The Assessment of potential and promotion of new generation of renewable technologies - Geothermal Energy

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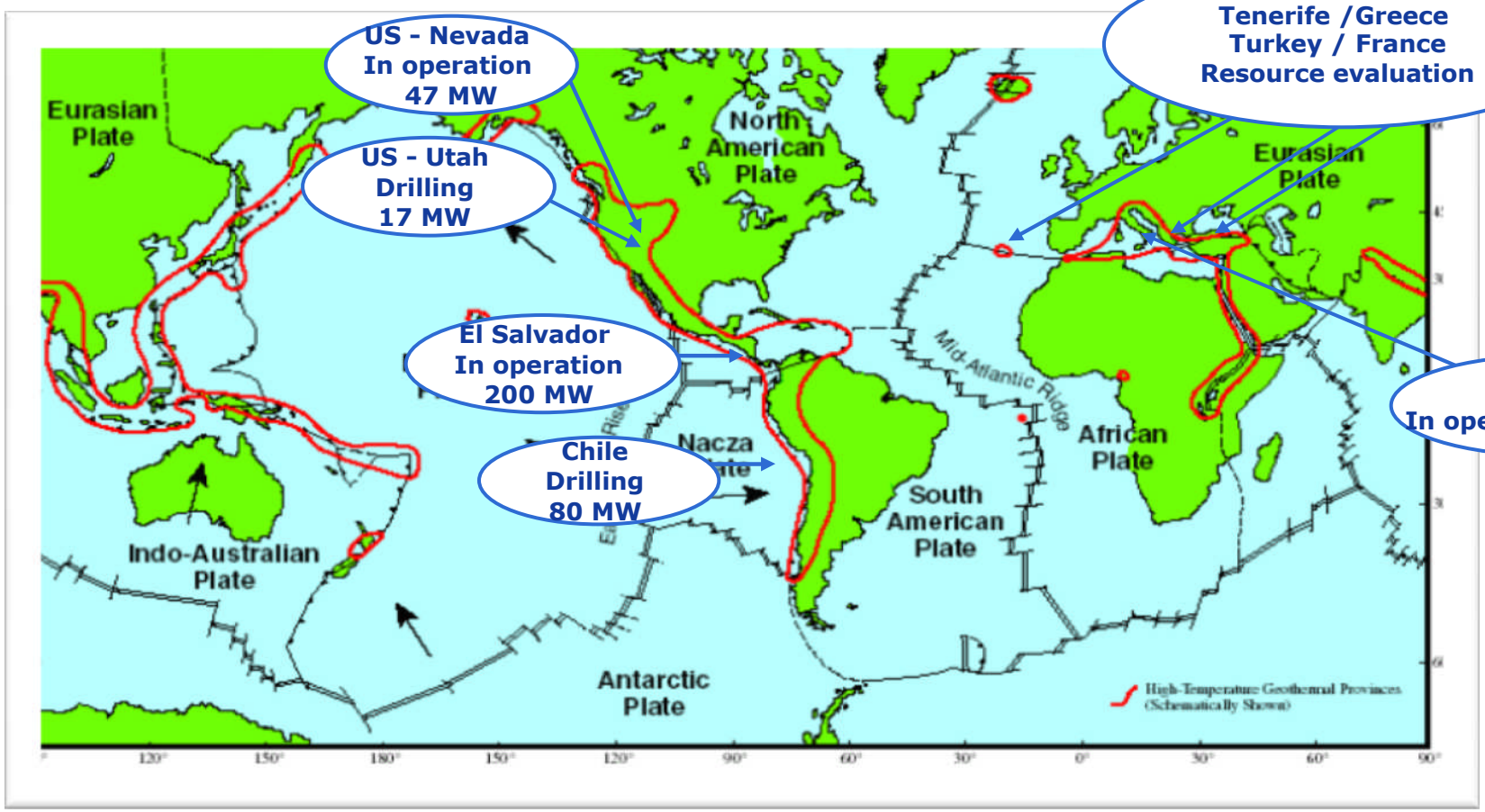
Bruxelles, 22nd March 2011

Global Resources Availability and EGP presence

- 35 plants - 750 MW* - 5,200 GWh
- 460+ people involved in operation
- Types: dry steam, flash steam and binary cycle
- Operations since 1904



* *Consolidated MW as of June 2010. El Salvador capacity is not consolidated.*

European Geothermal Energy Council

WHO IS EGEC ?

THE VOICE OF THE GEOTHERMAL SECTOR IN EUROPE

EGEC, the European Geothermal Energy Council, was founded in 1998 as an international non-profit association in Brussels. Its office is based nearby the European Institutions.

- EGEC has now members from 20 different European countries
- EGEC is a member of EREC, the European Renewable Energy Council, which groups together all main European renewable energy industry and research associations under one roof, in the Renewable Energy House.
- EGEC is also a member of the International Geothermal Association (IGA).

OBJECTIVES

The aims of our organisation are to promote the use of geothermal energy, as follows :

- Promote the market deployment of geothermal energy in Europe and the export of European geothermal technology, services and equipment to other parts of the world.
- By exercising appropriate actions among European institutions to implement a legal and institutional framework and fiscal instruments allowing geothermal sources to compete with conventional energy systems, and to secure economic support in consideration of the environmental benefits.
- By encouraging R&D in the field of geothermal utilisation of the existing resources in Europe and allowing the public at large to access to the R&D results and maximise the utilisation of this renewable energy.
- By representing the interests of the European geothermal energy industry and users to governments and international organisations, with a view to improving business conditions for the industry.
- By co-operating with national geothermal associations, and in particular with the International Geothermal Association (IGA) and its European branch, and with any other associations promoting research and application of renewable energy sources, in order to join forces to achieve successful development and implementation in the field of geothermal energy use throughout Europe, and to foster Inter-European cooperation.
- By disseminating, through publications, meetings, discussions or any other activity, the use of geothermal energy, as well as its marketing, and to forward information on products and services to authorities, industry, and the public at large.
- By publicising, at European level, the opinions of researchers, engineers, managers, and any other commentators or proponents on the use of geothermal energy, and bringing them to the attention of governments, national and international organisations, decision makers, and the public at large.

Photo credits: EGEC, IGA

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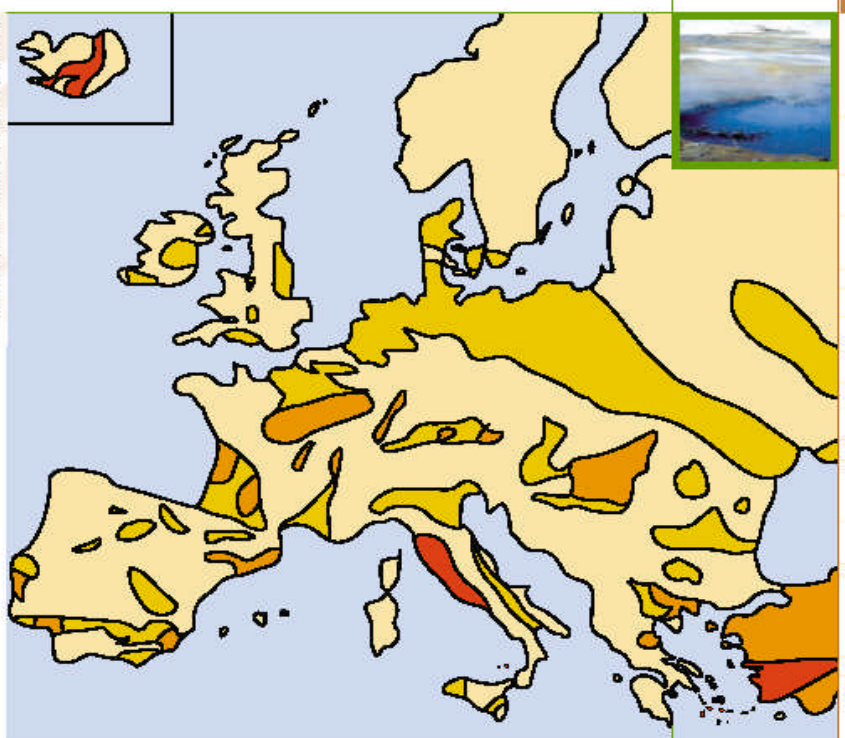
EUROPEAN GEOTHERMAL ENERGY COUNCIL



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GEOTHERMAL ENERGY

GEOTHERMAL ENERGY :

from the earth, a renewable energy resource delivering heat and power 24 hours a day throughout the year, an energy resource nearly infinite and available all over the world.

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European Geothermal Power Market
Vision 2050 – EU27

EU27 - Geothermal Power Installed Capacity (2007-2050)

Geothermal Electricity (MW)	2007	2010	2020	2030	2050
Electricity Conventional	815	920	1,200	2,000	2,500
Electricity Low Temperature	15	70	300	5,000	7,500
Electricity EGS	-	10	4,500	15,000	90,000
Total Installed Capacity	**830**	**990-1,000**	**1,500-6,000**	**7,000-21,000**	**10,000-100,000**
Yearly Electricity Production (TWh)	**6.5**	**8.0**	**50.0**	**234**	**780**

Based on existing technologies

EGS still at very early stage of development

Source: EGEC data in RE-thinking 2050, April 2010.

Note: At the end of 2010 10MW EGS pilot plants will be operating (of which: 1.5MW in France, expected to be upgraded to 5MW by year-end and 3MW in Germany). In order to achieve the forecasted installed capacity, EGS commercial plants are expected to have an average capacity of 25-50 MW each.

European Geothermal Power Market
Breakdown by Key Markets - 2020

EU27 Markets

Installed Capacity (MW)	2009	2015	High / Low Enthalpy in the Country
Italy	843	923	High / Low
Portugal	23	60	High
Spain	-	40	Low
Greece	-	30	Low *
France	17	35	High
Germany	7	15	Low
UK	-	-	Low
Austria	1	5	Low
Czech Republic	-	5	Low
Hungary	-	5	Low
Romania	-	5	Low
Slovakia	-	5	Low
Netherland	-	5	Low
Latvia	-	-	Low
Poland	-	1	Low
Total	**891**	**1.134**	

Other European Markets

Installed Capacity (MW)	2009	2015	High / Low Enthalpy in the Country
Iceland	573	800	High
Turkey	87	206	High / Low
Russia	82	194	High
Total	**742**	**1.200**	

Industry development plan in Europe should be in both traditional high temperature resources and binary projects

Sources: IGA, EGP estimates, ABS The Geothermal Energy Report, EER.
** High enthalpy is available in Greece, but public opposition is blocking every commercial initiative in this technology.*

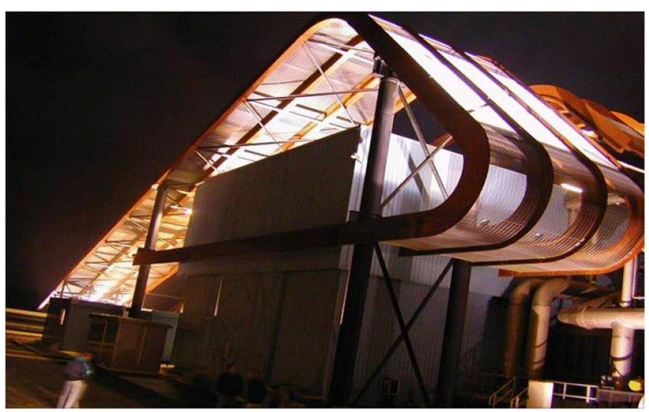
European Geothermal Power Market
Key Barriers and Actions Needed

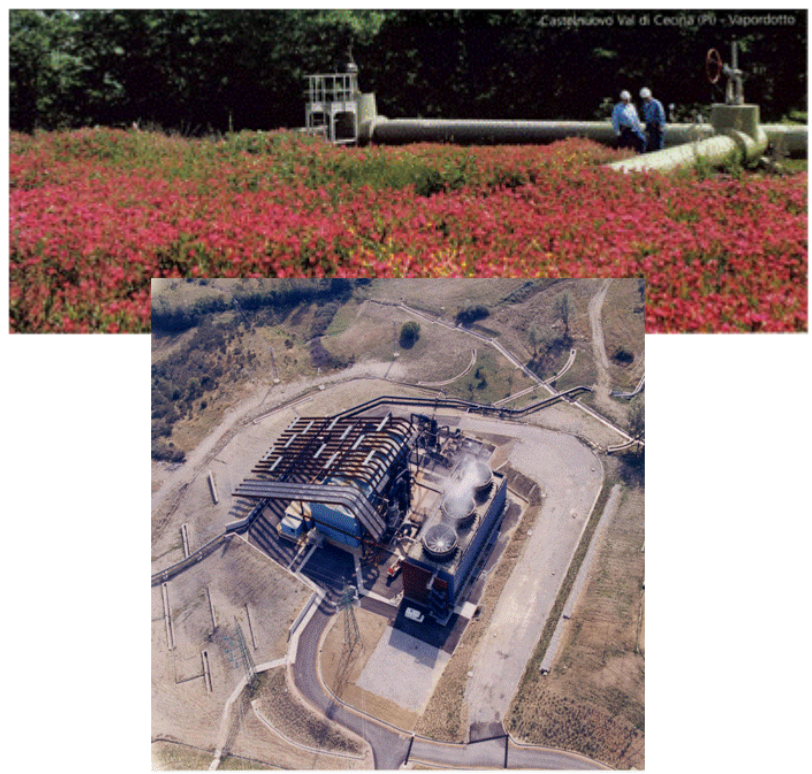
Barrier	Description	Actions Needed
Resource	• Geothermal resource availability • Well productivity & field capacity • Presence of earthquakes-volcanic activity near the resource	• R&D activity: technology improvements to identify the resource and to exploit geothermal resources at different temperatures • Coordination of activities to share exploration results (i.e. public databases providing location of resources)
Environment	• Regulation for construction and operations • Air emissions & noise pollution • Visual impact	• Coordination of activities to address permitting issues • Technological solutions (i.e. Enel development of AMIS technology) • Architecture solutions
Project economics	• High initial investment costs • High O&M costs • Financial support and incentives	• Coordination at EU, national and regional levels to support and regulate the sector, providing visibility • Support bank financing
Social	• Misleading information • Lack of knowledge • Local hostile institutions / environmental associations	• Creation of consensus through information and communication • Improvement of the relationship with communities
Demand	• Trend of energy demand • Competition from other renewable sources	• Planning of geothermal projects with grid access • Support to distributed generation/smart grids

EGP in Italy

To reduce environmental impacts

- Innovative AMIS© technology to decrease H_2S and Hg emissions
- Environmental plans: 30 M€ invested in land recovery
- New architecture solutions to create consensus and avoid negative visual impact





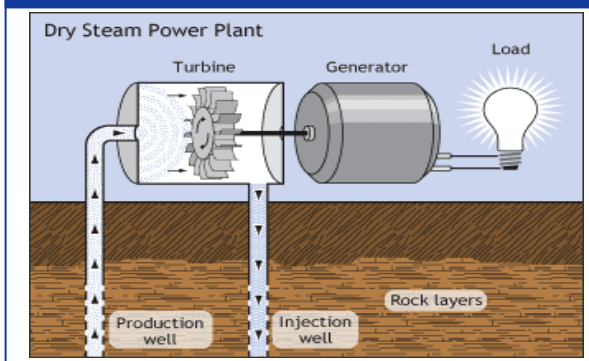
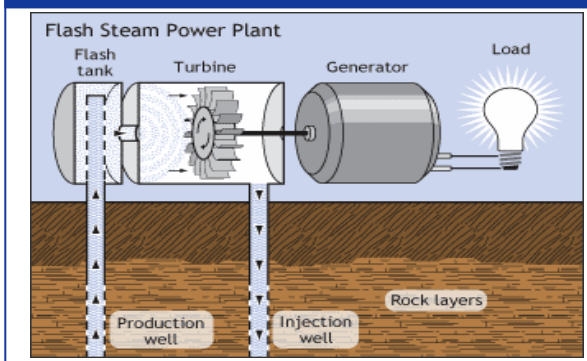
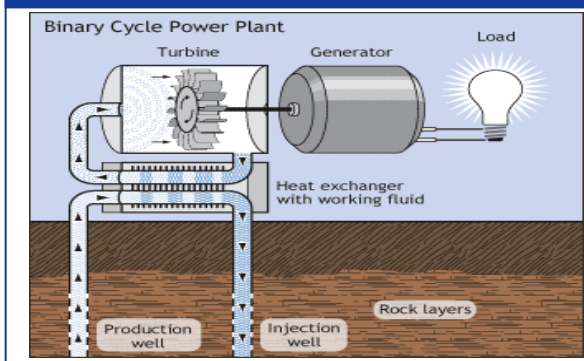
To increase social acceptance

- Improved communication to local communities (ISO 14001 certification for each power plant, technical data on air and water quality, etc.)
- Diffusion of knowledge on geothermal technology (i.e. cooperation with schools)
- Improved cooperation with the regional Authority to achieve an agreement in terms of environmental standards

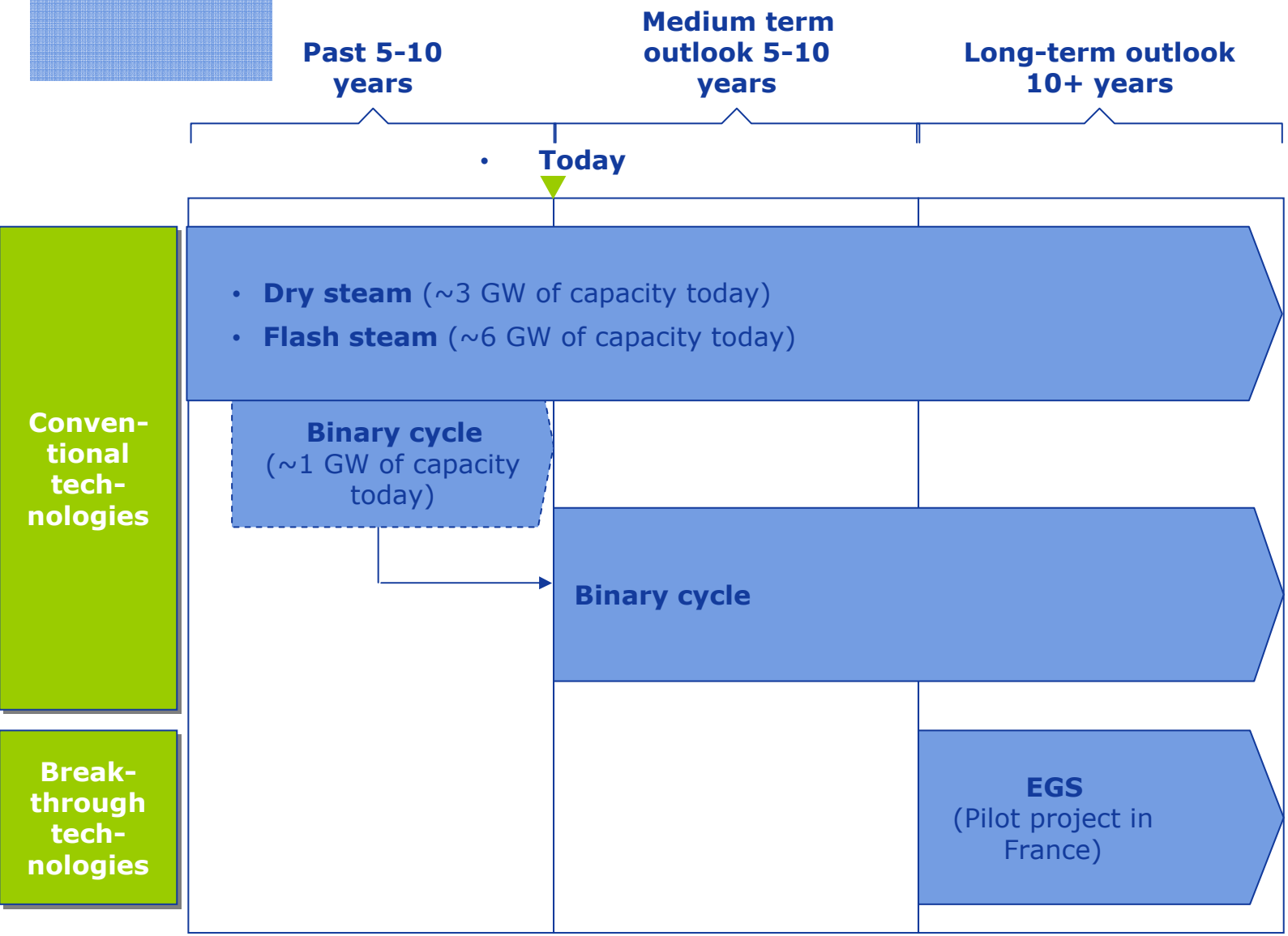
Classification of Geothermal System

	Water presence (as carrier medium)	
	Wet•	**Dry•**
•Shallow reservoirs •5: 500 m	**•Conventional hydrothermal systems or heat exchange** • **Description: Hot shallow** reservoirs are used for generation of electricity in a conventional geothermal system • **Cold shallow** reservoirs are used for heat exchange, cooling buildings in summer and heating in winter • **Uses:** Electricity generation and heat	**•Heat exchange** • **Description:** Heat pumps are used to transfer heat between the surface and subterranean levels • Methods include horizontal loops, borehole heat exchanges, and energy piles • **Uses:** Heat exchange
•Deep reservoirs •500: 5000 m	**•Conventional Hydrothermal systems** • **Description:** Super heated ground water is released through geothermal wells and is transformed into steam to generate electricity as it travels toward the surface • **Uses:** Electricity generation	**•Enhanced geothermal systems** • **Description:** Hot dry rock reservoirs are developed by injecting high pressure water into a stressed zone, causing it to fracture. Heat is transferred to the water, used for generation and re-injected into the reservoir, forming a closed-loop system • **Uses:** Electricity generation

Classification of Geothermal Plants

•Dry steam power plants	•Flash steam power plants	•Binary cycle power plants
		
Dry steam plants use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity.	**•Flash steam power plants** tap into reservoirs of water with temperatures greater than **182ºC**. As it flows, the fluid pressure decreases and some of the hot water boils or "flashes" into steam. The steam is then separated at the surface and is used to power a turbine/generator unit	**•Binary cycle power plants** operate on water at lower temperatures of about **107-182ºC**. These plants use the heat from the geothermal water to boil a working fluid, usually an organic compound with a low boiling point.
Global Installed capacity 2007		
Units	58	195	237
Capacity (GW)	2.6	5.6	0.8
• Highly cost competitive but geographically limited	• Most dominant in terms of global capacity	• Useful alongside geothermal heating, hot springs, etc

Geothermal Forecasting



- **Rationale**

- **Mostly proven** and cost-effective technologies
- **Incremental plant technological advances** going forward
- **Binary only** as an **ancillary** application due to infancy stage of technological development (i.e., higher costs)

- **Binary** proven to be a **self-standing technology**, increasing overall installable potential
- **Economics** not yet in line with steam technologies (dry and flash), **expected to improve in the long term**

- **Technology still in "development"** phase
- **Under certain technological development outlook** (i.e., fast decrease in technology costs), expected to **increase installable potential**
- To be addressed current issues of seismic complications and poor replicability across sites

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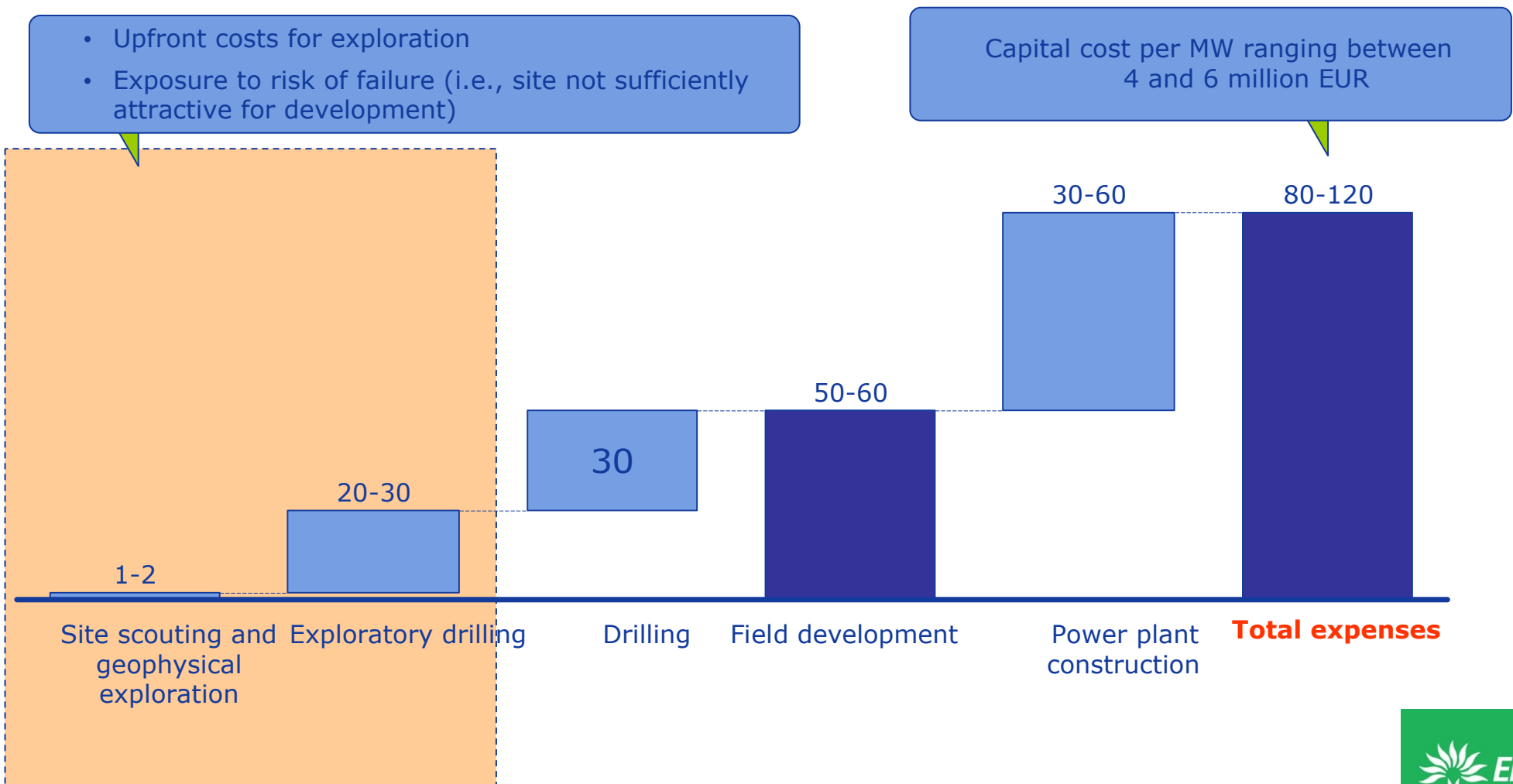
Geothermal electricity Cost

MAIN GOVERNING FACTORS

- Nature of the Project (greenfield vs. expansion)
- Size of the project (economy of scale)
- Rock and Resources characteristics (site accessibility, depth, permeability, volume of reservoir, temperature, well productivity, water table level, chemical and gas contents, fluid pressure, thermodynamical fluid characteristics)
- Permitting and Environmental constraints
- Grid access
- Cooling system: water vs. air
- Scaling, corrosion, H_2S abatement system , non-condensable gas

Geothermal electricity Cost

EUR million, based on a 20 MW plant

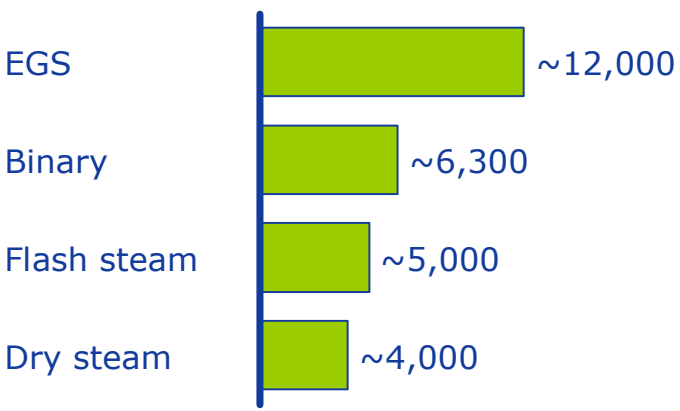


Geothermal electricity Cost

Costs for geothermal are site specific and differ by technology…

Capital cost

2007, EUR/KW installed



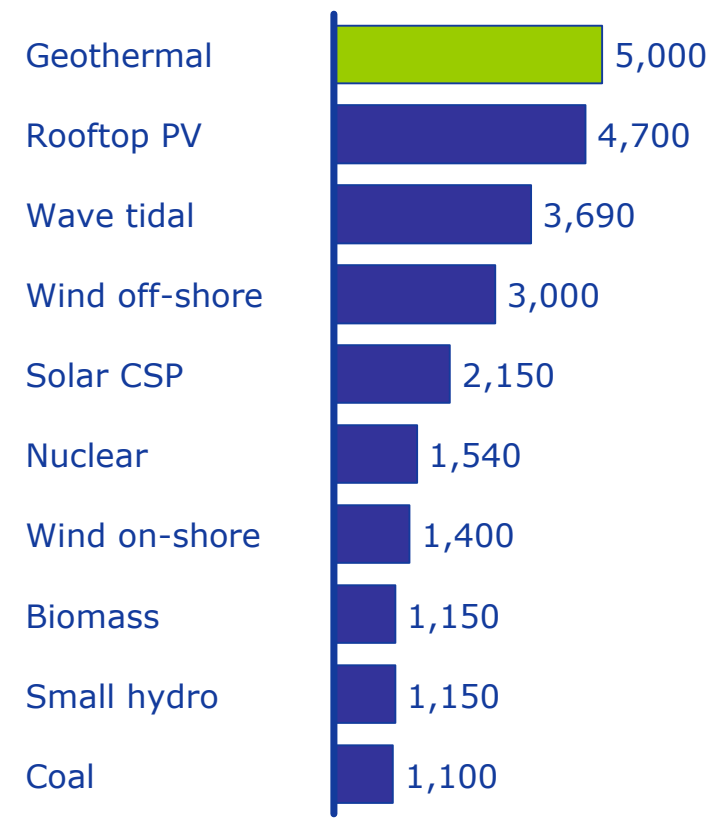
Capital cost is highly dependent upon drilling

- The **number of geothermal wells** required (mass-flow rate)
- The **depth of drilling** (temperature required)

…and do not yet compare well to non-renewable technologies

Capital cost

2007, EUR/KW installed

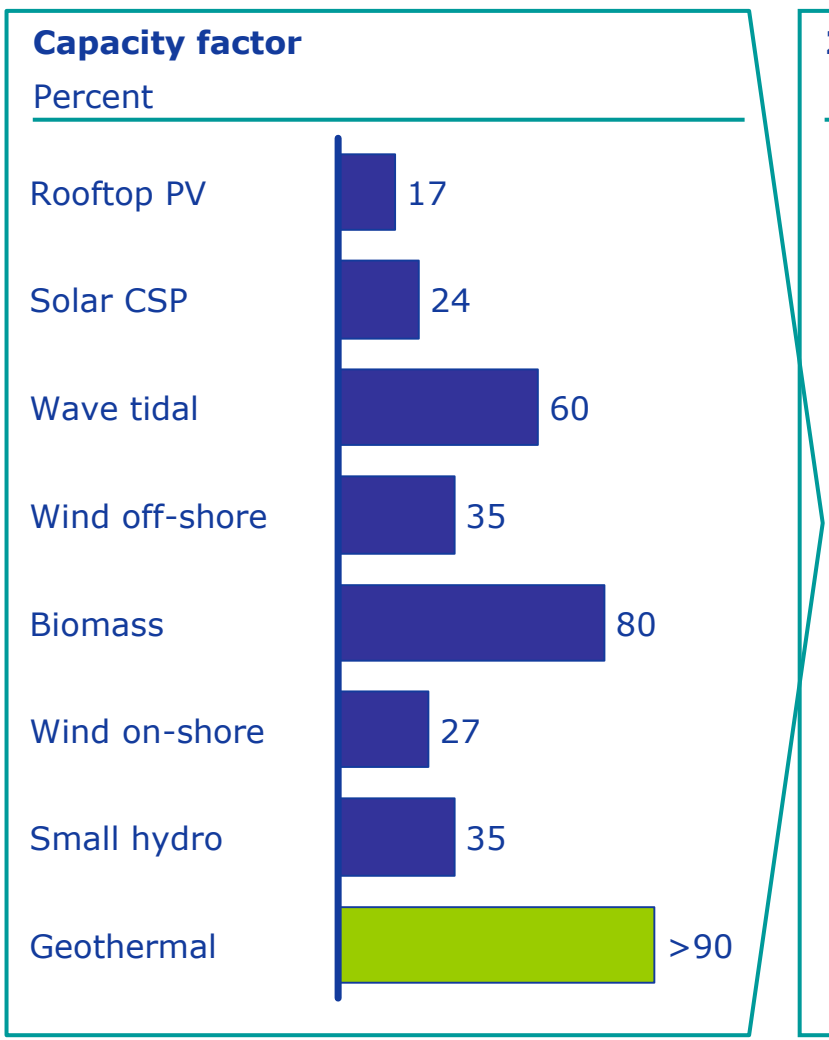


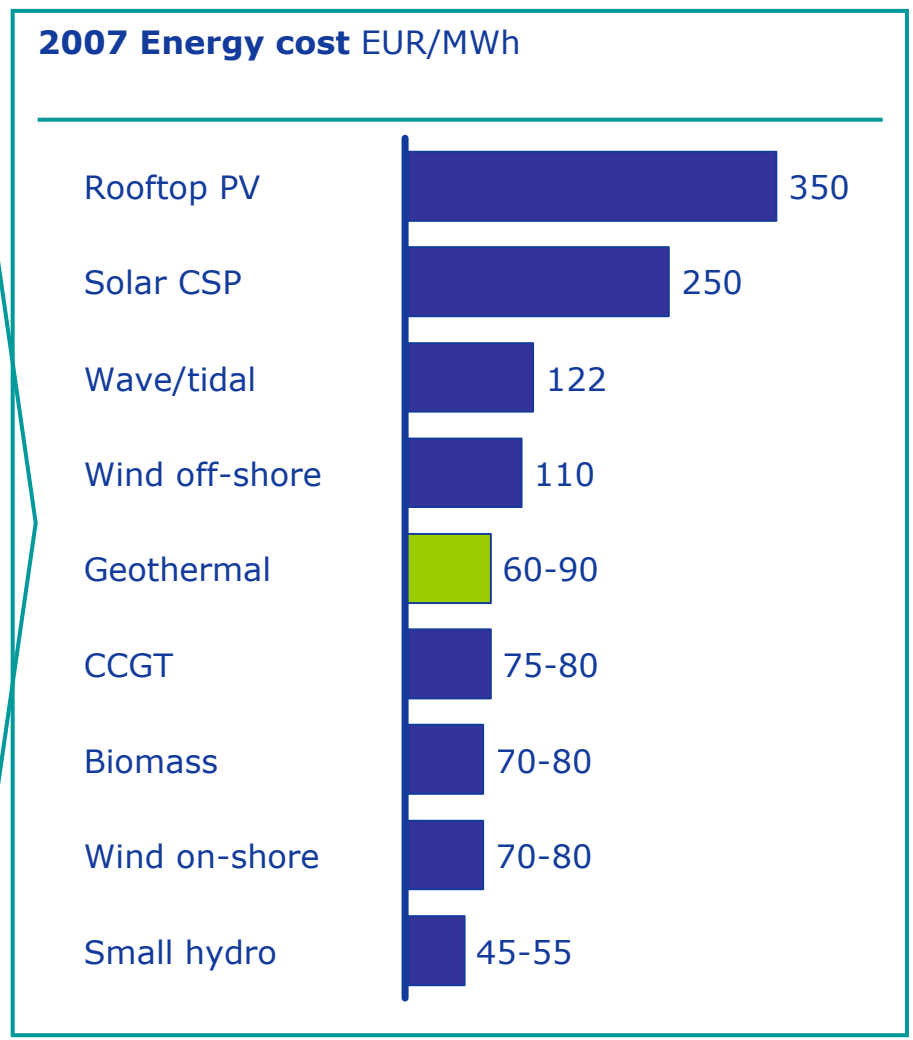
Geothermal generation capital costs

- Are large and highly dependent upon the specific site and technology
- Require a greater investment than all other renewable and conventional technologies

13

Geothermal electricity Cost





Among the renewable, **geothermal energy is best suited for base load capacity**, having

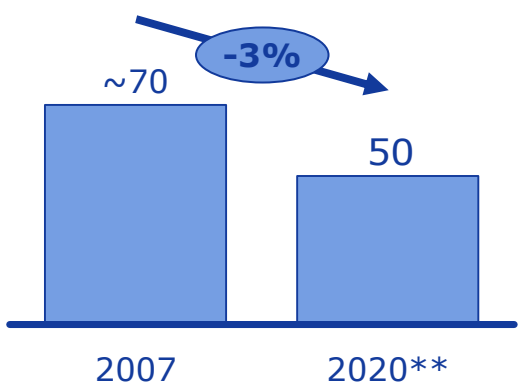
- High capacity factors
- Low full generation costs

14

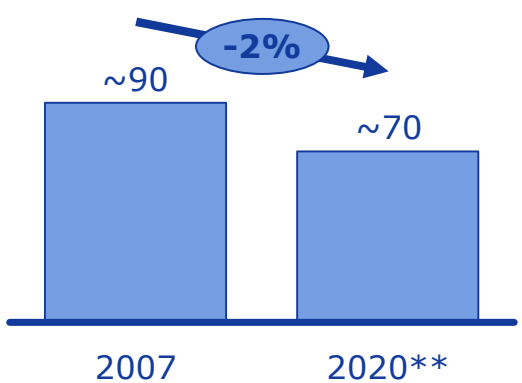
Geothermal electricity Cost

LCOE, EUR/MWh

Dry and flash steam



Binary cycle



Assumptions

- Reduction in **drilling and exploration** costs of 25% (improvement beneficial to all geothermal technologies)
- Incremental decrease in **plant construction** cost of ~1.3% p.a. (driven by 10% historical learning effect and demand evolution from current ~10 GW to ~30 GW by 2020) driving CAPEX
  - » From ~5 million to 4 million/MW for flash steam technology
  - » From 6 million to ~5 million/MW for binary cycle technology
- Higher **plant availability** from 6/7000 hours of utilization to 8,400 hours

Geothermal and other Renewables

* = Estimated

	Installed capacity		Production per year		Capacity factor (%)
	GWe	%	TWh/yr	%	
Hydro	778	87.5	2,837	89	42
Biomass	40*	4.5	183	5.7	52*
Wind	59	6.6	106	3.3	21
Geothermal	**9**	**1.0**	**57**	**1.8**	**72**
Solar	4	0.4	5	0.2	14
Total	890	100	3,188	100	41

Geothermal energy is available day and **night every day of the year** and can thus serve as a partner with energy sources which are only available intermittently.

It is most economical for geothermal power stations to serve as **base load** throughout the year.

Geothermal and other Renewables

	GWh	%
Coal	6.944.328	39,61
Gas	3.418.676	19,50
Nuclear	2.738.012	15,62
Oil	1.170.152	6,67
Other sources	2.292	0,01
Non-renewables total	**14.273.460**	**81,42**
Hydro	2.889.094	16,48
Biomass	149.811	0,85
Waste	77.471	0,44
Wind	82.259	0,47
Geothermal	55.896	0,32
Solar thermal	1.608	0,01
Solar PV	840	0,00
Tide, Wave, Ocean	551	0,00
Renewables total	**3.257.530**	**18,58**
Total world generation	**17.530.990**	**100,00**

The present geothermal installed capacity of 10 GW is expected to increase up to **11 GW in 2010.**

The overall CO_2 saving from geothermal electricity can be in the range 1000 (coal)/500 (gas) million tons per year, if the target of 140 GW will be reached

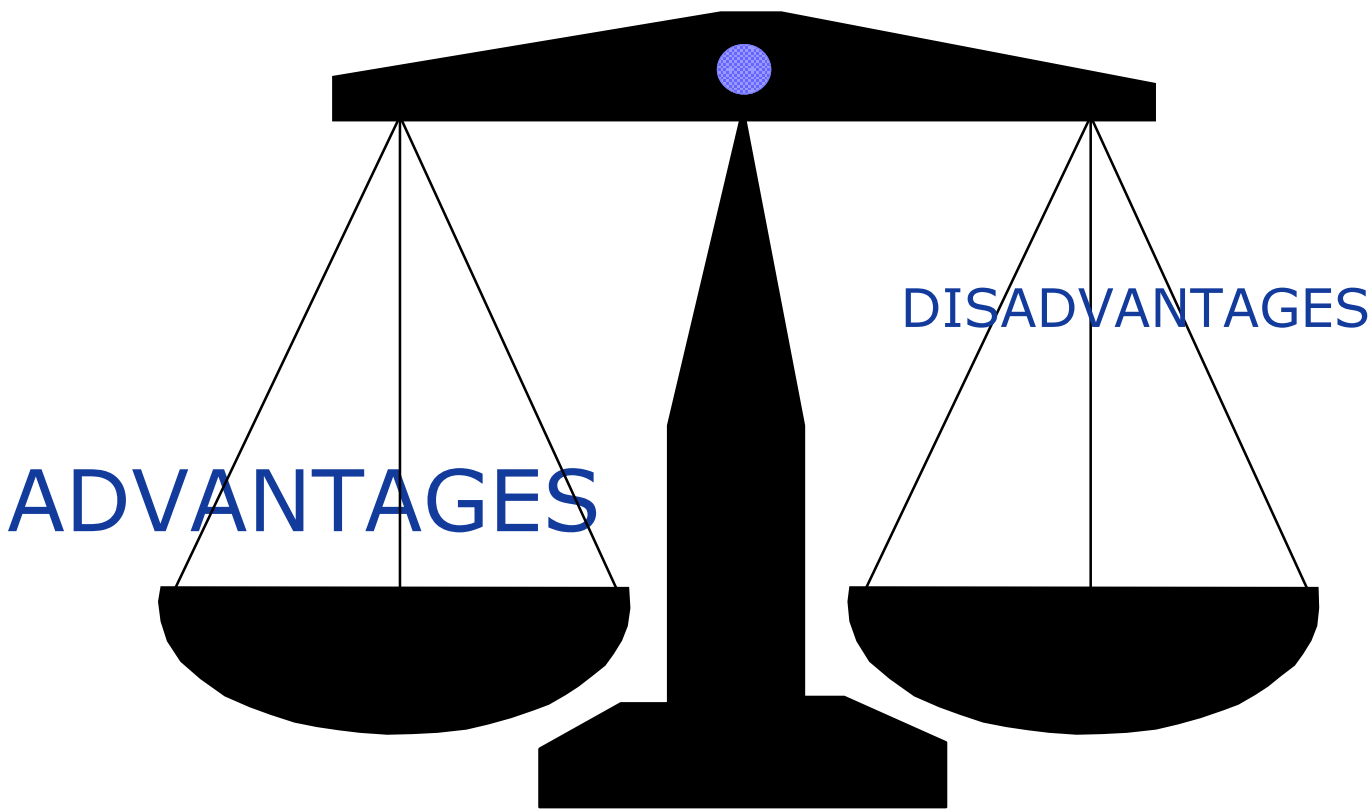
Geothermal and other Renewables

Favorable

Not favorable

	Current costs	Technology features					Environment	
	Electricity generation costs	Technical potential	Maturity	Base load stability	Capacity factor	CHP potential	CO_2	Footprint (land use)
Geothermal								
Conventional hydrothermal								
EGS								
Wind								
Photovoltaics								
Biomass								
Small hydro								

Geothermal Advantage



Geothermal Advantage

ADVANTAGES

Indigenous and Sustainable Resource

Environmentally Benign

Readily Available, Easily Tapped

Competitive Cost

Enormous Resource Base

High Availability, not bounded by external factors

Appropriate for Electricity Generation as Base Load Resource

Cascade Direct-Heat Utilization

Geothermal Advantage

ADVANTAGES

IT IS CLEAN

IT IS HOMEGROWN

IT IS SUSTAINABLE

IT IS CHEAP

Geothermal Advantage

DISADVANTAGES

Electricity production, with present technology,
is bounded only to limited areas
where geological conditions are favorable

It requires big initial investment,
generally not accessible to small companies

It requires a risky exploration phases,
which can result as a no-profit activity
in case of negative results

Geothermal Advantage

Geothermal Energy:

FIRE

WITHOUT

SMOKE