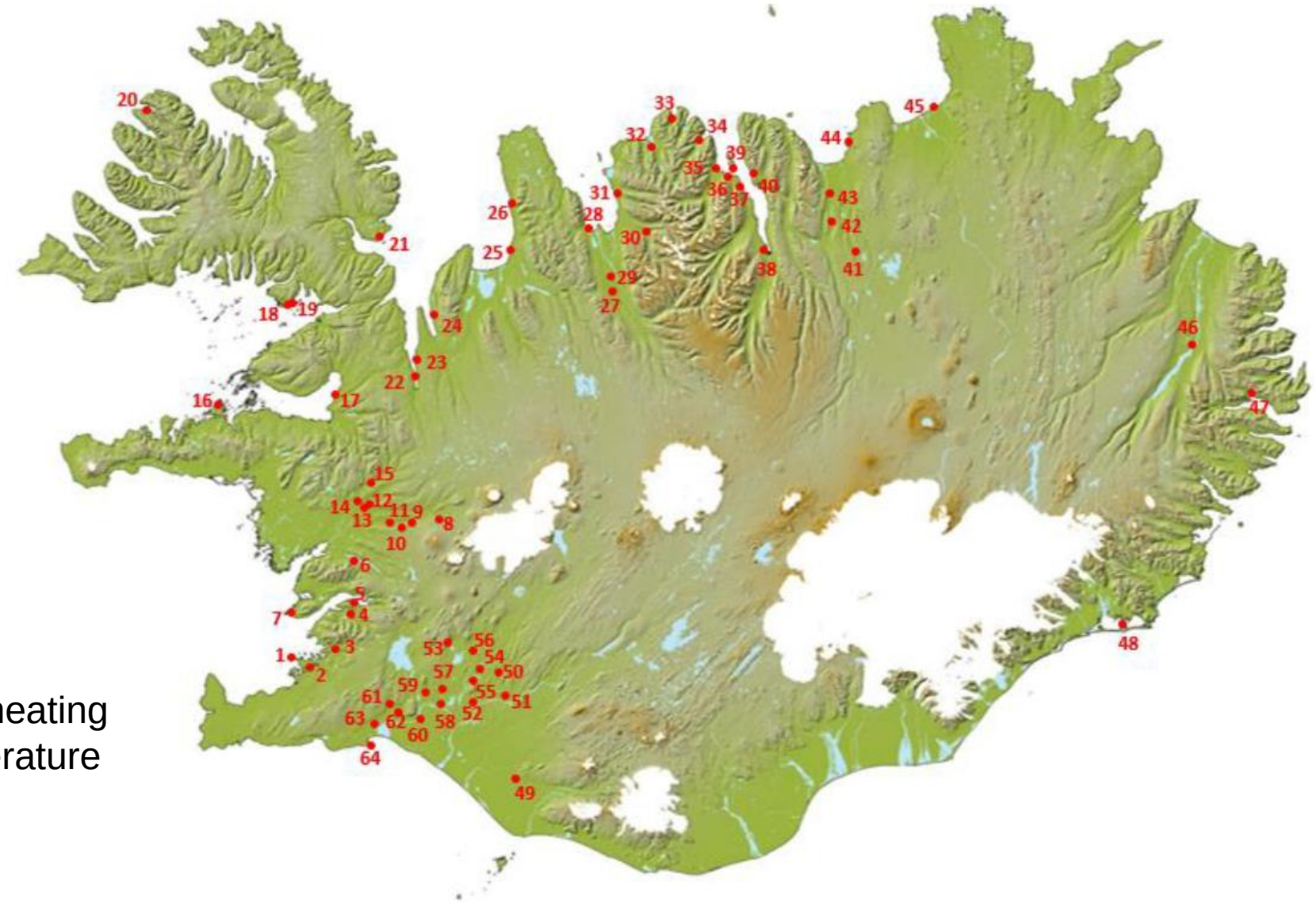


# Geothermal utilization in Iceland

- Geothermal energy plays a major role in the energy economy providing over 60% of the **primary energy consumption**
- Principal use for **space heating** with about 90% by geothermal energy through direct use of the heat
- Also other direct uses and electricity generation

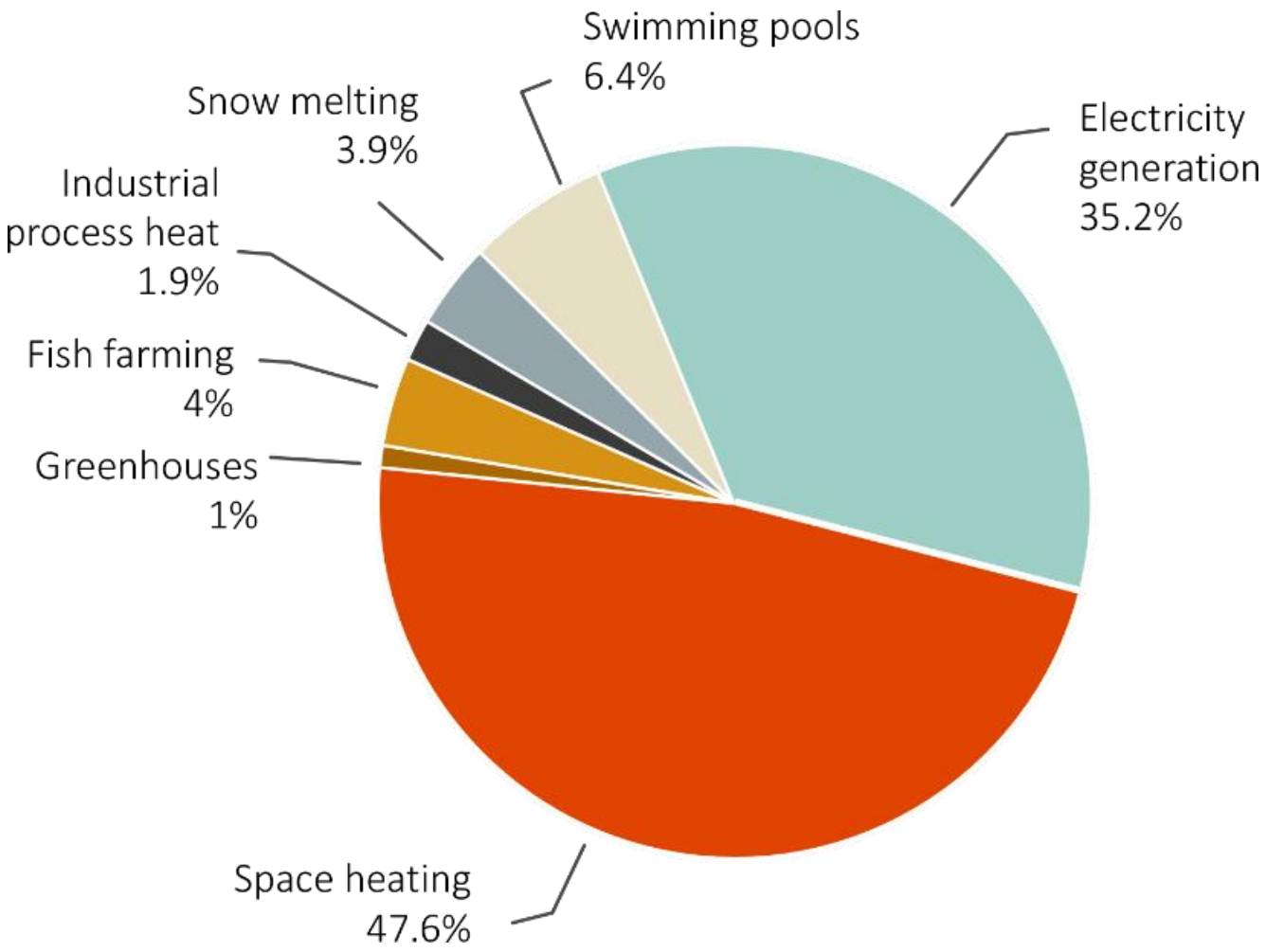


# Major district heating services in Iceland




55 of 64 public district heating systems use low-temperature geothermal resources

# Geothermal utilization in Iceland




# Sustainable development

Brundtland report (1987):

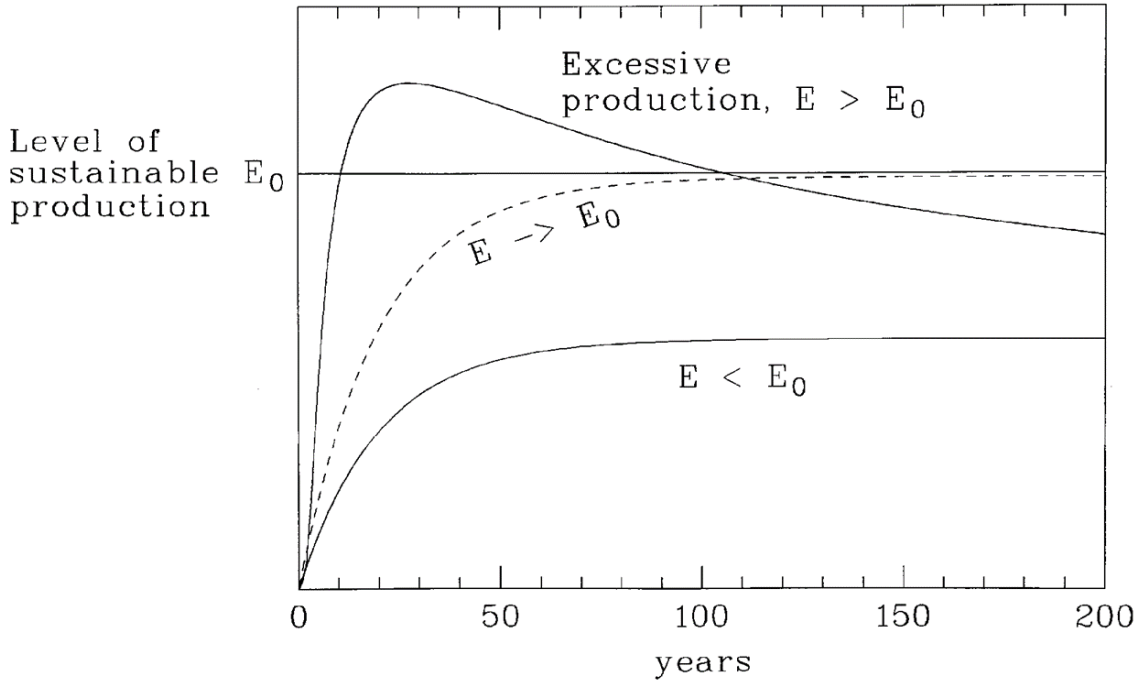
*Development that meets the needs of the present without compromising the ability of future generations to meet their needs*

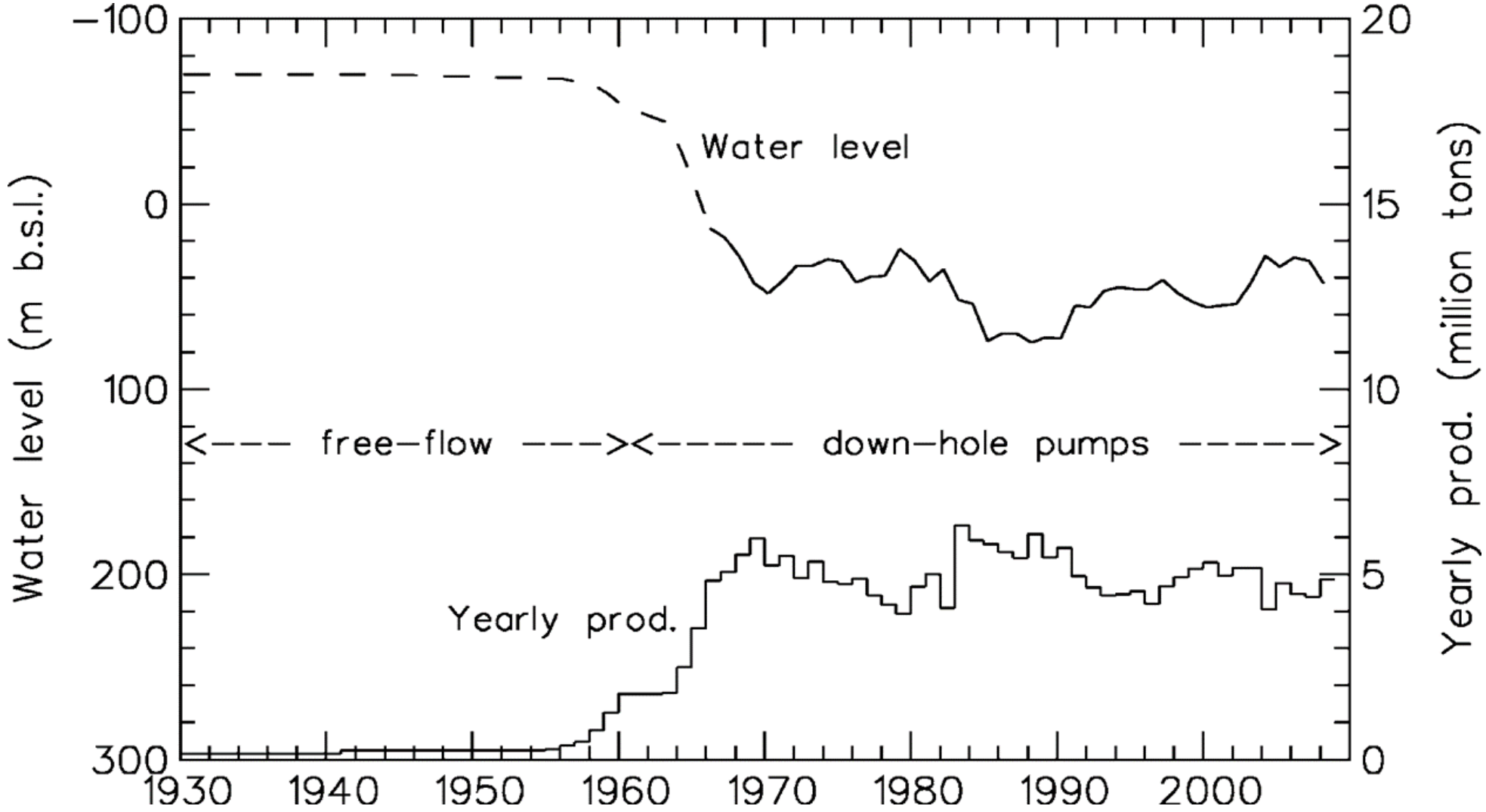
- Very general – but includes energy needs and development
- **Geothermal energy can play a role**
- Definitions + policies lacking
- Resource sustainability the key, but also includes environmental, social and economic aspects

# Can geothermal utilization be sustainable?

Two main issues:

- Can geothermal resources be utilized in a “sustainable” manner, i.e. can given production be maintained for a long time? This has been confirmed by **long utilization histories** and modelling studies.
- What **time-scale** should be used as reference?
  25-30 years is too short and 1,000,000 years too long!
  Icelandic Working Group (2001) proposed **100-300 years**. Others have proposed 50-100 years.






Production- and response history of the Laugarnes geothermal system (Reykjavík, Iceland) 1930 – 2009. Note approximate **pressure (water-level) stabilization**

# What has LT utilization experience shown

- Several long case-histories ranging **40 – 90 years**
- **No signs of resource depletion** (insufficient pressure, cooling, etc.)
- Relatively **few problems** related to the utilization
- Case-histories demonstrate that the low-temperature resources **can be utilized in a sustainable manner**
- Long term reservoir **monitoring** has proven to be invaluable – key reason for success


Photo: Tobias Weisenberger

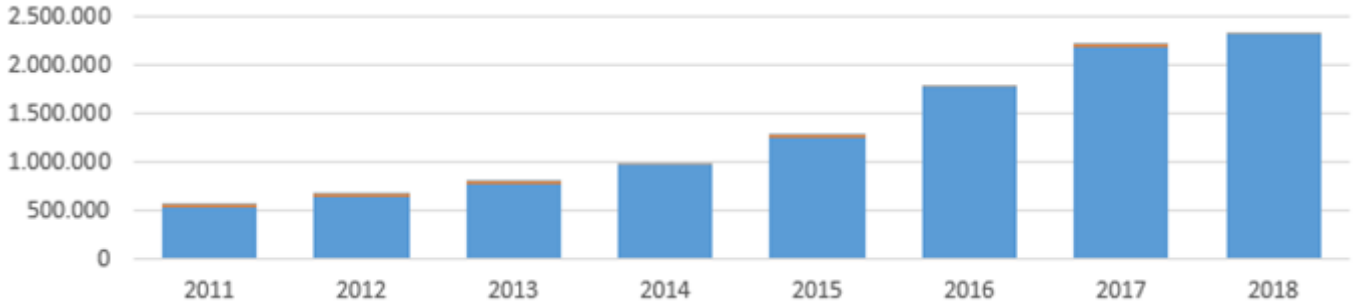
# Long-term geothermal resource management

- Essential to maintain production, avoid overexploitation and other problems
- Comprehensive and accurate **monitoring** of response to production, including:

  Direct monitoring of: mass extraction,
  water temperature,
  reservoir pressure and
  chemical content

- **The past is the key to the future**
- **Modelling** of varying complexity to predict future behavior and aid decision making
- **Reinjection**, which helps maintain reservoir pressure, especially in systems with limited natural recharge – Requires comprehensive testing/research, particularly tracer tests

# Challenges / Problems




- **Increasing demand** due to population growth and tourism
- **Overexploitation,** excessive pressure draw-down (rare today)
- **Colder water or seawater inflow**, such as production well cooling and changes in chemical composition
- Changes in reservoir conditionsdue to **earthquake-activity**
- **Corrosion and scaling**
- **Technical problems** associated with wells (casings), pumps, etc.

# Solutions

- **Improving energy efficiency** of associated heating systems
- **Deeper drilling**
- More focused drilling (e.g. **directional drilling**)
- Finding new drilling targets **or new low-temperature resources**
- Utilize **lower-grade heat** from electricity generation
- Return water **reinjection**
- Use of scaling- and corrosion **inhibitors**
- Technical solutions for surface problems

# Future outlook for geothermal space-heating in Iceland

- All low-temperature resources currently in use can likely be utilized for decades to come, even centuries
- Increasing demand met with finding new LT-resources
- And by utilizing HT-resources as well
- Continued monitoring, modelling and exploration of key importance

# Worldwide possibilities

- Mainly sedimentary geothermal resources distributed worldwide:
  - China, mainly NE-part
  - Paris Basin
  - Molasse-Basin in S-Germany
  - N-Germany, Holland and Belgium
  - Pannonian-Basin
  - Other parts of E-Europe
  - Kazakhstan
- Also other fracture-controlled LT-systems
- And HT-systems through combined use


Thank you