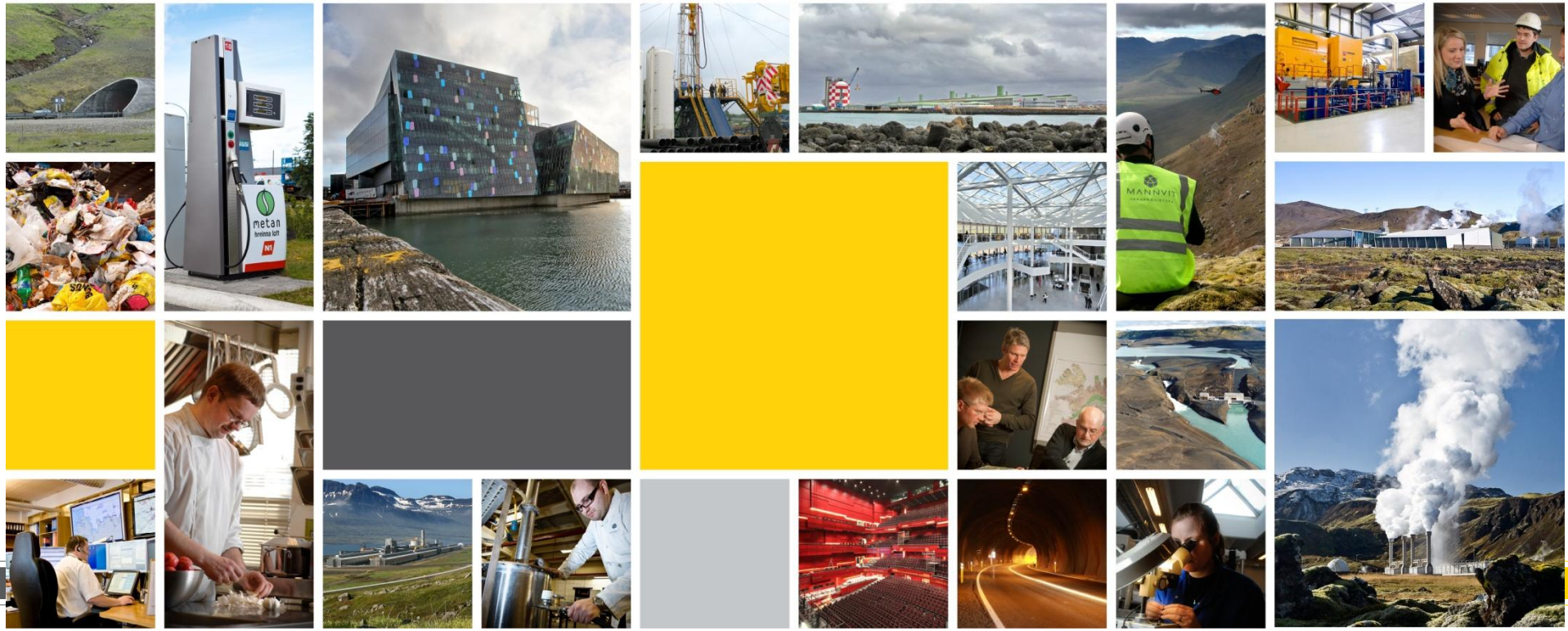
Workshop on EU-Iceland-Japan Cooperation in Geothermal Issues

Case Study from Iceland

Runólfur Maack – Senior Manager

08 March 2012



Mannvit at a glance

An international consultancy offering a wide range of services in the fields of engineering, consulting, management, operations and EPCM contracting.

- Founded in 1963. Employee-owned by over 100 shareholders
- Employees approximately 400
- Headquarters in Reykjavik and 8 offices in Iceland
  - Branch offices or affiliates in Hungary, UK, Germany, Chile and the USA
- Turnover in 2011 was €38 million
- Quality Management System certified - ISO 9001:2008
- ISO 14001:2004 Environmental QMS certification

ISO 9001
FS 551557

Affiliations

Geothermal reservoir engineering, groundwater, hydrology, river hydraulics, surface runoff, air pollution and environmental modelling.

Major project developments in the aluminum industry

Vatnaskil
Land & Water Resource Consultants Ltd

Wide experience in the fields of water resources, water supply, wellfield development, environmental impact and groundwater contamination.

Provides wide range of servces and consulting in the field of geothermal energy , geology, drill engineering, geomodelling, energy- and hydro-engineering and licensing procedure.

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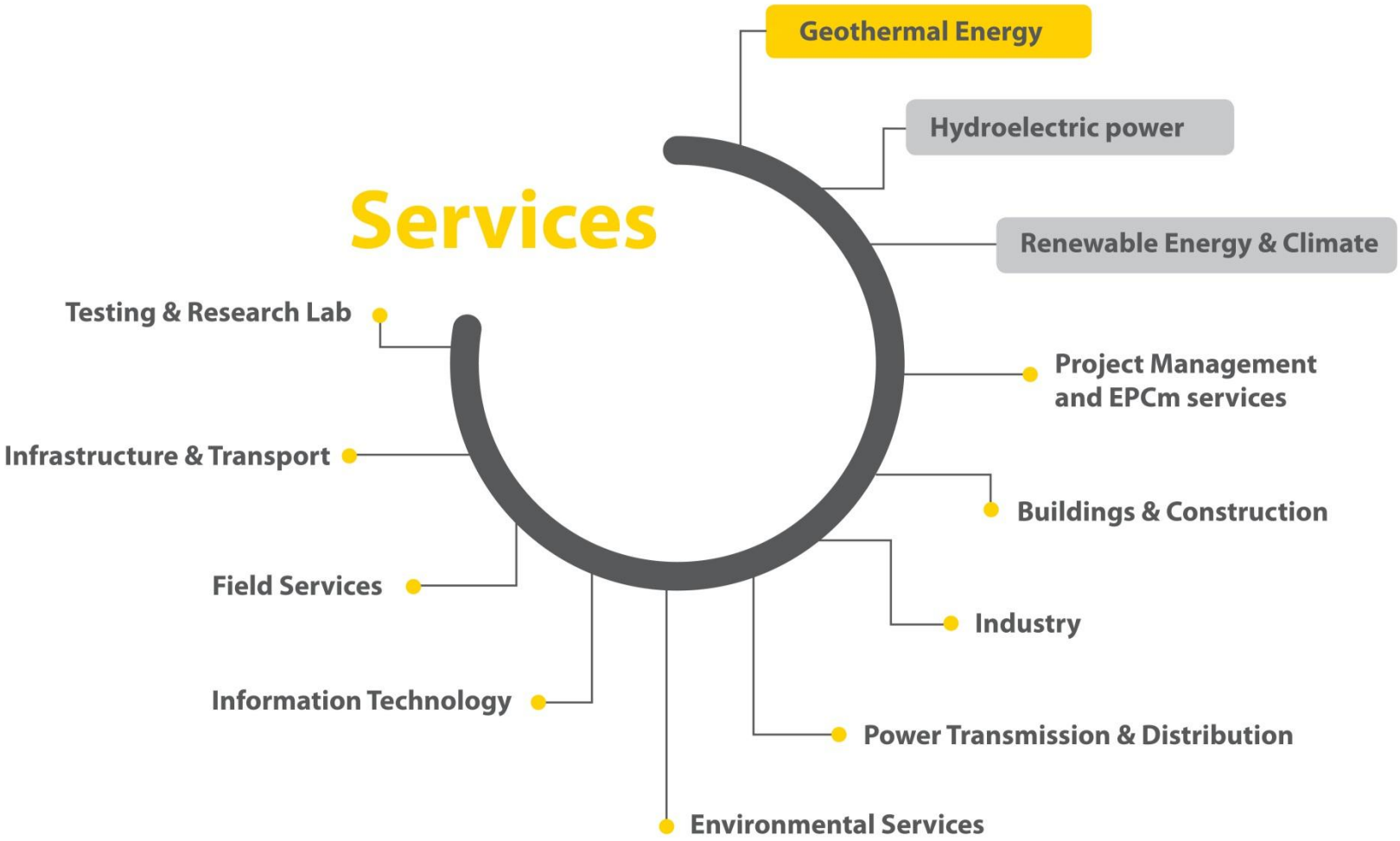
Services
Geothermal Energy
Hydroelectric power
Renewable Energy & Climate
Project Management and EPCm services
Buildings & Construction
Industry
Power Transmission & Distribution
Environmental Services
Information Technology
Field Services
Infrastructure & Transport
Testing & Research Lab

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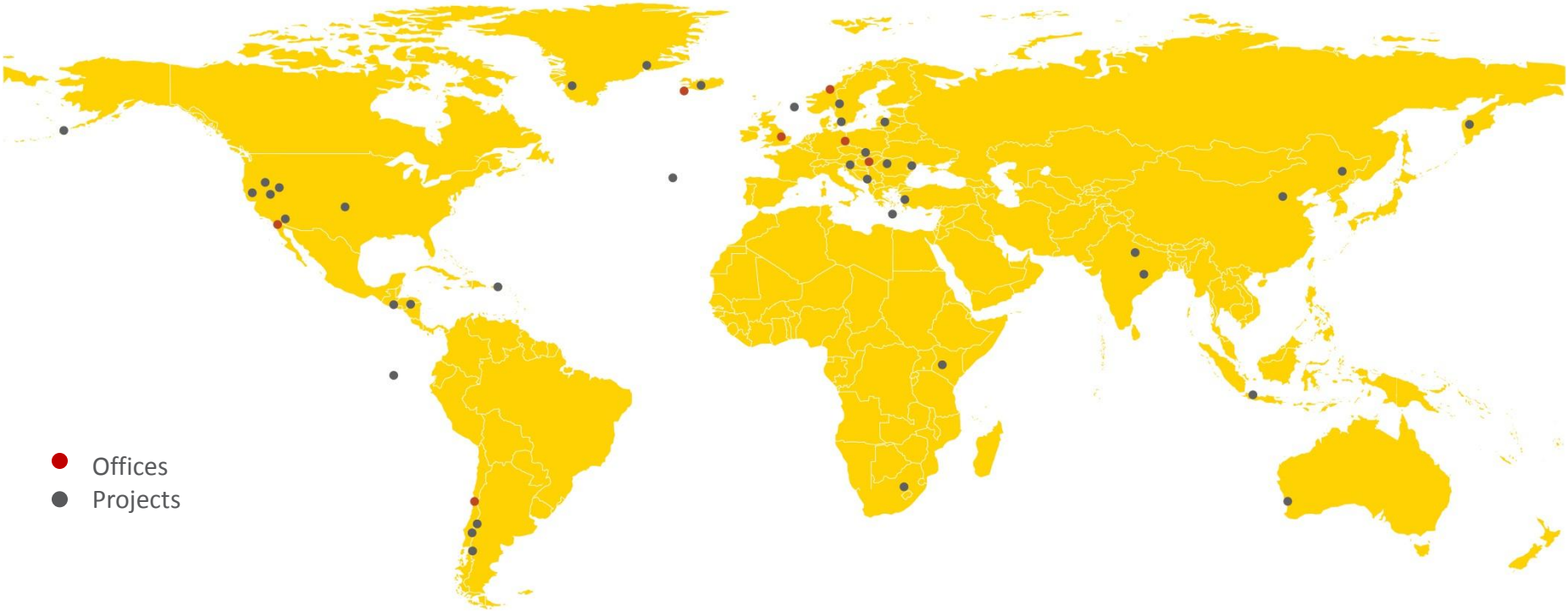
Project map & markets



USA
Geothermal Energy
Geothermal Development
Geothermal Exploration
Geothermal Drilling
Geothermal Power Plants

ICELAND
Eight locations

UNITED KINDOM
Industry
Anaerobic Digestion
Small Scale Hydro
Water Source Heat Pumps
Geothermal Energy

HUNGARY
(Central and Eastern Europe)
Geothermal Energy
Hydroelectric Power

NORWAY
Hydroelectric Power
Power Transmission & Distribution
Infrastructure & Transport
Buildings & Construction

CHILE
Geothermal Energy
Hydroelectric Power
Power Transmission & Distribution

Geothermal projects in Iceland

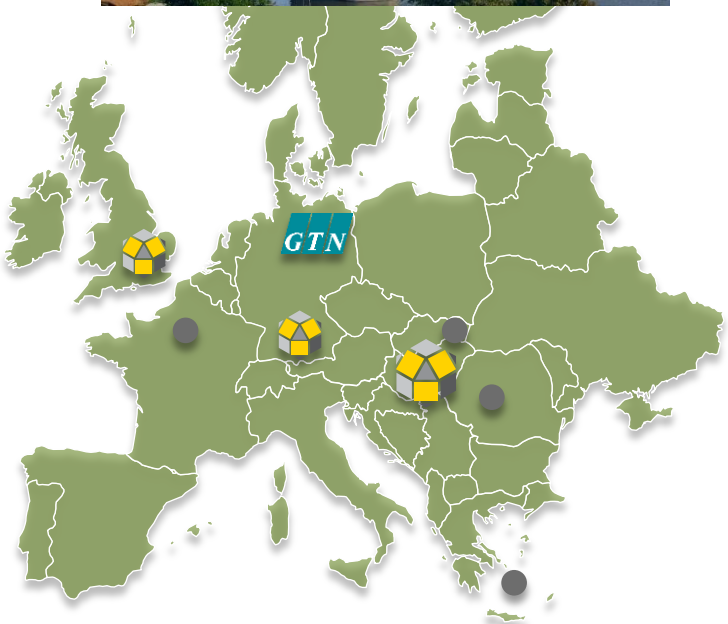
Nesjavellir	
Geothermal Power Plant in Iceland	
Size	• 120 MWe, 300 MWt
Project Cost	• 600 m €
Year	• 1986 - 2004
Role	• Lead design

Hellisheiði	
Geothermal Power Plant in Iceland	
Size	• 300 MWe, 400 MWt
Project Cost	• 1.000 m €
Year	• 2002 -
Role	• Lead design

Þeistareykir	
Geothermal survey and research	
Size	• 150 MW
Project Cost	• 190 m €
Year	• 2007
Role	• Project supervision and execution, model installation

Geothermal Energy – Mannvit Central Europe

- Office in Budapest since 2006
- Main goal: provide services in the green energy sector in Central-Europe, in line with EU 2020 goal
- 12 employees
- Continuous collaboration between Icelandic and Hungarian professionals
- Cooperation with local experts



Roots - Background

First Houses heated 1908

Drilling in Reykjavik 1928

Municipality Election 1938

Geothermal Service Map

Environmental Consulting

Services include:

- Geological and Hydro-geological analysis
- Air & Water quality
- Soil investigations
- Environmental modelling
- Project management
- Strategy assessment
- Operational licenses
- Environmental monitoring and mitigation
- Environmental Impact Assessment and modelling (surface flow groundwater and air)

Geothermal Exploration

Services include:

- Data mining & review
- Geological mapping
- Geochemical sampling & analysis
- Well siting
- Databases and data management
- Geophys. exploration:
  - Resistivity
  - Gravity
  - Seismic interp.
- GIS services & cartography

Geothermal Drilling

Services include:

- Pad preparation
- Well design
- Bid preparation
- Tender evaluation
- Supervision of drilling contracts
- Drilling Engineering
- Mud logging
- Inspection
- Work over programs
- Drilling supervision

Reservoir Engineering

Services include:

- Conceptual modeling
- Reservoir modeling
- Underground cold & heat storage
- Resource assessments & code classification
- Well testing and evaluation
- Reservoir monitoring
- Well logging

Power plants

Services include:

- Feasibility studies
- Cost estimations
- Conceptual design
- Process design
- Overall plant design
- Site layout & planning
- Equipment specifications
- Bid preparation and bid evaluation
- Site supervision
- Commissioning
- Acceptance test
- Training of operators
- Project management

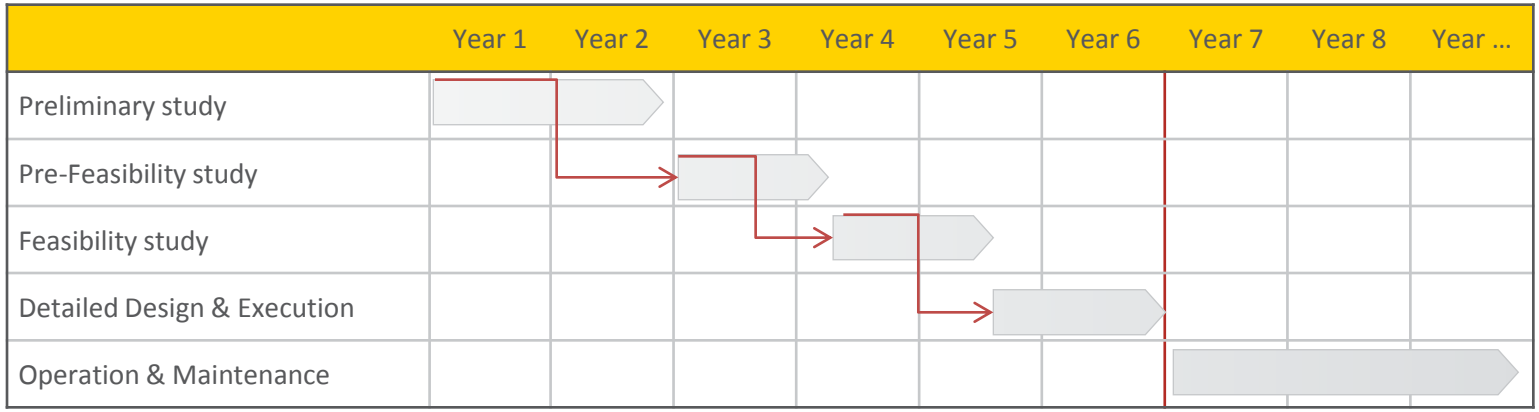
Geothermal Project Life Span

Example of 5 MW geothermal power plant

Mannvit is equipped to perform all tasks in the process

Project start up

- Reconnaissance
- Legal work
- Concession
- Permitting



Exploration

Preliminary

- Data collection & Analysis
- Geological survey
- Geochemistry
- Geophysical surveys
- Temperature gradient drilling
- GIS

Pre-feasibility

Data collection & Analysis

- Focused exploration
- Drilling of slim wells
- Drilling of deep exploration wells
- Resource evaluation
- Simple modelling

Feasibility

- Drilling of the first successful full-sized production well
- Confirmation wells
- Resource testing
- Resource power potential assessment
- Preliminary plant design

Implementation

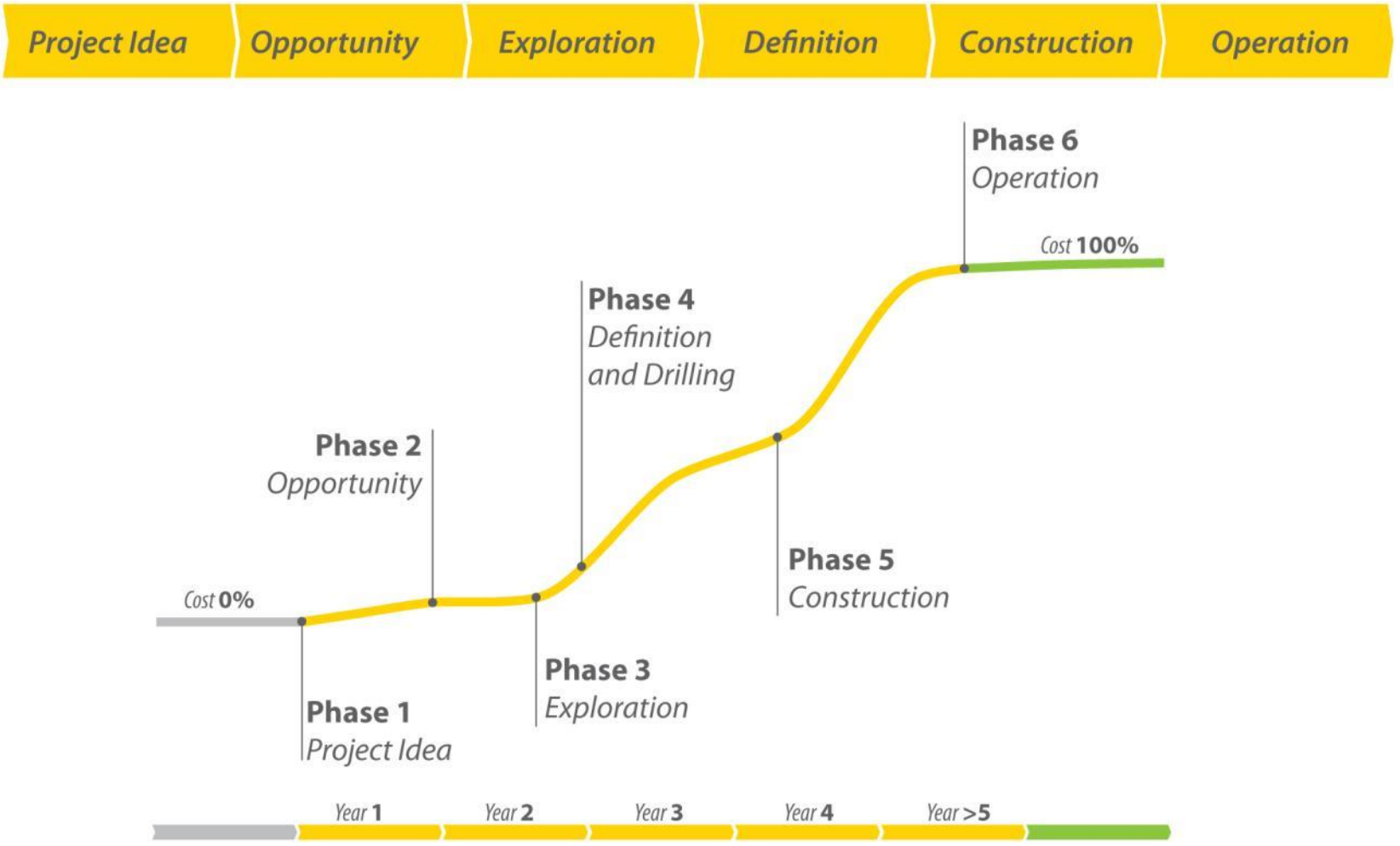
Det.design & Execution

- Drilling and testing of remaining wells
- Final plant design
- Plant construction
- Commissioning

Operation & Maint.

- Monitoring system
- Resource management
- Detailed modelling
- Plant maintenance
- Drilling of make up wells

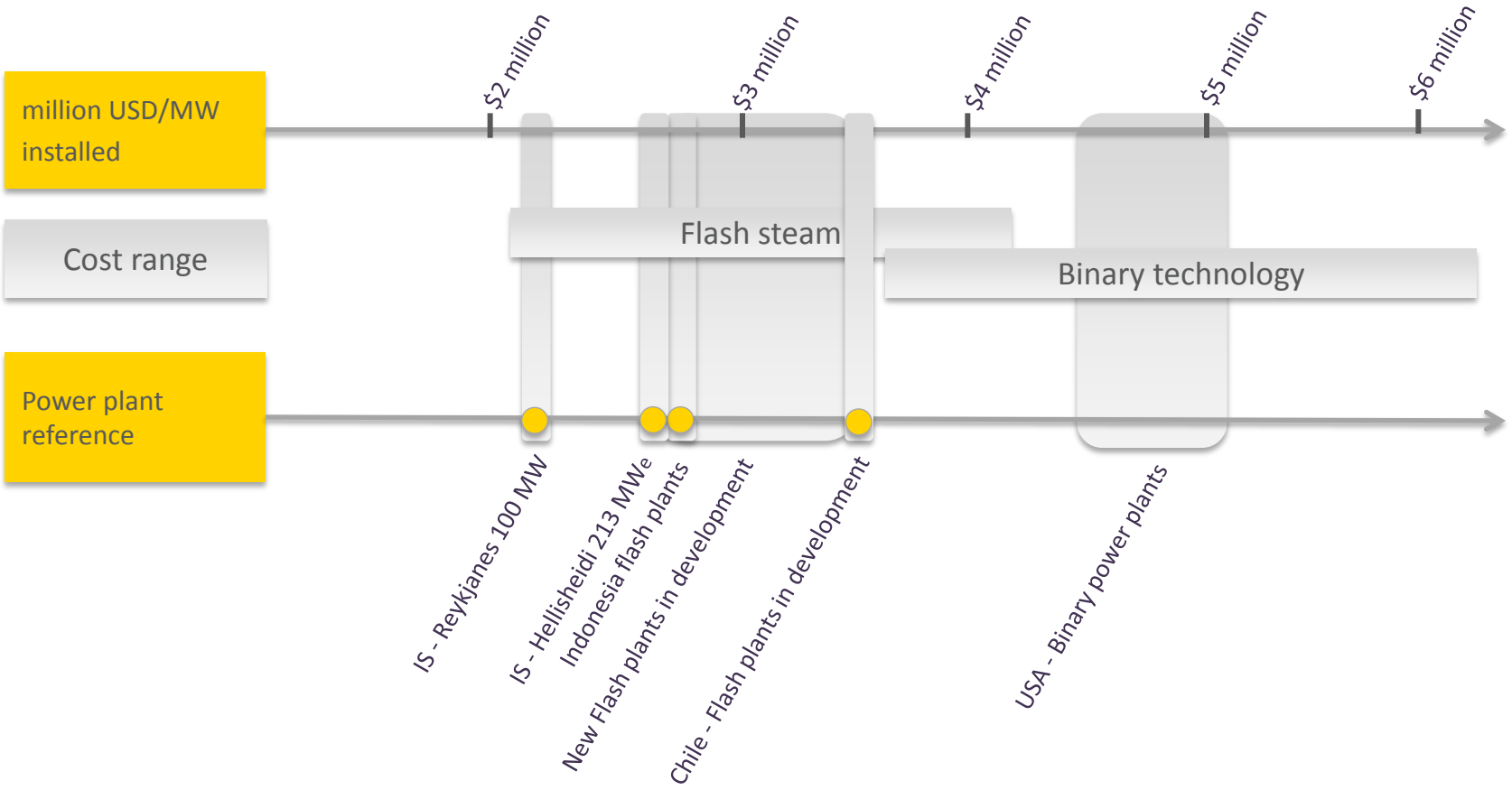
Project Development Cycle & Cost



Source: Mannvit

Typical geothermal project costs

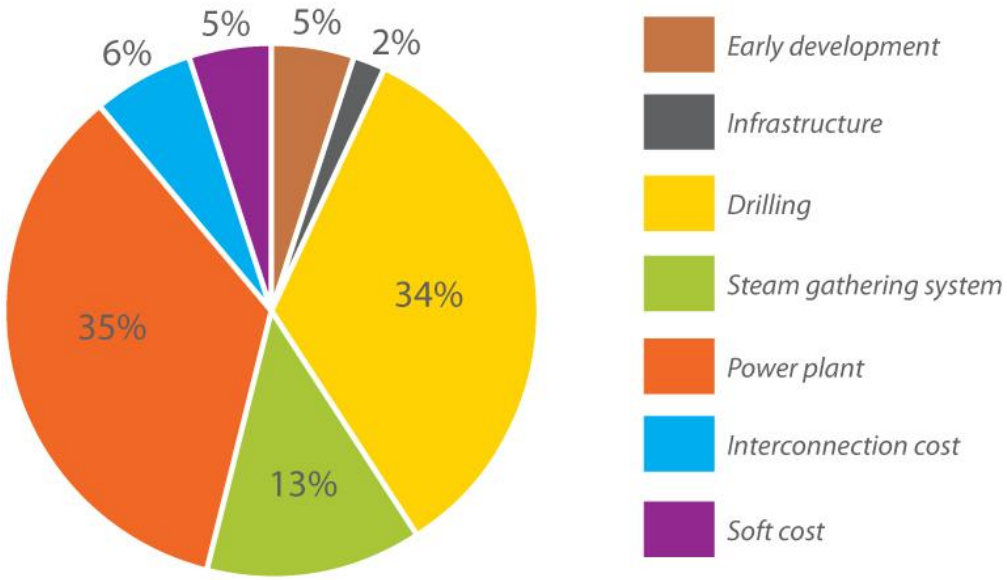
Costs of geothermal power dependent upon; fluid temperature, reservoir depth, fluid chemistry & gas content, well flow, pumping and cooling. Plant size is also an important factor.



Cost breakdown of a geothermal project

Typical cost

50 MWe flash plant



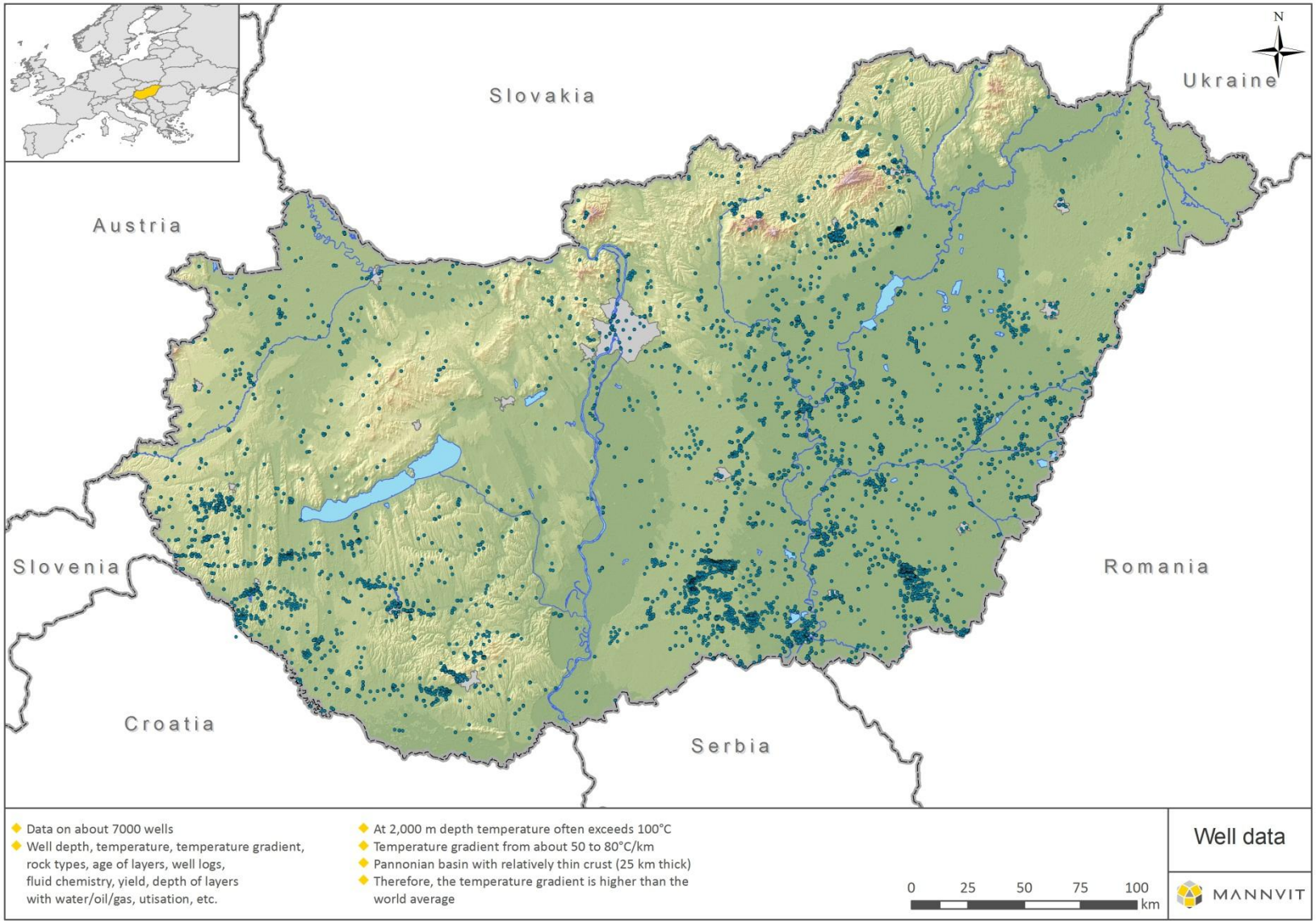
Source: Mannvit

Typical investment cost in flash plants in Iceland [1] pr MW electrical: US$ 2.5 to 3.0 million. Elsewhere this cost can be higher ($3-4.5 M).

The levelized (LCOE[2]) generation costs for flash steam to binary power plants is between **$42 to $80 per MWh** without tax credits.

1) Based on mean well output of 5 MWe . Includes drilling cost. Excluding transmission cost.
2) Levelized cost of Energy (LCOE) includes all the costs of producing the energy over the plant lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital and tax credits.

Well data


Slovakia
Ukraine
Austria
Slovenia
Romania
Croatia
Serbia
N
Data on about 7000 wells
Well depth, temperature, temperature gradient, rock types, age of layers, well logs, fluid chemistry, yield, depth of layers with water/oil/gas, utisation, etc.
At 2,000 m depth temperature often exceeds 100°C
Temperature gradient from about 50 to 80°C/km
Pannonian basin with relatively thin crust (25 km thick)
Therefore, the temperature gradient is higher than the world average
0 25 50 75 100 km
Well data
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Seismic measurements in Hungary

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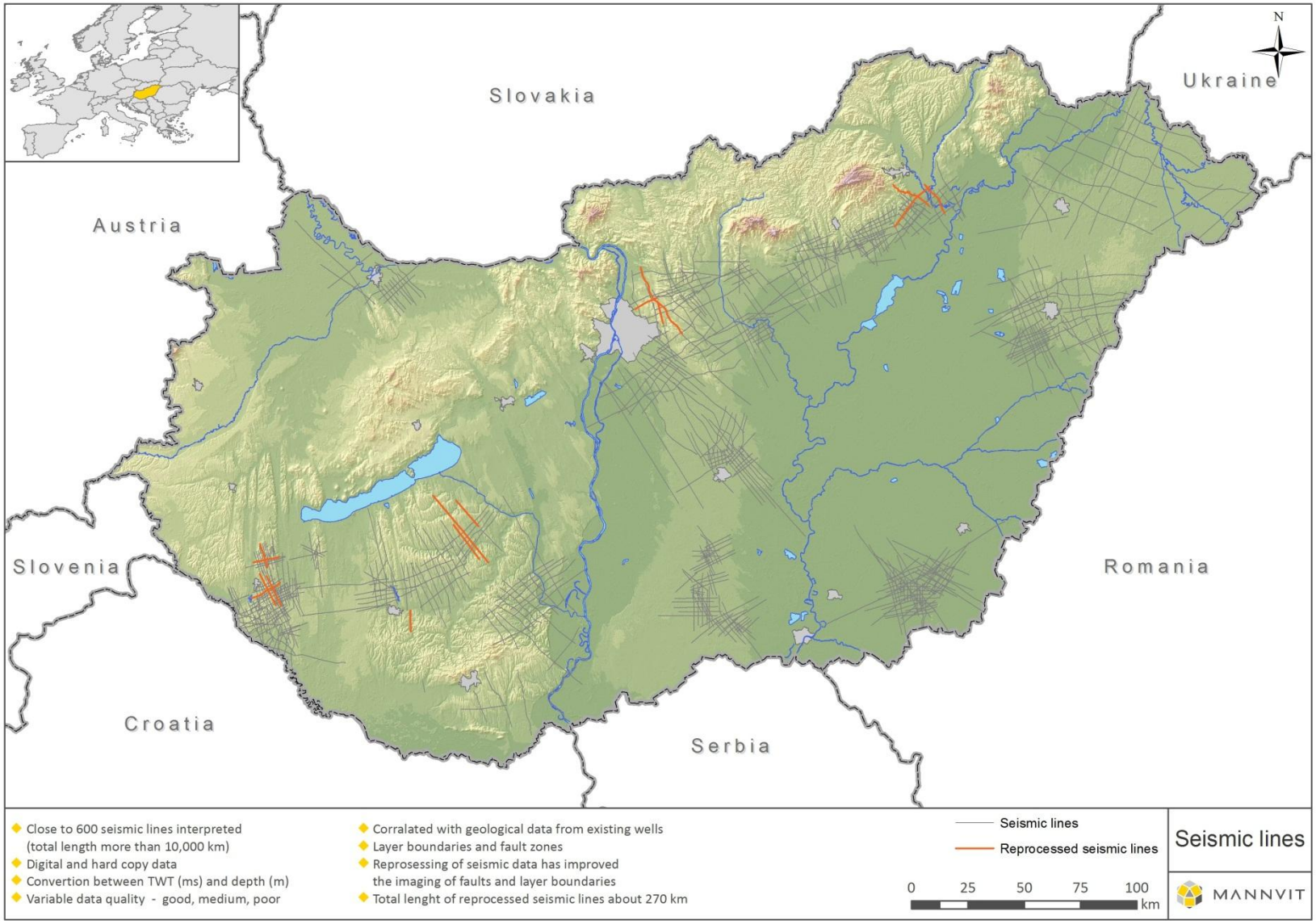
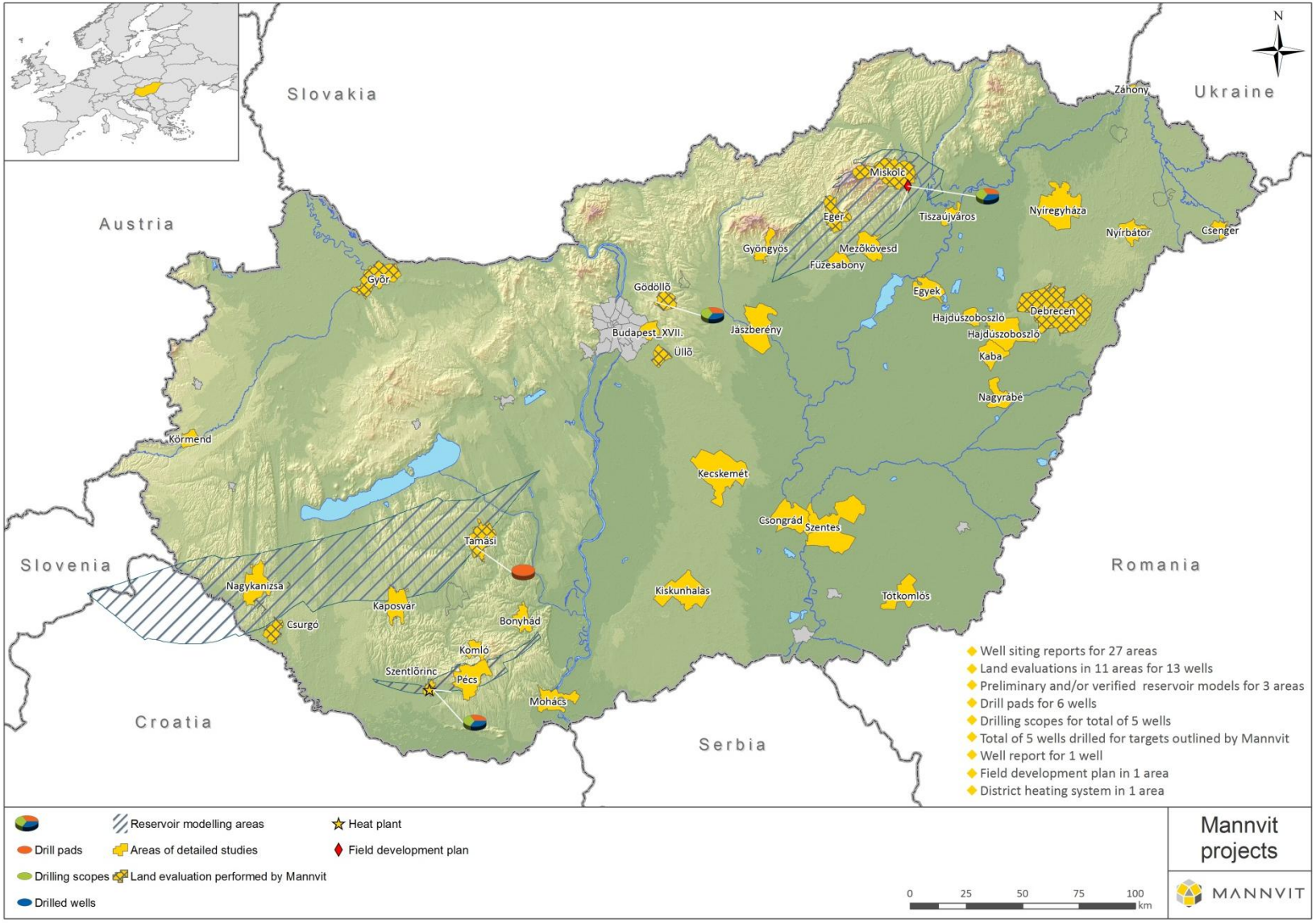
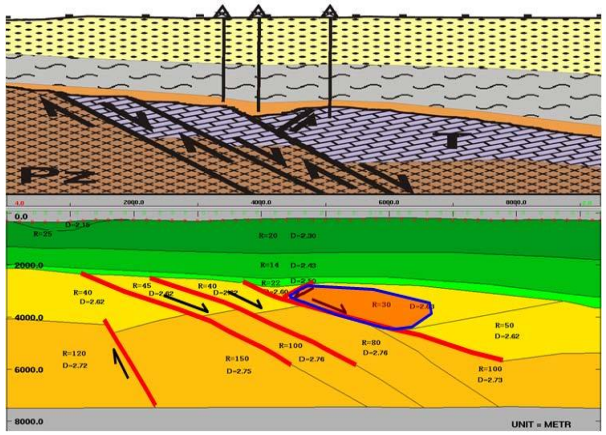
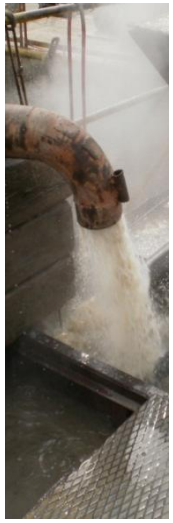


Projects


Slovakia
Ukraine
Austria
Slovenia
Romania
Croatia
Serbia
N
Záhony
Miskolc
Tiszaújváros
Eger
Nyíregyháza
Nyírbátor
Csenger
Gyöngyös
Mezőkövesd
Füzesabony
Gödöllő
Egyek
Debrecen
Hajdúszoboszló
Budapest_XVII.
Jászberény
Üllő
Kaba
Nagyrábé
Körmend
Kecskemét
Csongrád
Szentes
Tamási
Nagykanizsa
Kaposvár
Csurgó
Bonyhád
Kiskunhalas
Tótkomlós
Komló
Szentlőrinc
Pécs
Mohács
Well siting reports for 27 areas
Land evaluations in 11 areas for 13 wells
Preliminary and/or verified reservoir models for 3 areas
Drill pads for 6 wells
Drilling scopes for total of 5 wells
Total of 5 wells drilled for targets outlined by Mannvit
Well report for 1 well
Field development plan in 1 area
District heating system in 1 area
Reservoir modelling areas
Heat plant
Drill pads
Areas of detailed studies
Field development plan
Drilling scopes
Land evaluation performed by Mannvit
Drilled wells
0
25
50
75
100
km
Mannvit projects
MANNVIT

Geothermal Project Examples – Central Europe





Hungary

Evaluation of Geothermal Utilization

Type	• Geological and Geophysical studies. Site ranking and selection Technical viability
Project Cost	• 3,5 m €
Year	• 2006 - 2010
Role	• Lead consultant

Szentlőrinc, Hungary

Geothermal District Heating

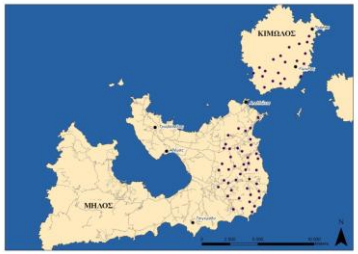
Project Data	• 3,1 MWth; 1820 m; 87°C; 26 l/s • 55 000 GJ deliverable heat
Project Cost	• 4 m € (with 34% subsidy)
Year	• 2008 - 2010
Role	• Geological and geophysical studies • Licensing and permitting • Well siting, design and testing • Drilling supervision • Reservoir modeling • EPCm - contractor

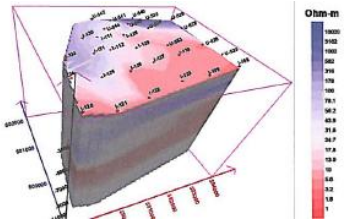
Miskolc

Geothermal Exploration for Heating

Project Data	• 2305 m; 105°C; 90 l/s • 410 000 GJ deliverable heat
Year	• 2008 - 2011
Role	• Geological and geophysical studies • Licensing and Permitting • Field Deveopment Plan • Well design and testing • Reservoir modeling • Environmental modeling • Drilling consultancy

Geothermal Project Examples – Central Europe





Slovakia	
Pre – Feasibilty Study for Electricity Production in Kosice	
Project Data	• 5-6 MWe expected capacity
Project Cost	• 300.000 €
Year	• 2009 - 2010
Role	• Geoscience studies • Geothermal reservoir modelling • Well siting • Environmental assessment • Drilling preparation • Pre - Engineering

Greece	
Geophysical Investigation on Milos and Kimolos	
Tasks	• Surveying 2 fields, Feasibility Study
Project Cost	• 350.000 €
Year	• 2008 - 2010
Role	• Lead consultant

Projects in Central Europe

Other Activities – various countries

- EU project, mapping CHP and geothermal potential in Serbia. Subcontractor of Eptisa s.e.e.
- Project Sponsors of Hungary NER300 application, Enhanced Geothermal System. In consortium with EU-FIRE-EGS
- Deep drilling exploration project in Prekmurje region, Slovenia together with Geoeks, purpose to produce electricity.
- Participation in the Geoelec EU project, purpose to attract investors and electrical utilities to invest in geothermal electricity
- Mannvit is working in Bosnia Herzegovina developing geothermal possibilities in the city of Banja Luka in cooperation with the city and the ministry of Energy and Mining for the Republic of Srpska.

Clear benefits …

… of geothermal energy

Budapest January 7th 2009

Szentlörinc
Sept. 13th 2009, clean renewable energy

Miskolc
Sept. 1st 2010, clean renewable energy

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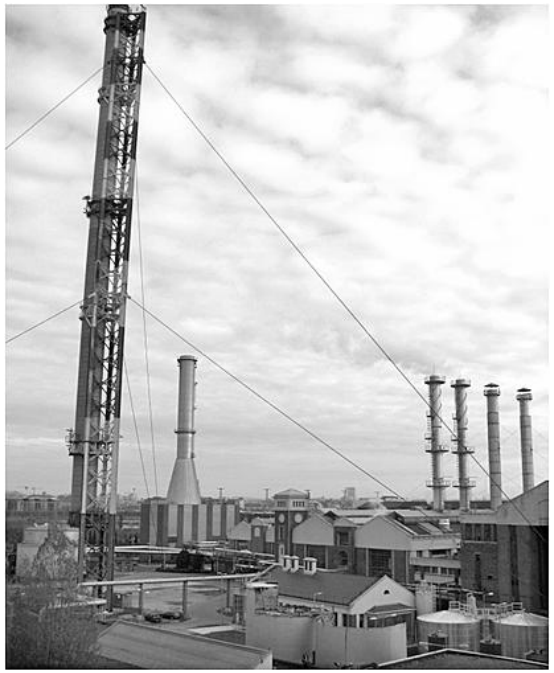
Present



Future

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