

Orkustofnun

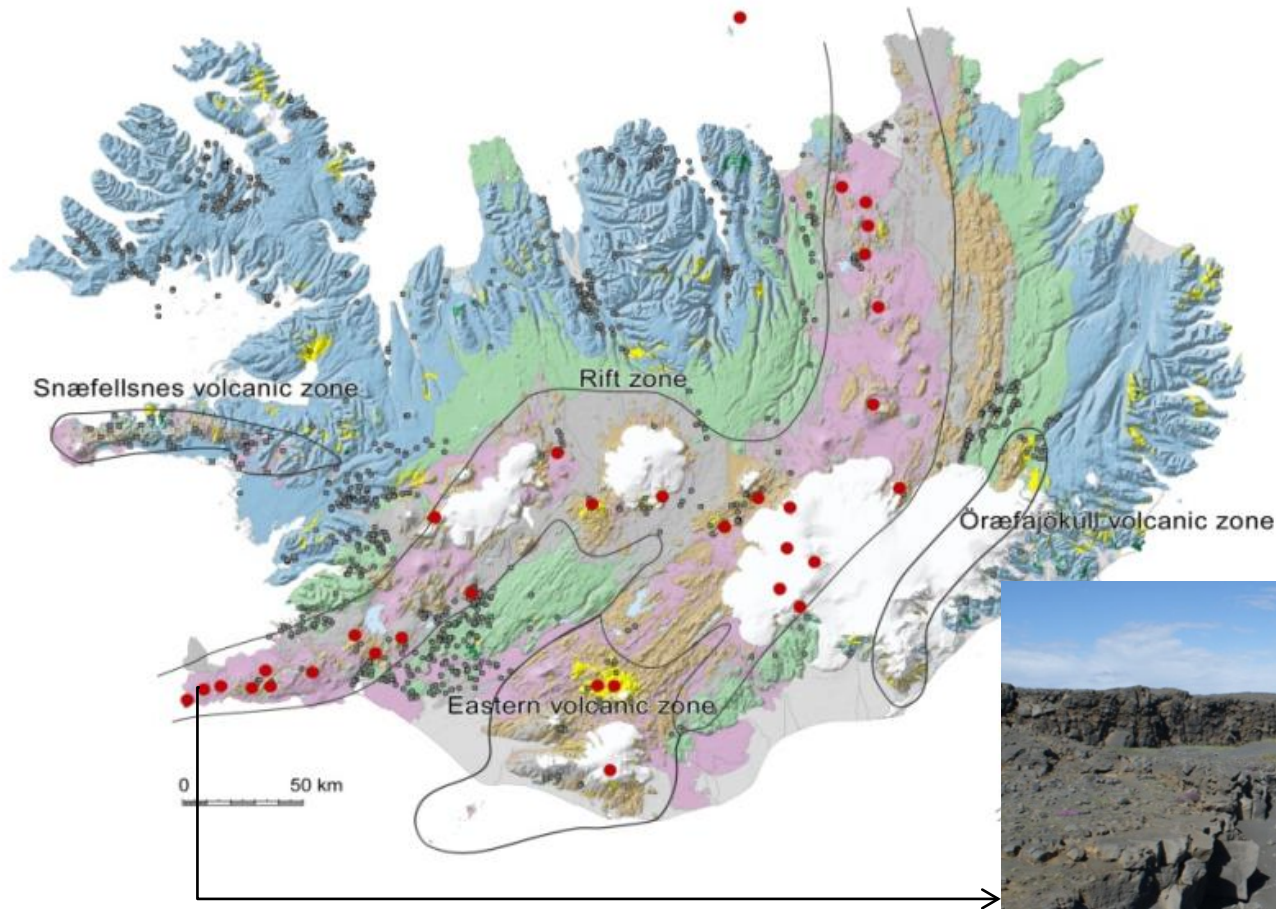
The Icelandic National Energy Authority

Prof. Dr. Gudni A Jóhannesson
Director General



EVOLUTION OF PUBLIC SUPPORT MODELS FOR GEOHERMAL DEVELOPMENT IN ICELAND

Hot spot on the Mid- Atlantic ridge



Geothermal map of Iceland. (Basemap: Geological map of Iceland by Haukur Jóhannesson and Kristján Sæmundsson 1999. Iceland. 1:1.000.000. Icelandic Institute of Natural History

Role of Orkustofnun

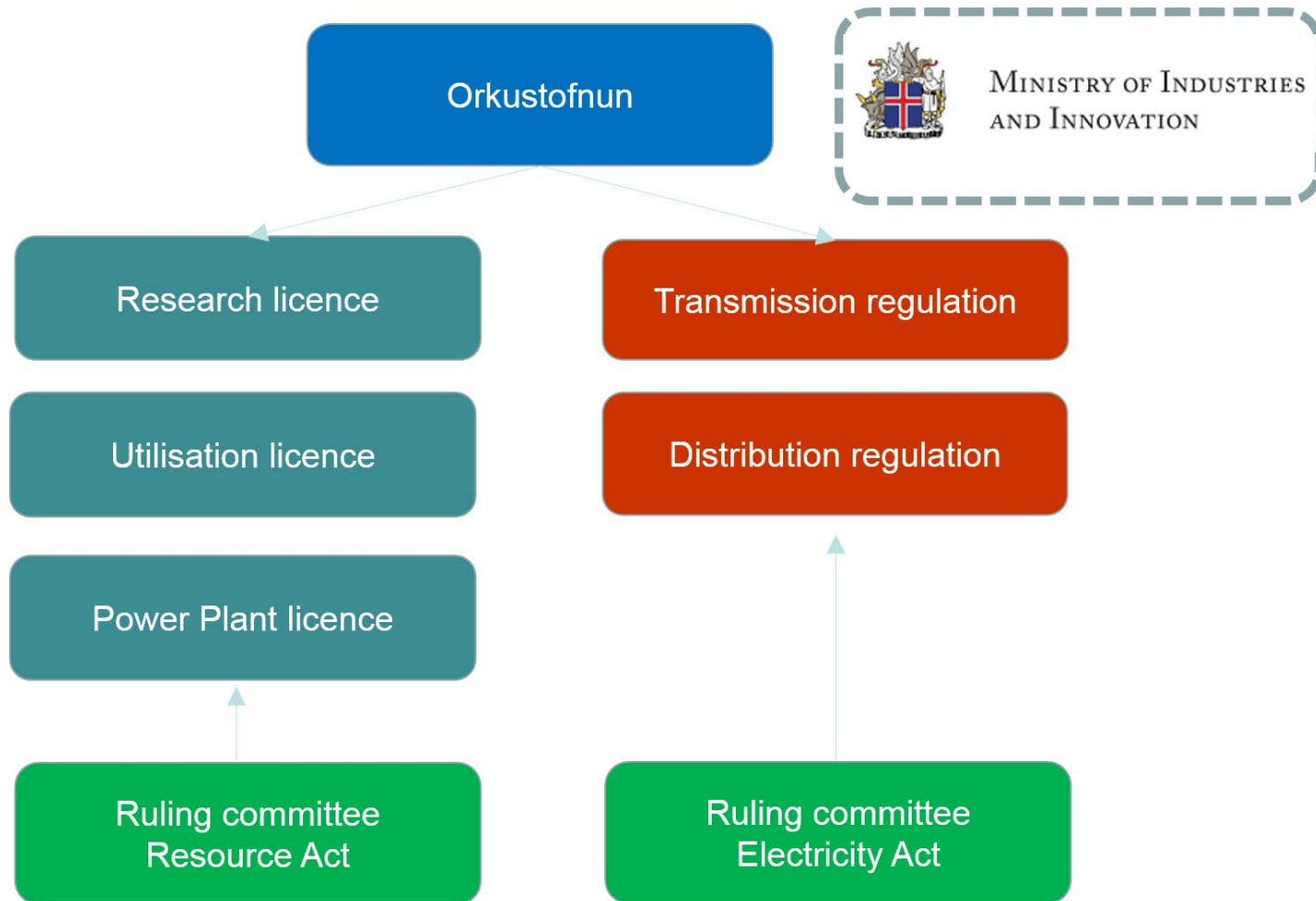
- Public administration of the energy sector and advisors to the government
- Long term planning of energy use, utilisation of the resources and the energy infrastructure
- Contracting and conducting research on resource utilisation
- Accumulating and maintaining databases on energy utilisation and forecasts for future trends



Role of Orkustofnun

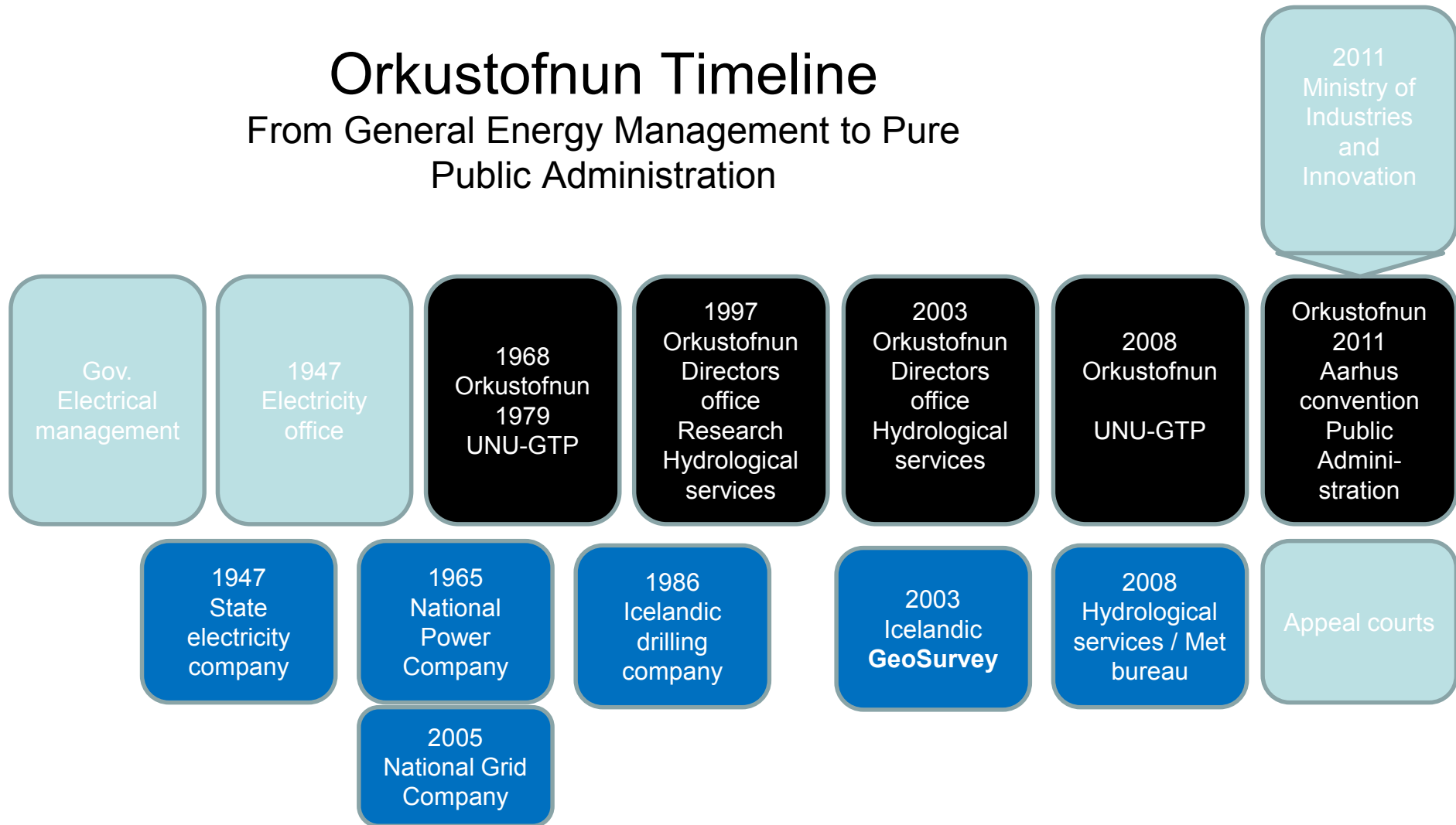
- Issues permits for exploration and utilisation of energy and earth based resources
- Issues power plant licences
- Is the regulator for the national grid
- Is the official monitoring body of issued licenses
- Fuel sector administration and work on transition to low carbon fuels
- Administrates The Energy Agency, The Energy Fund and special initiatives for geothermal exploration
- Hosts the UNU University Geothermal Training Programme

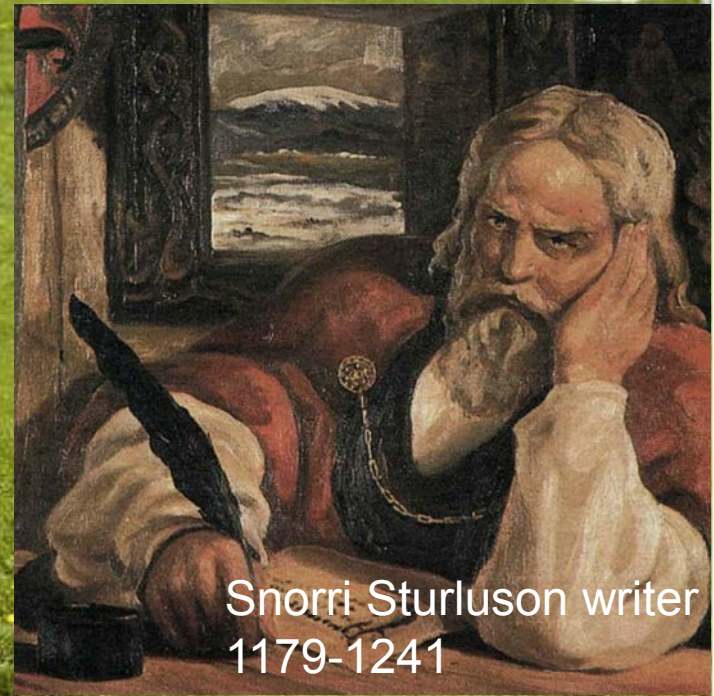
Role of Orkustofnun



Orkustofnun Timeline

From General Energy Management to Pure Public Administration





Snorri Sturluson writer
1179-1241

Energy Security during the Great Frost Winter 1917–1918

- Due to the First World War, 1914–1918, the market price for coal increased and coal was rationed.
- Combined with extremely cold weather conditions when temperatures measured minus 25 degrees Celsius in Reykjavik at the most on January 21, 1918 possibilities of geothermal based DHS was discussed.
- At that time the farm Suðurreykir had been heating buildings with geothermal for a decade.
- The Prime Minister, Jón Þorláksson, an engineer, initiated the discussion on building a district heating system in Reykjavik in 1926. He later became the Major of Reykjavik in 1933–1935.



Laugarveitan

First Geothermal based DHS in 1930

Laugarnes Production Field 3 km away

- After two years of drilling in Laugarnes 14 shallow wells were drilled. The result was 14 l/s of artesian flowing water at 87° C (deepest 246 m).
- The water was transported 3 km in a pipeline from the geothermal field to the Laugarveitan District Heating System.
- Two primary schools, a swimming hall, the main hospital, public buildings and 60 family homes in the capital area were connected over the next decade with good success.



Drilling in Laugarnes



The primary school Austurbæjarskóli

District Heating in Reykjavik

- Great Frost Winter 1917–1918
 - Market price for coal increased and coal was rationed.
 - Minus 25 degrees Celsius in January 21, 1918
 - The farm Suðurreykir had been heating buildings with geothermal for a decade.
- Laugarveitan First Geothermal based DHS in 1930
- Expansion of the DHS 1934–1955
Reykir Production Field 18 km away



Political and legal milestones

- **1937–1938** Bill for Geothermal Research introduced to the parliament which didn't pass.
- **1938** Expansion of the DHS was an influential part of the municipality elections in Reykjavik
- **1940–1945** National Research Council supported exploration drilling into high temperature systems.
- **1944** DHS in Olafsfjordur inaugurated.
- **1948** DHS in Selfoss & Hveragerdi
- **1953** The parliament passed a law allowing the state to finance up to 80% of the total investment cost of drilling and building a DHS outside of the capital area.
- **1953** DHS at Saudarkrokur
- **1961** Geothermal Energy Fund and State Drilling Company established offering financing for research and drilling.
- **1961–1983** Over 350 loans issued for drilling and building DHS across the country and over 20 DHS where built.

Morgunblaðið
St. Úp, 24. Út. — Framfarir 24. Júní 1953

Kjósidd hitaveituna í dag — C-listann
Reykurinn yfir hönnu, senn hitaveitar útrýmt!

Þessi vott fréttila, á þessum og kostnaði vill heilbrigðisgættu.

Þessi vott hefur all hvern í síð öðrum, og veitubúnaði all rúm um allan tíð.

Hönnuð hefur yfir Reykjavíð, þegar hitaveitun er lönguð Súla og tíu fulla!

Kokkryðun og drifun, kálfurinn, hálurinn, hálurinn. Með einu kálfurinn er hlönnuð vottu senn útrýmt.

Með hitaveitunni hefur hefur vott í öðrum. Út vott hitaveitun er löngu all hvern um veitubúnaði, þar senn veitubúnaði veitubúnaði, hlönnuð senn útrýmt.

Reykvíkingar! Tryggið yður hitaveituna með því að kjósa C-listann

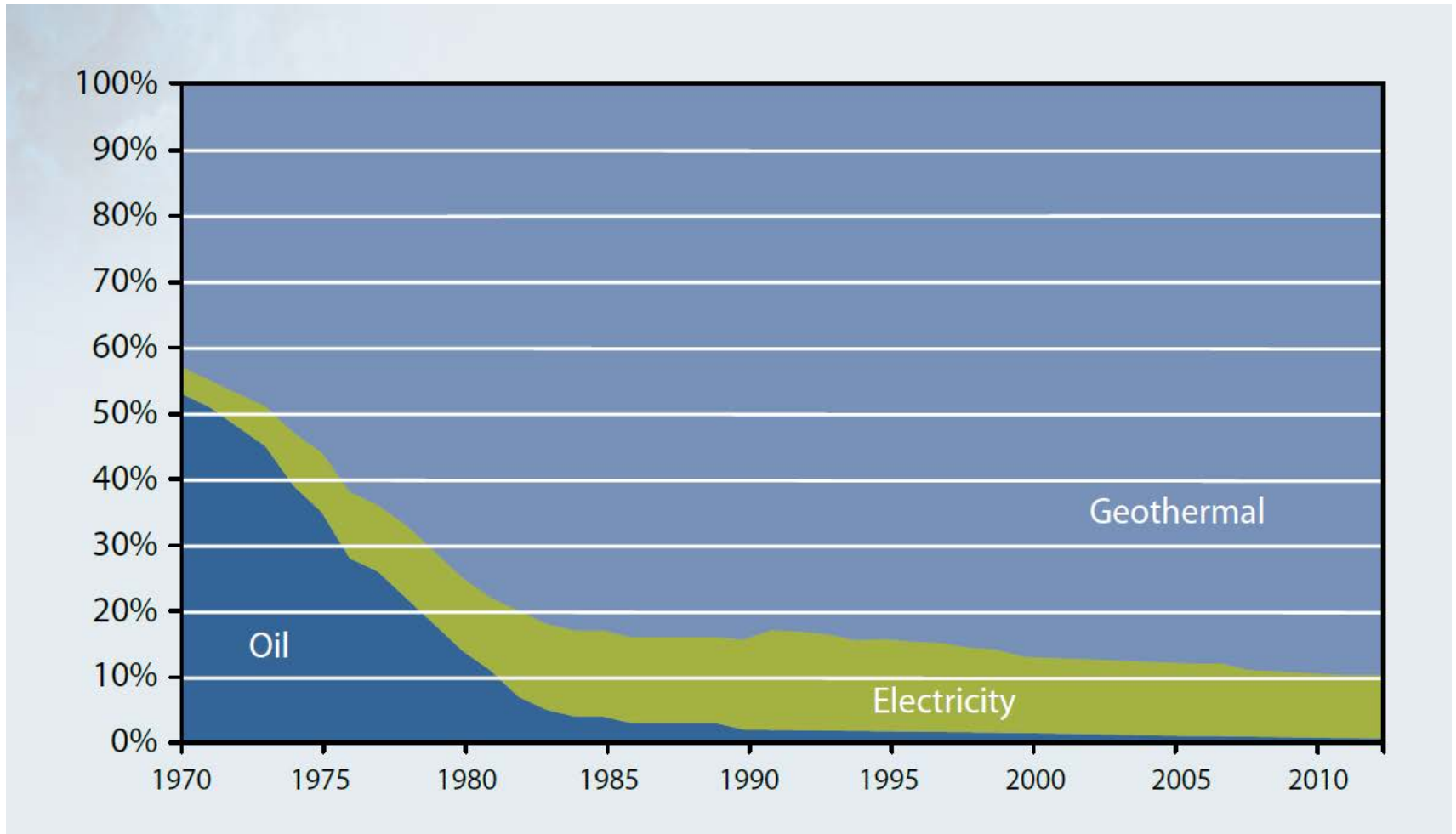
Geothermal Boreholes in Reykjavik



Geothermal District Heating Storage Tanks in Reykjavik



Space Heating by Source from 1970

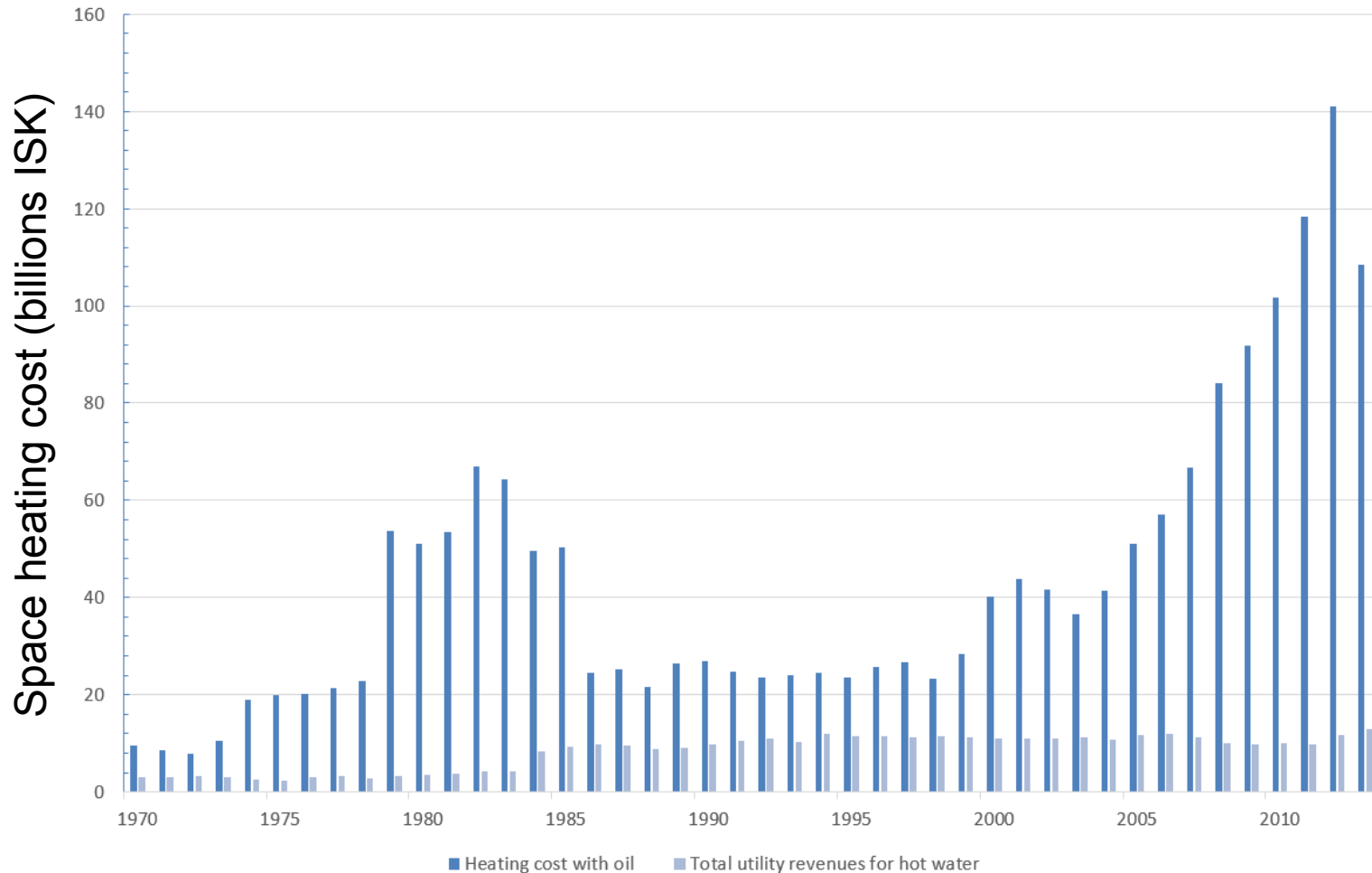


Impact on Economy

From an economical perspective, the present value of the estimated savings of house heating with geothermal instead of oil between 1970 and 2008 is estimated at 880.000 million ISK

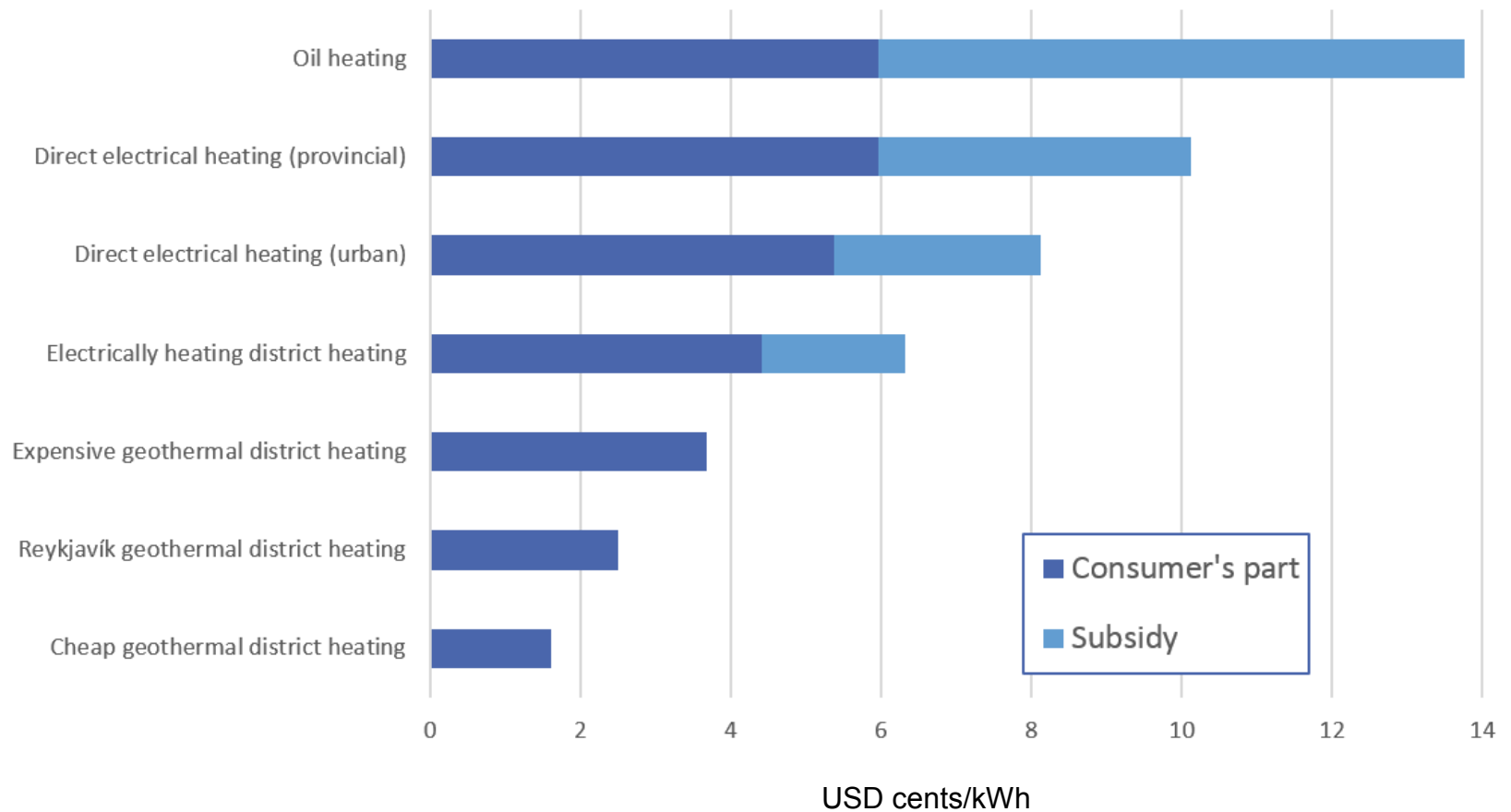
In 2008 the estimated savings of that year amounted to about 12% of the value of imported goods or almost equivalent to the total imports of refined oil products.

Avoided cost



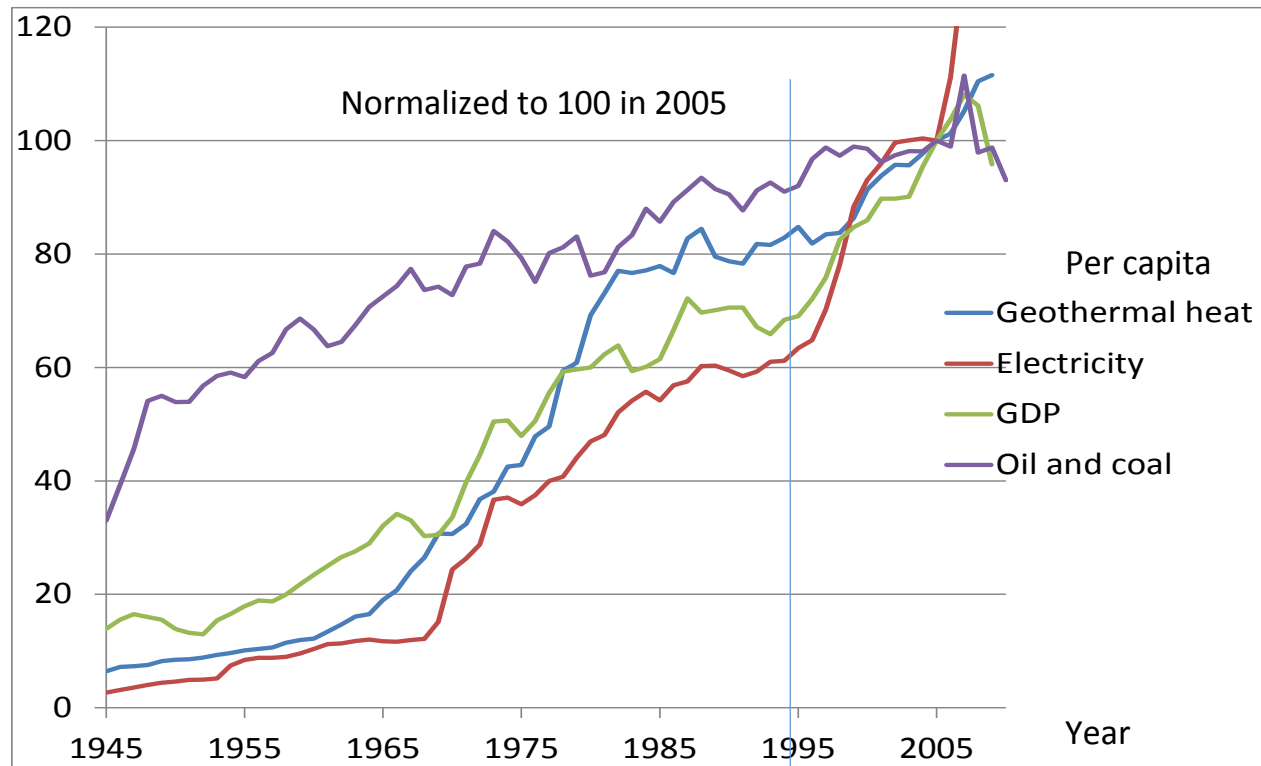
From an economical perspective, the present value of the estimated savings of house heating with geothermal instead of oil between 1914 and 2013, using 2% real interest rate over the cost price index, is estimated at 2,500 billion ISK (132 ISK/US\$). In 2014 the estimated savings of that year amounted to about 5.5% of the GDP of Iceland or 2,300 US\$ per capita.

Comparison of Energy Prices for Residential Heating Mid year 2014



ICELAND 1945 - 2005

<http://www.os.is/>



<http://www2.stjr.is/frr/thst/rit/sogulegt/english.htm>

A Game Changer for Public Health

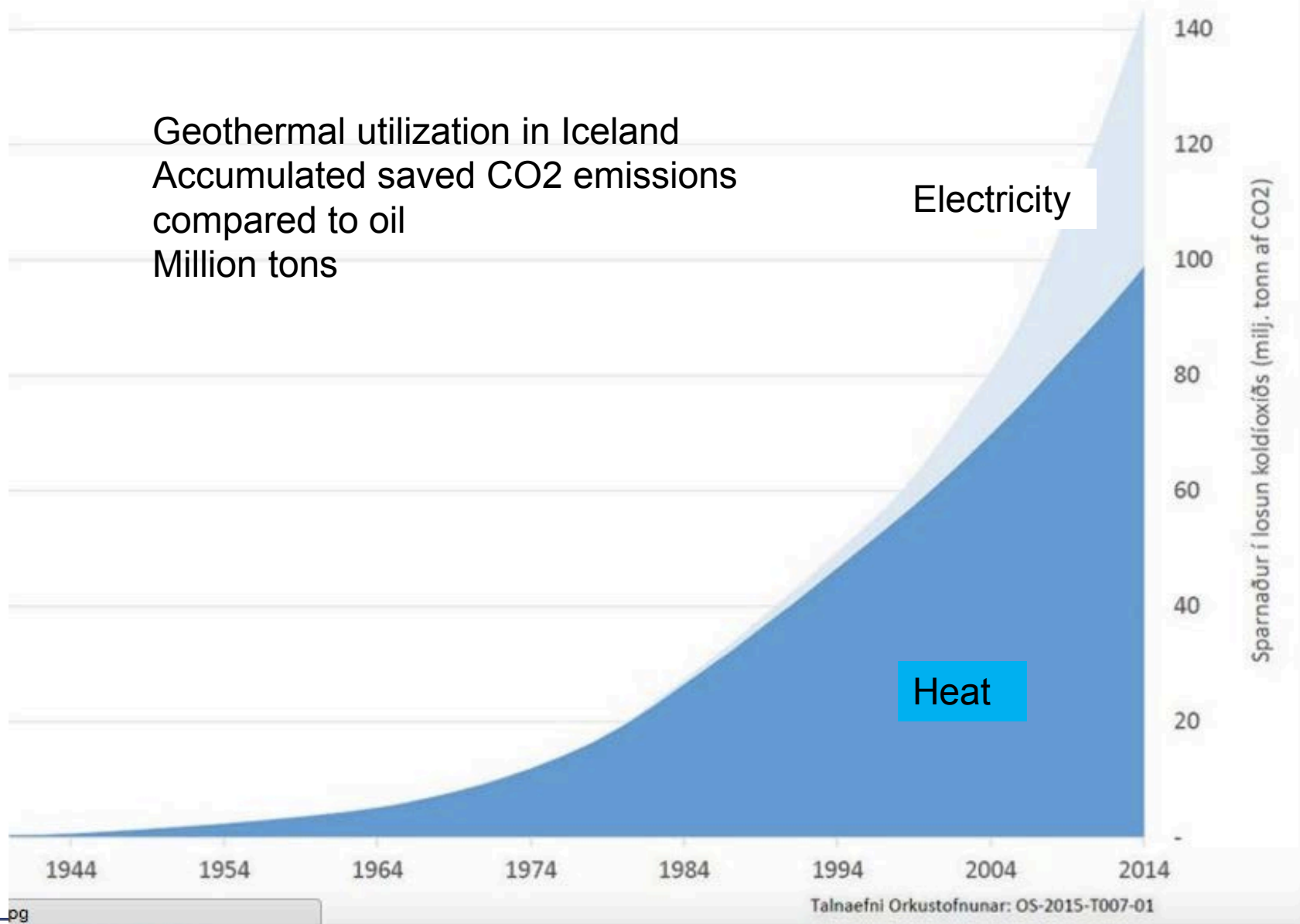
Reykjavík 1933



Reykjavík today



Geothermal utilization in Iceland
Accumulated saved CO2 emissions
compared to oil
Million tons



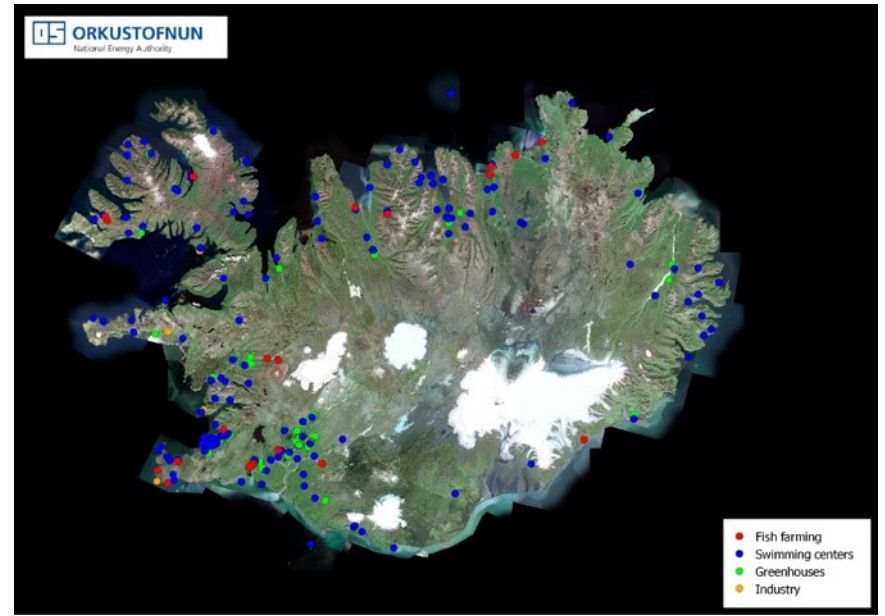
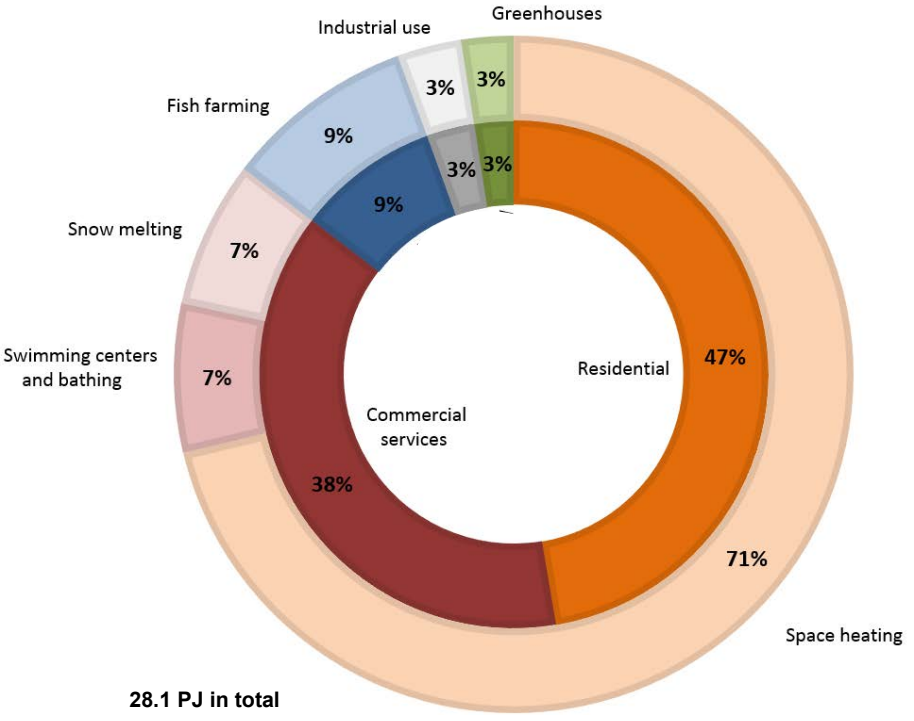
Sparnaður í losun koldíoxíðs (milj. tonn af CO2)

Electricity

Heat

Talnaefni Orkustofnunar: OS-2015-T007-01

Geothermal Heat 2014



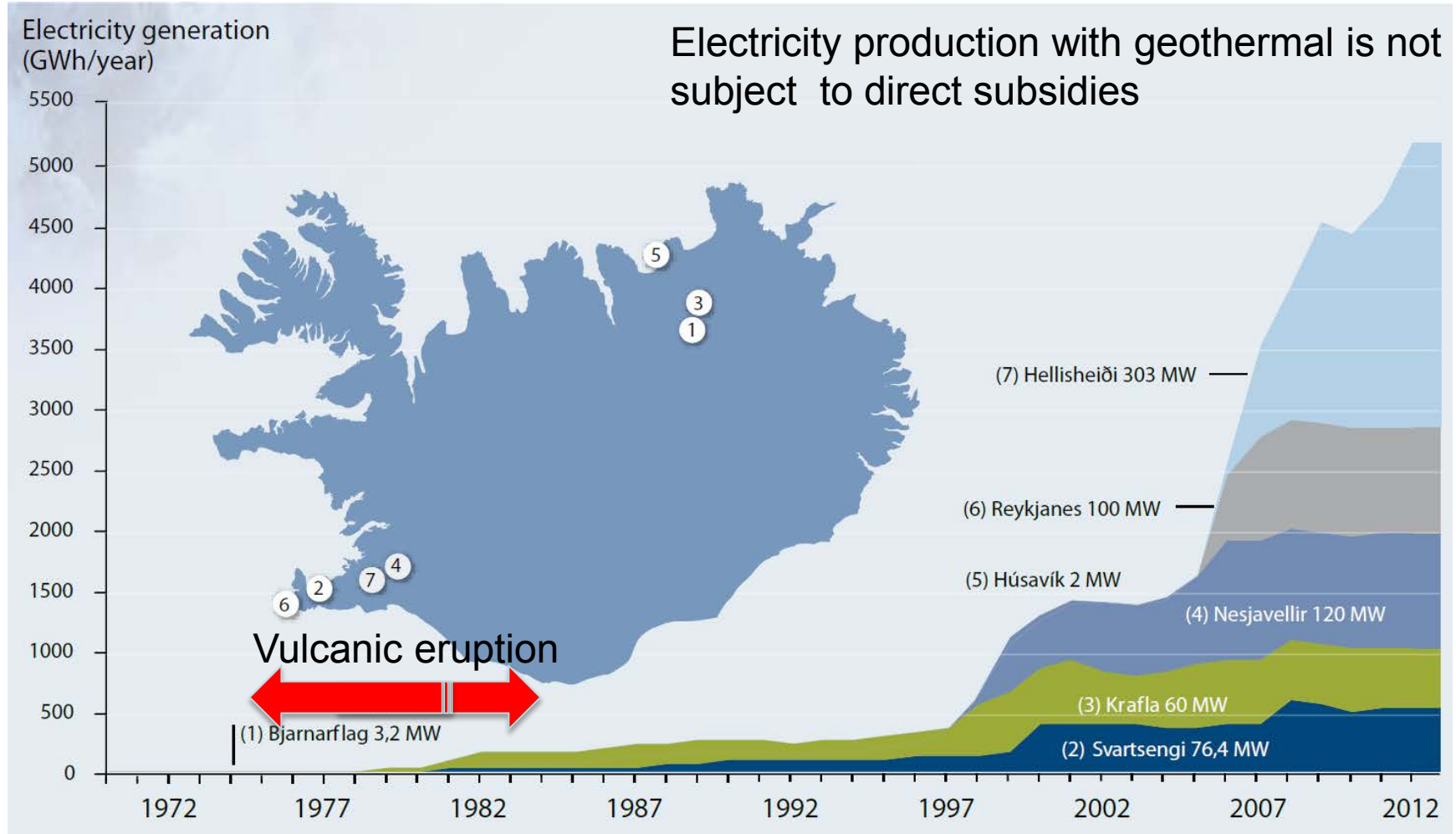
Electricity Generation and Use 2014

General use	3 TWh	17%
Large industries	14 TWh	77%
System loss and plant use	0,4 TWh	2%



Electricity Generation with Geothermal

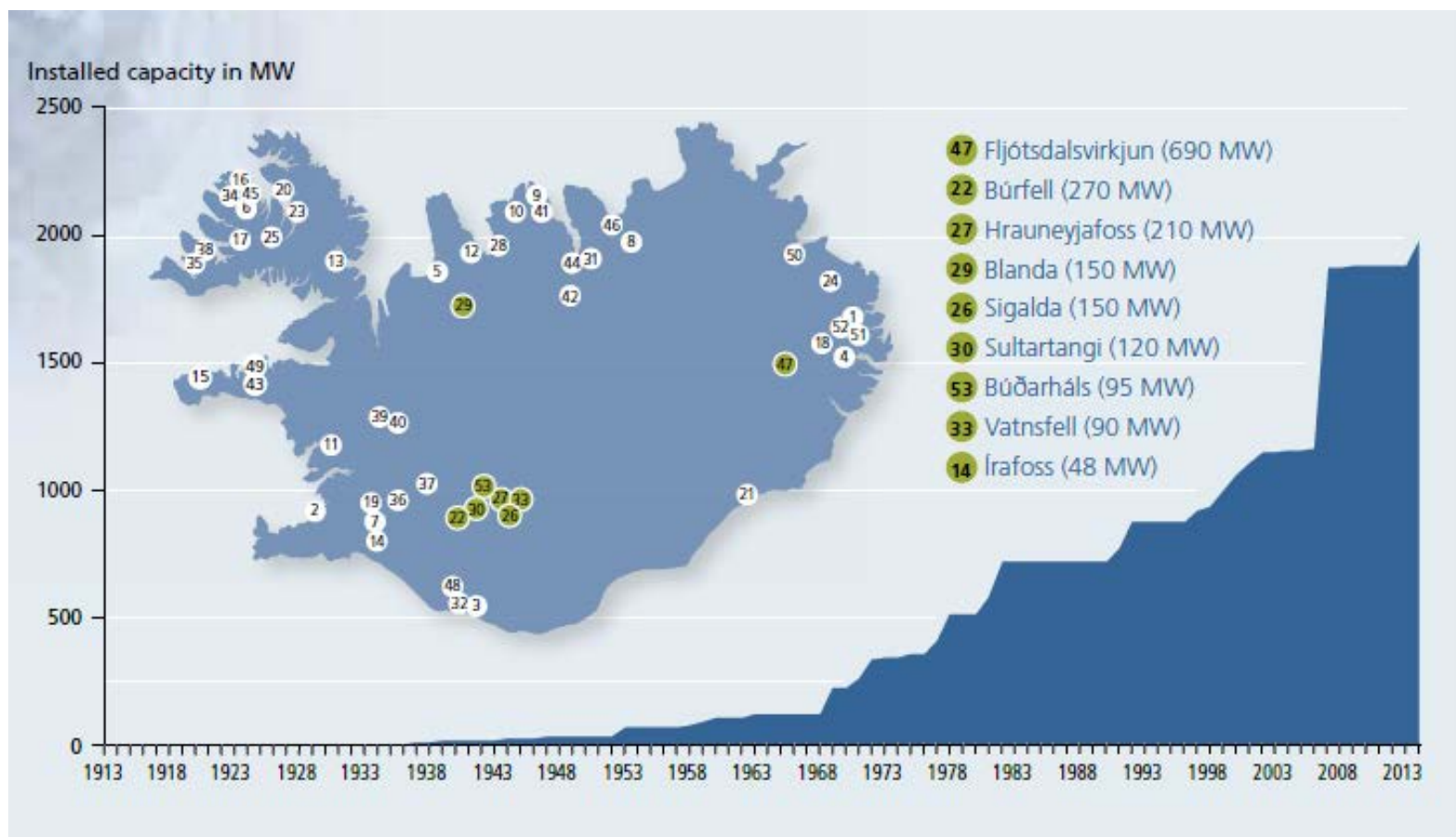
Electricity production with geothermal is not subject to direct subsidies



Implicit Support for Geothermal

- Scientific research
- Surveying
- Early power plant development
- Legal and regulatory framework
- Central data register
- Financial Backup
- International cooperation
- GEORG
- The Deep Drilling Project
- The Master Plan

Installed capacity in hydro power plants



Masterplan - The vision

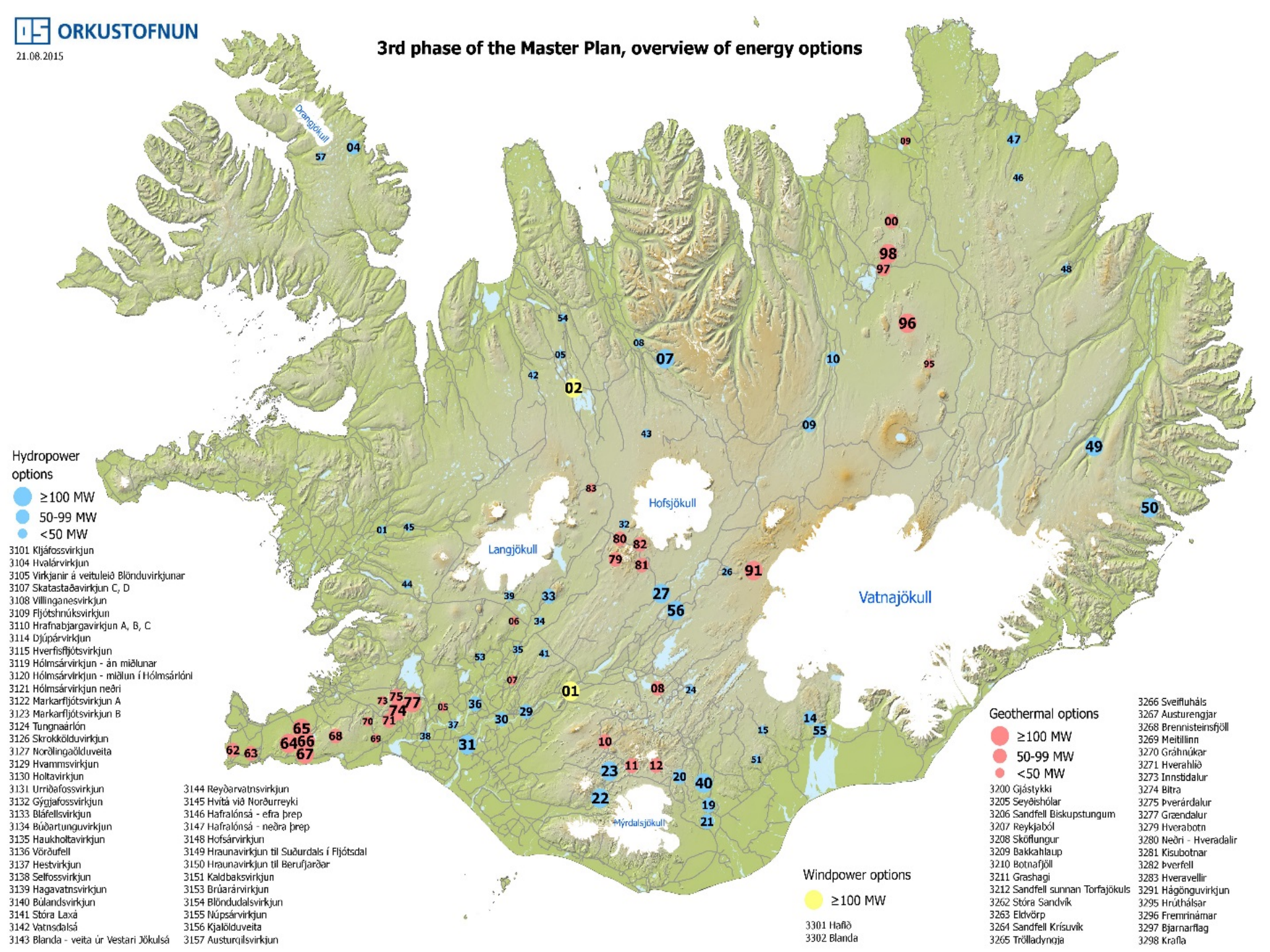
Prepare an overview of the various potential energy projects

Hydro and geothermal (+?)

Evaluate and rank the projects based on their

- energy and economic potential,
- national economy
- estimated impact on nature, environment, cultural heritage and the society
- potential for other uses of the areas in question.

3rd phase of the Master Plan, overview of energy options



Hydropower options

- ≥ 100 MW
- 50-99 MW
- < 50 MW

- 3101 Kijáfossvirkjun
- 3104 Hvalárvirkjun
- 3105 Virkjanir á veituleið Blönduvirkjunar
- 3107 Skatastaðavirkjun C, D
- 3108 Villinganesvirkjun
- 3109 Fljótshnúksvirkjun
- 3110 Hrafnabjargavirkjun A, B, C
- 3114 Djúparvirkjun
- 3115 Hverfisfljótsvirkjun
- 3119 Hólmsárvirkjun - án miðlunar
- 3120 Hólmsárvirkjun - miðlun í Hólmsárlóni
- 3121 Hólmsárvirkjun neðri
- 3122 Markarfljótsvirkjun A
- 3123 Markarfljótsvirkjun B
- 3124 Tungnaárlón
- 3126 Skrokkölduvirkjun
- 3127 Norðlingaölduveita
- 3129 Hvammsvirkjun
- 3130 Holtavirkjun
- 3131 Urriðafossvirkjun
- 3132 Gýgjafossvirkjun
- 3133 Bláfellsvirkjun
- 3134 Búðartunguvirkjun
- 3135 Haukholtavirkjun
- 3136 Vörðufell
- 3137 Hestvirkjun
- 3138 Selfossvirkjun
- 3139 Hagavatnsvirkjun
- 3140 Búlandsvirkjun
- 3141 Stóra Laxá
- 3142 Vatnsdalsá
- 3143 Blanda - veita úr Vestari Jökulsá
- 3144 Reyðarvatnsvirkjun
- 3145 Hvítá við Norðurreyki
- 3146 Hafalónsá - efra þrep
- 3147 Hafalónsá - neðra þrep
- 3148 Hofsvirkjun
- 3149 Hraunavirkjun til Suðurdals í Fljótssdal
- 3150 Hraunavirkjun til Berufjarðar
- 3151 Kaldbaksvirkjun
- 3153 Brúarvirkjun
- 3154 Blöndudalsvirkjun
- 3155 Núpsárvirkjun
- 3156 Kjalölduveita
- 3157 Austurqilsvirkjun

Geothermal options

- ≥ 100 MW
- 50-99 MW
- < 50 MW

- 3200 Gjástykki
- 3205 Seyðishólar
- 3206 Sandfell Biskupstungum
- 3207 Reykjaból
- 3208 Sköflungur
- 3209 Bakkahláup
- 3210 Botnafjöll
- 3211 Grashagi
- 3212 Sandfell sunnan Torfajökuls
- 3262 Stóra Sandvík
- 3263 Eldvörp
- 3264 Sandfell Krísvík
- 3265 Trölladyngja
- 3266 Sveifuháls
- 3267 Austurengjar
- 3268 Brennisteinsfjöll
- 3269 Meitilinn
- 3270 Gráhnúkar
- 3271 Hverahlöð
- 3273 Innstidalur
- 3274 Bltra
- 3275 Þverárdalur
- 3277 Grændalur
- 3279 Hverabotn
- 3280 Neðri - Hveradalir
- 3281 Kisubotnar
- 3282 Þverfell
- 3283 Hveravellir
- 3291 Hágönguvirkjun
- 3295 Hróthálsar
- 3296 Fremrinámur
- 3297 Bjarnarflag
- 3298 Krafla

Windpower options

- ≥ 100 MW
- 3301 Haðö
 - 3302 Blanda

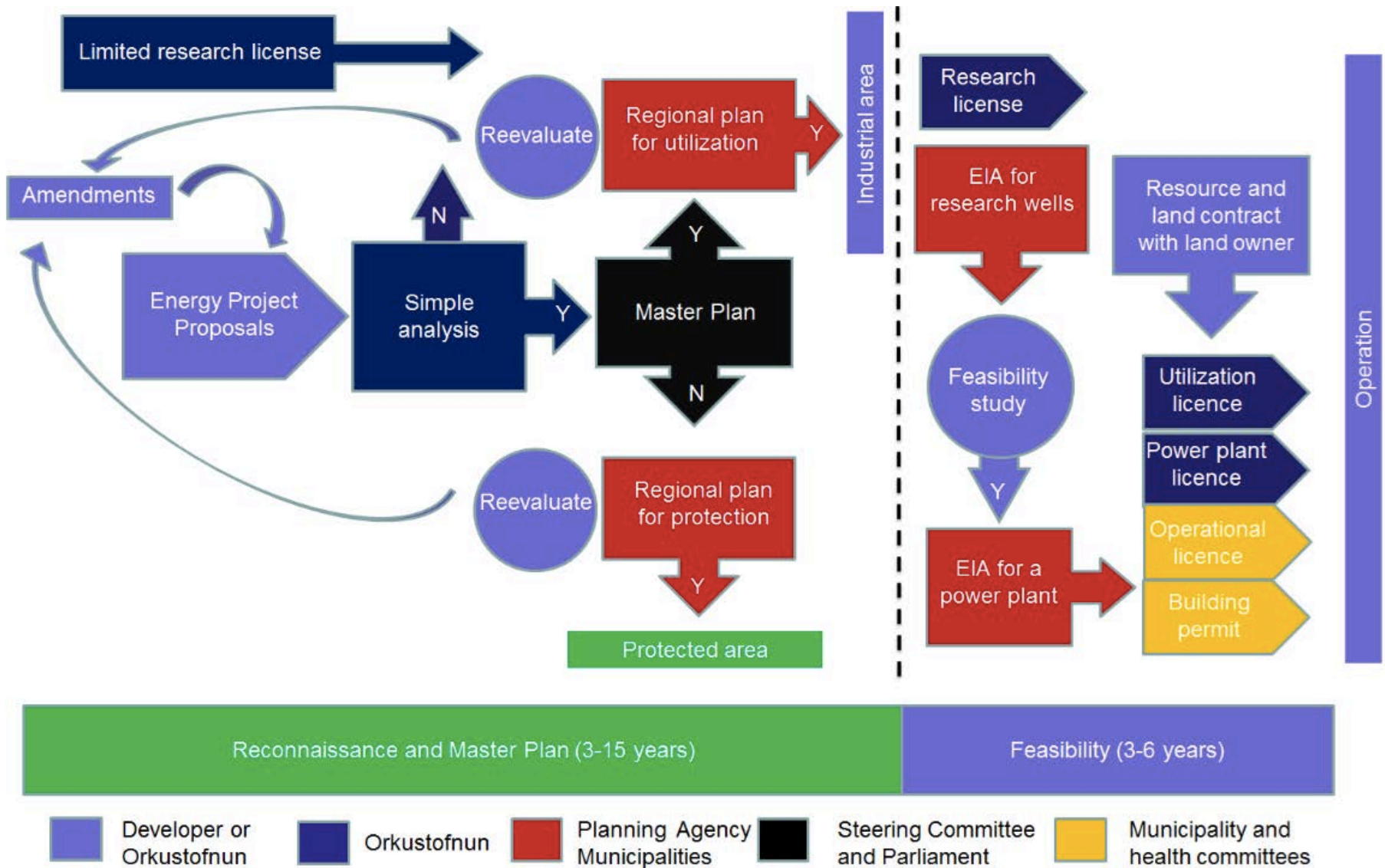


Figure 8: Flow diagram illustrating the processes around the Master Plan.

Results from Master Plan Phase II

A total number of 84 potential power projects were evaluated during the second phase in 2011

Master Plan ranking 28 hydropower projects and 38 geothermal projects approved by the Parliament in 2012.

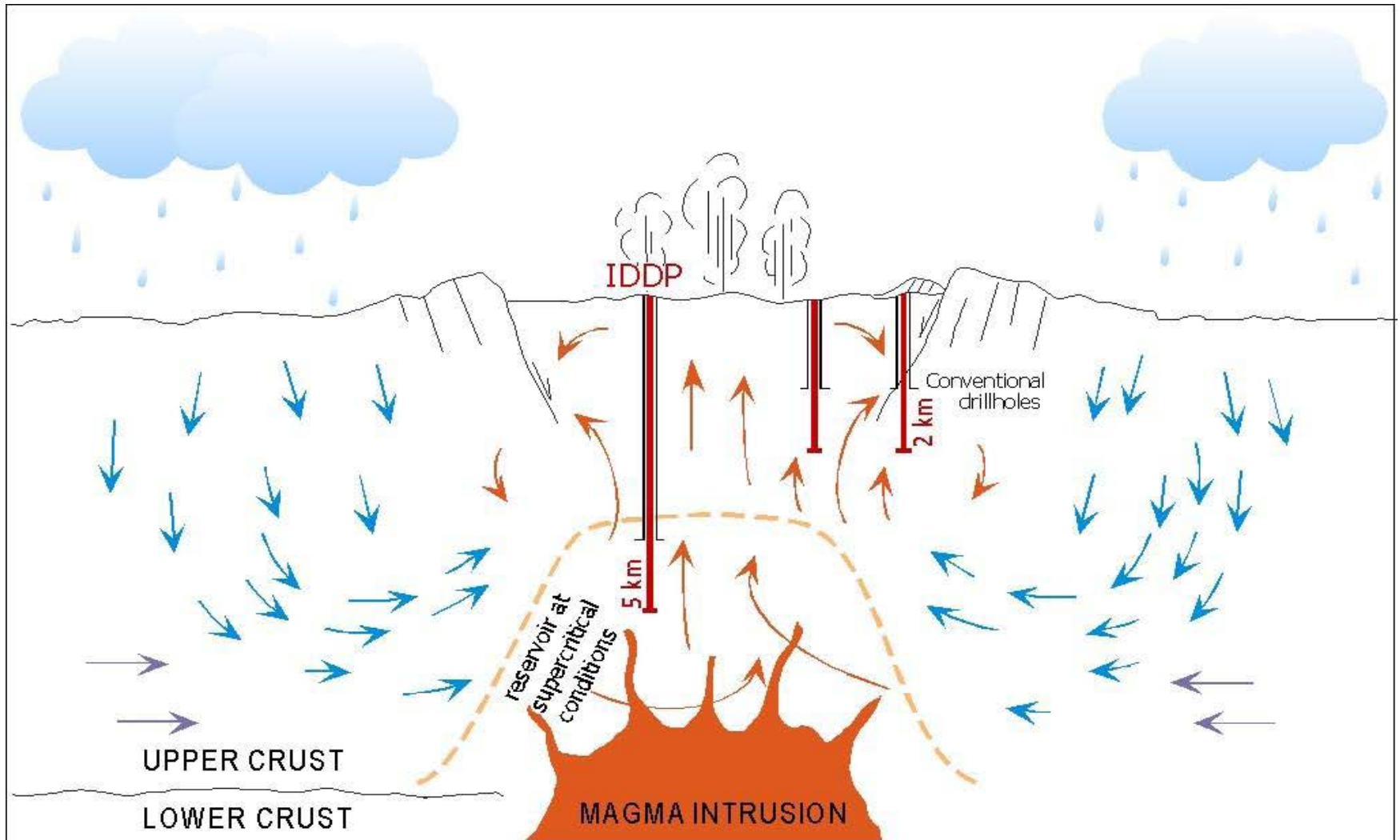


2nd Master plan

Class Sizes in Final Resolution

Electric Power Potential	Hydro GWh/a	Geo- thermal GWh/a
Electricity Production (2010)	12,592	4,465
Appropriate for Development	1,024	8,801
Existing & To be developed	13,616	13,266
Appropriate for Protection	7,745	17,765
Awaiting further Consideration	8,310	4,205
Total – Existing & Master Plan	29,671	35,236

The Deep Drilling Project



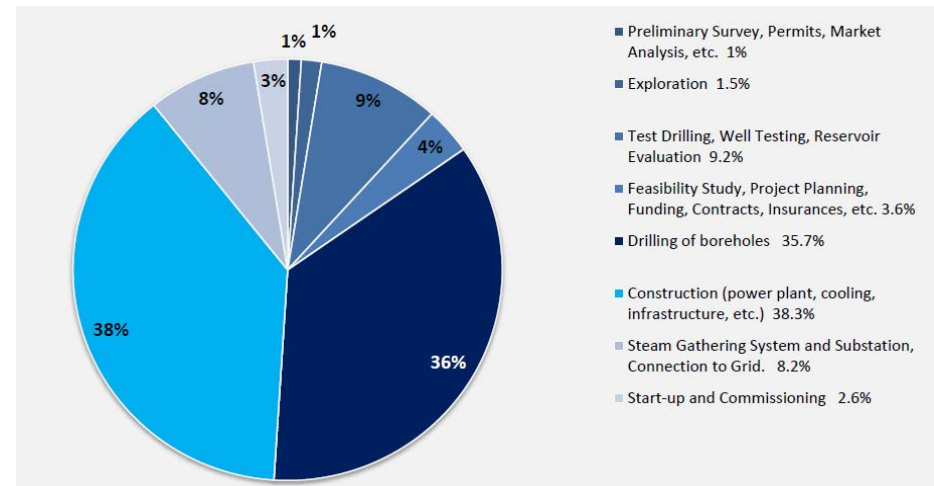
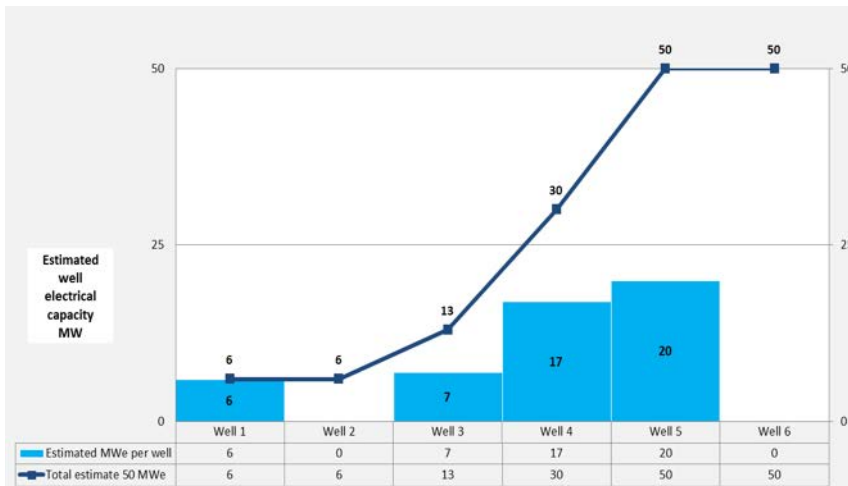
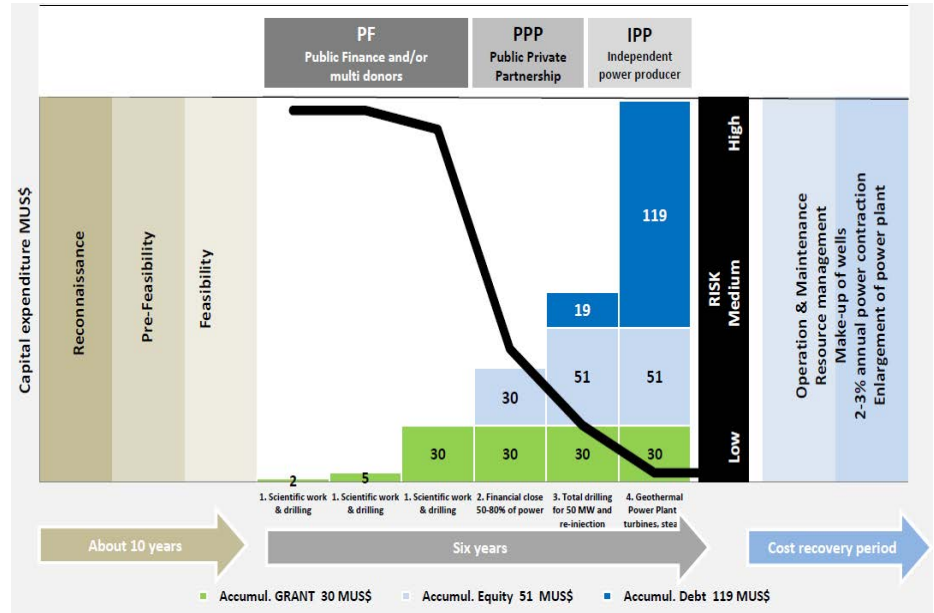
Lessons learned from Iceland

Important to lower the risk of projects in the beginning by supporting exploration and test drilling

Grants to homeowners for transformation to GeoDH

Important for financial institutions to recognize opportunities with GeoDH

Longterm savings for the economy tremendous by using domestic resources



Conclusion

- Utilisation of geothermal power has expanded rapidly during the last decades.
- Global crises effect national policies.
- Loans important to support exploration drilling to lower the risk of GeoDH operations.
- Iceland's long-term objective is to ensure long term utilisation of the resource and the legal amendments as future implementation of the Master Plan are steps in maintaining and sustaining this objective.
- The legal framework is extensive.
- Effective policy making and official monitoring for sustaining a renewable energy society is crucial for a long-term sustainable yield of the resource.



Thank
you