26th – 29th April 2016 • Reykjavik, Iceland
The Iceland Geothermal Conference 2016

Early Stage Geothermal Development Support: PLUTO and EBRD's Experience in Turkey

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Energy Efficiency and Climate Change (E2C2)

European Bank
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EBRD at a glance

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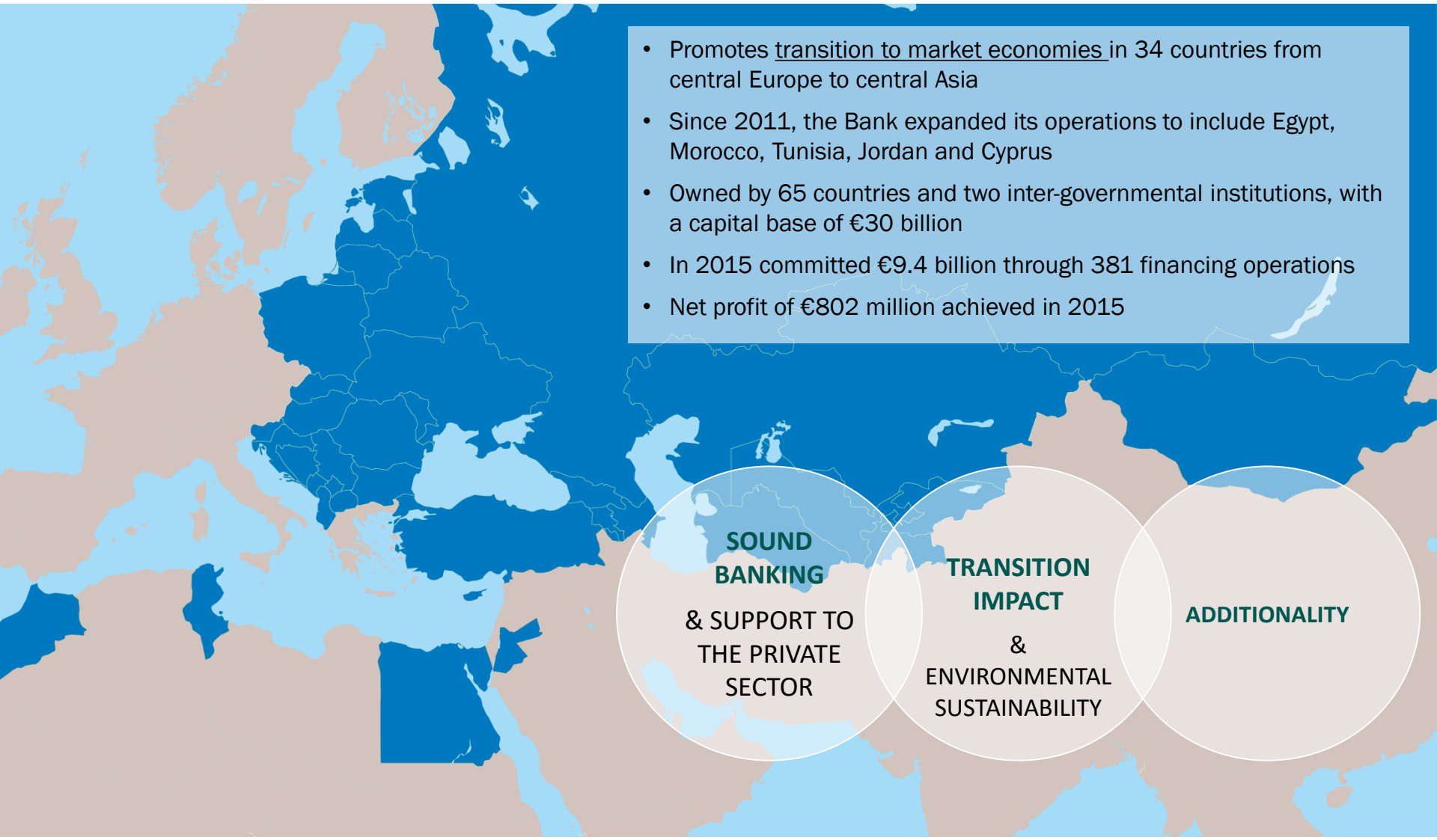

- Promotes transition to market economies in 34 countries from central Europe to central Asia
- Since 2011, the Bank expanded its operations to include Egypt, Morocco, Tunisia, Jordan and Cyprus
- Owned by 65 countries and two inter-governmental institutions, with a capital base of €30 billion
- In 2015 committed €9.4 billion through 381 financing operations
- Net profit of €802 million achieved in 2015

Sustainable Resource Initiative (SRI) – *business model for geothermal scale-up*

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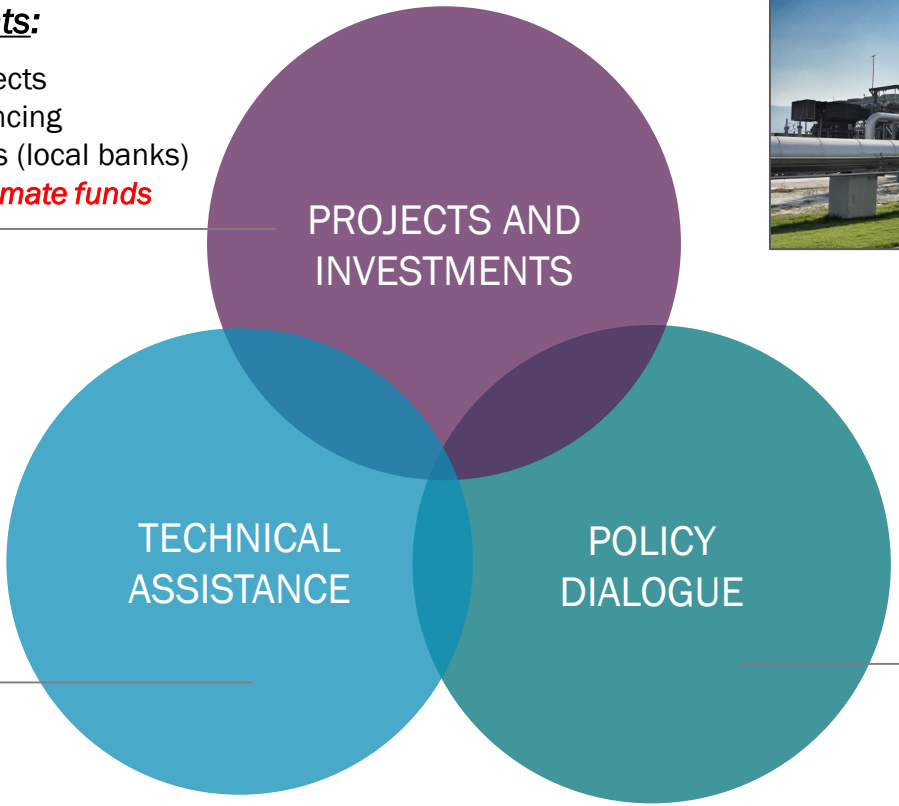
Various financing approaches that suit small and large projects alike

Tailored financial instruments:

- Direct financing for large projects
- Syndicated loans and co-financing
- Small scale projects via SEFFs (local banks)
- *Concessional finance from climate funds*

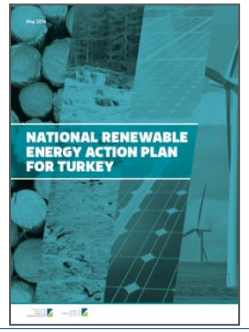


Industry best practices:

- Review of market potential
- Project development support
- Environmental assessment

Renewable Energy Action Plan:

Roadmap to achieving the 2023 1,000 MW GPP target



EBRD's experience in the geothermal sector

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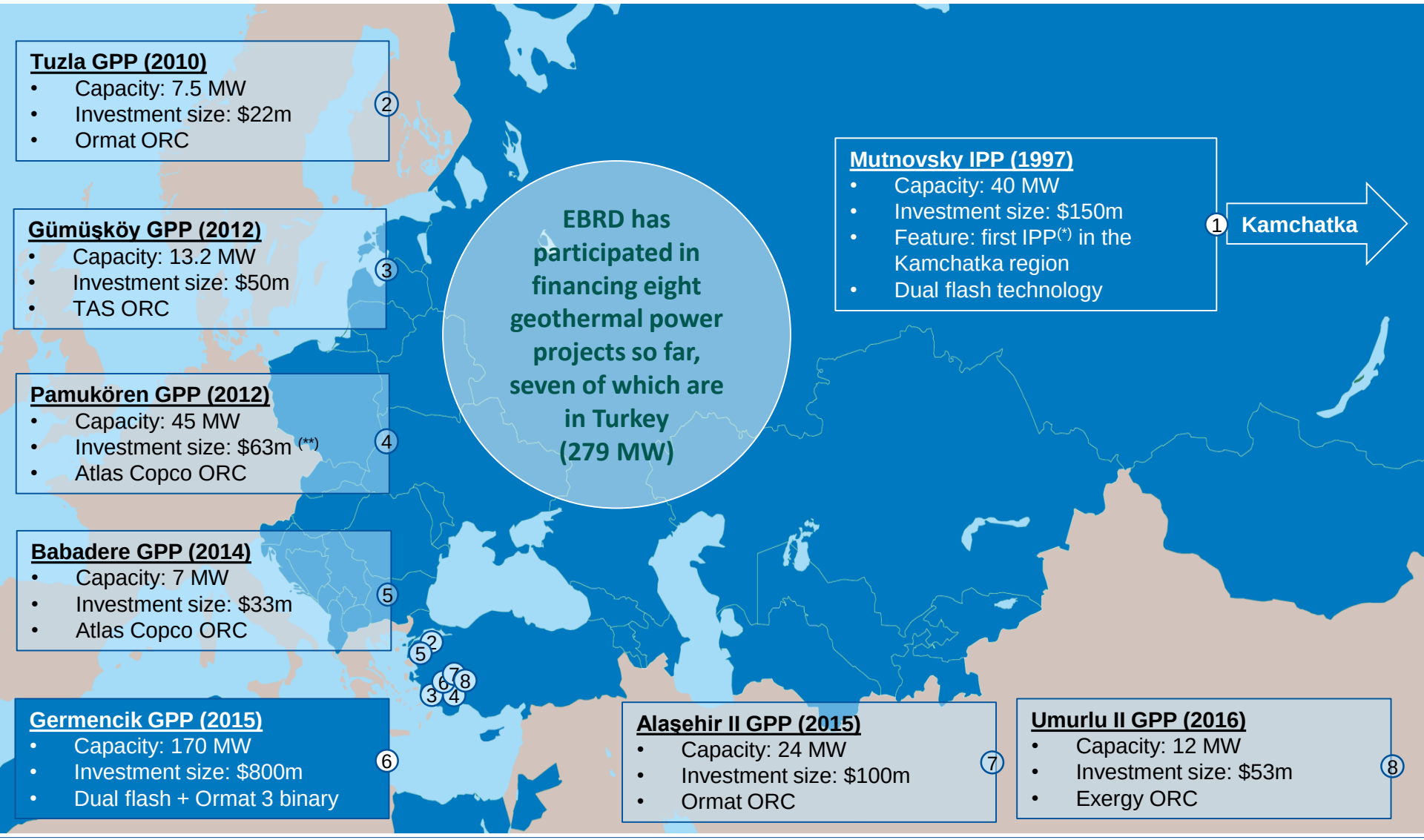
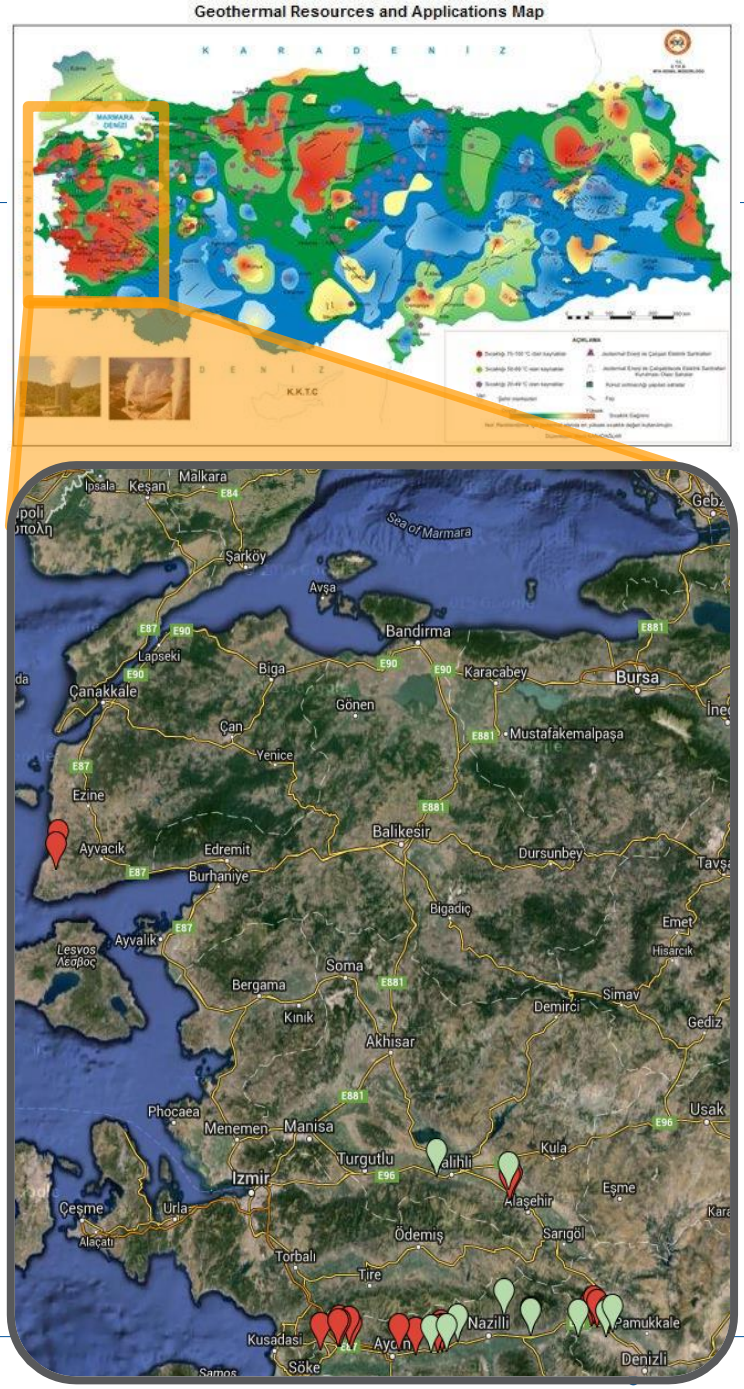


(*) IPP: Independent Power Plant
(**) Resource development costs were financed separately

Geothermal power in Turkey: *Historical Development*

History

- ***1935:*** General Directorate of Mineral Research and Exploration (MTA) was established
- ***1962:*** MTA conducted the first geothermal exploration in Balçova-İzmir
- ***1964:*** First geothermal heating system in Turkey was established in Gönen, Balıkesir
- ***1974:*** A pilot 0.5 MWe GPP was constructed in Kızıldere-Denizli; expanded to 15 MWe and privatised in 2008
- ***2005:*** Turkey enacted its Renewable Energy Law (No. 5346) and introduced an incentive mechanism (amended in 2011)
- ***2007:*** First private 8 MWe GPP became operational (Dora-1) and Geothermal Energy Law enacted
- ***2013:*** New Electricity Market Law (No. 6446) enacted, limiting license trading and setting a deadline to project development rights



Geothermal power in Turkey

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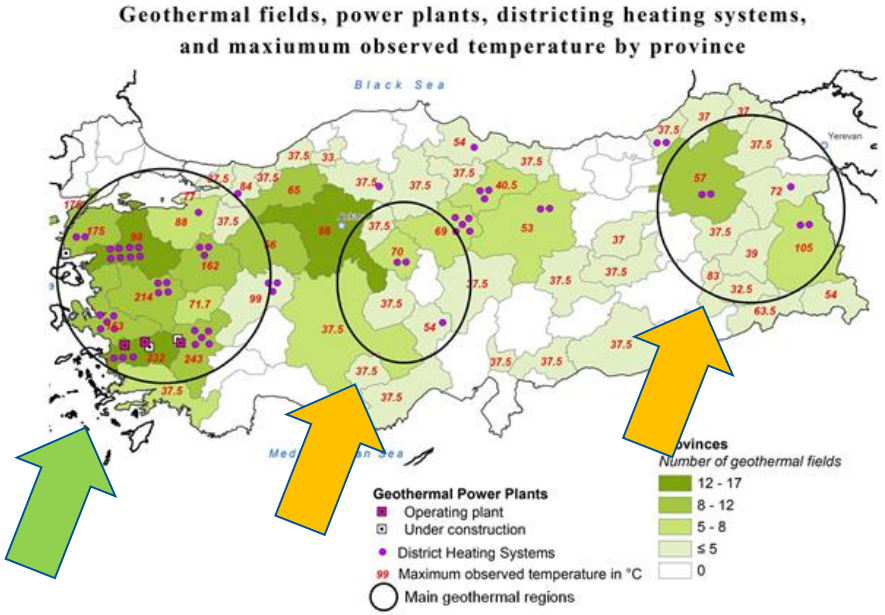
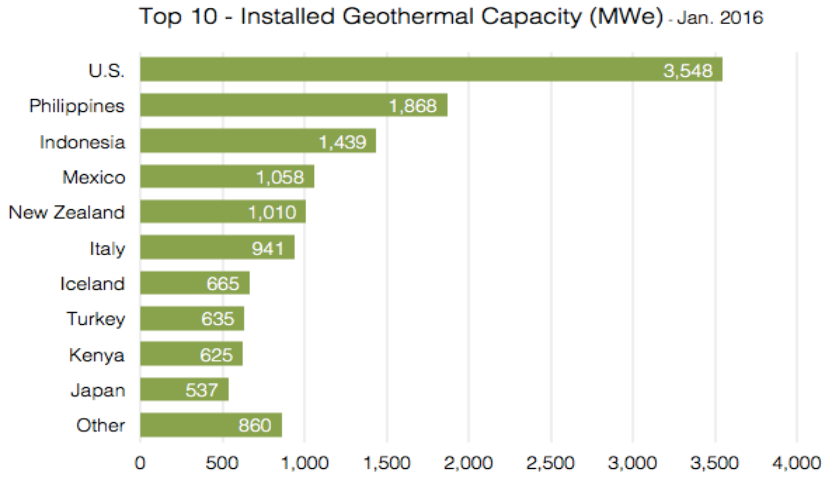
Turkey

Installed geothermal capacity: ***635 MW_e in 21 units (Jan 2016) or ~14% of the 4.5 GW_e*** estimated potential

Western Turkey currently holds the greatest potential for development of geothermal resources (initially developed by ***MTA***), with Central and Eastern Anatolia largely unexplored

Total Electricity Production, 2015– (share of geothermal)	260 TWh - (1%)
Installed Capacity, Jan 2016	635 MWe
Growth, 2010-2015	560%
Share of Global Installed Geothermal Capacity, 2015	5%





GPP cost and risk profile at stages of development

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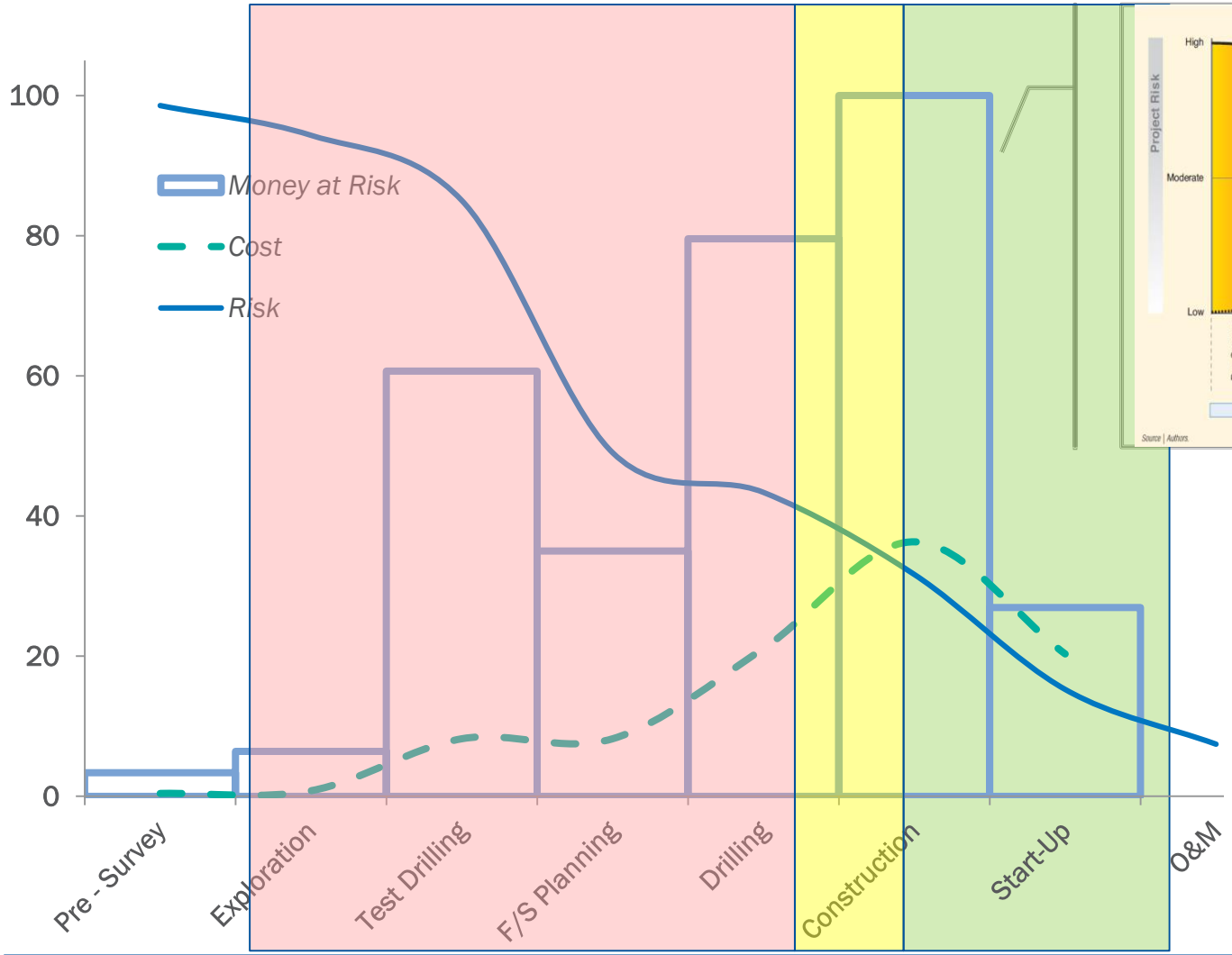

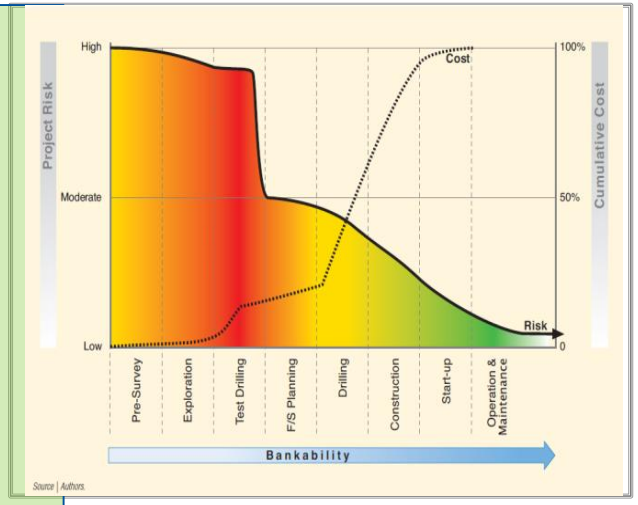

- Value @ risk mostly borne by equity investors
- Commercial banks only project finance once resources are developed
- Early-stage GPP development remains largest financing barrier

Adapted from ESMAP, 2012, Geothermal Handbook: Planning and Financing Power Generation, *Technical Report 002/12.*

Financing mechanisms for exploration

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Illustrative Assessment of Leverage Capability by Policy

Low leverage	Medium leverage	High leverage	Very high leverage
Government-led exploration: government incurs full cost of exploration and investment forfeiture in the case of dry wells	**Lending support mechanisms:** interest from loans could help defray costs, provided that the default rate remains low	**Loan guarantee:** high leverage in the case of limited guarantee payouts	**Quasi-equity support** (concessional financing) at early stage Conversion to **commercial financing** for GPP construction
Grants and cooperative agreements: represent a liability in either the case of direct payouts or foregone tax income		**Drilling failure insurance:** high leverage in the case of limited claims	Use of **revolving fund** for concessional portion after 2 years

EBRD framework

1. *addresses the equity gap at early stage;*
2. *tackles technical risks by utilising global experts; and*
3. *uses fast turnover of concessional funds to enhance the leverage capacity of climate finance*

Adapted from Speer et al., 2014. "Geothermal Exploration Policy Mechanisms: Lessons for the United States from International Applications."
The assessments of leverage provided here are general comparisons across the five policy types. Actual leverage will depend on the specifics of policy design.

Indicative cost pyramid for geothermal energy projects

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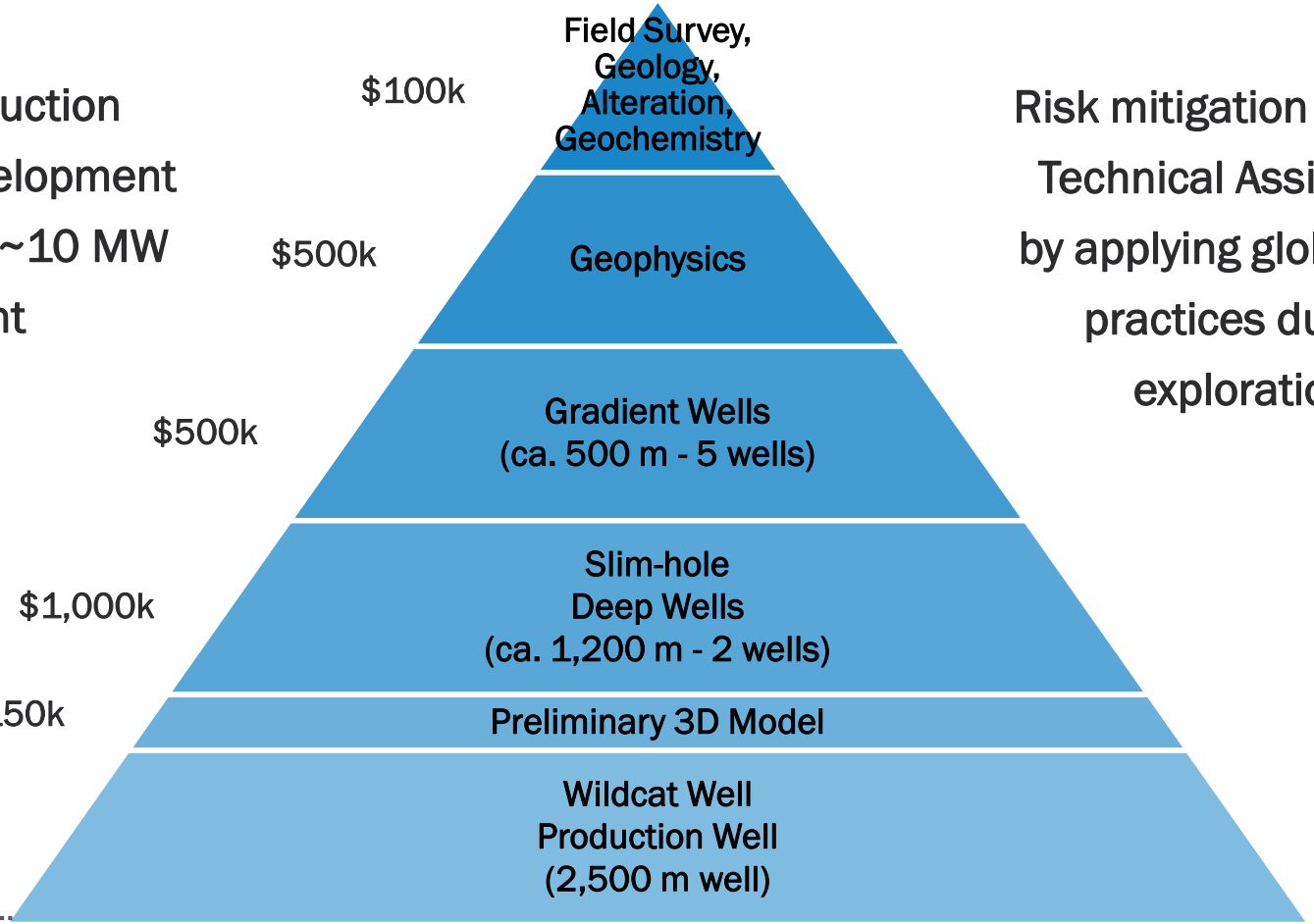
Pre-production drilling development costs for a ~10 MW plant



Risk mitigation through Technical Assistance by applying global best practices during exploration

Total:
$5 million

Subsequent production wells cost *circa* $1 million/km

In Turkey, 4 production + 2 re-injection wells are typically required to run a 10 – 15 MW plant

PLUTO: Early Stage Private Sector Geothermal Development Framework

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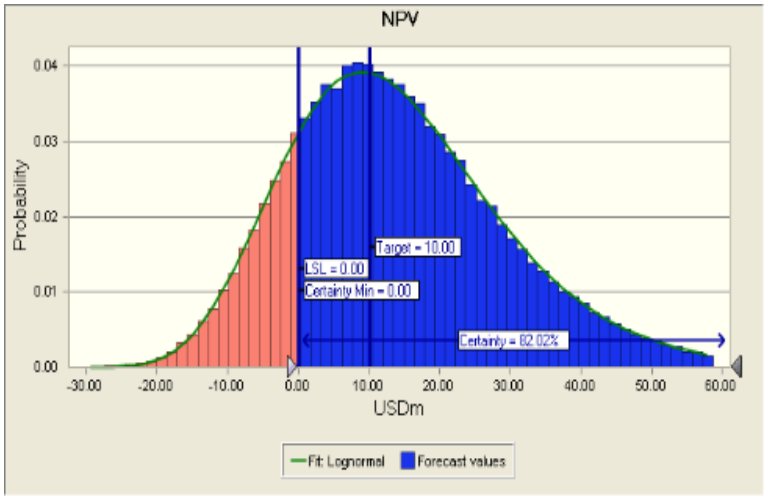
Currently developing a framework to ***support private sector early stage development***:

- Deploying $25 million of CTF concessional funds to partially mitigate early stage risk and unlock commercial direct financing
- Mobilising $100 million in EBRD financing and over $200 million in private sector resources to finance site and plant development
- Engaging global experts as to implement best industry practices at all stages



TC Funds and technical support – EU IPA 2013

Technical

- Surface modelling and site design
- Test drilling, assessment studies, site preparation & exploration drilling
- Production and reinjection wells drilling
- Power plant construction, testing and commissioning

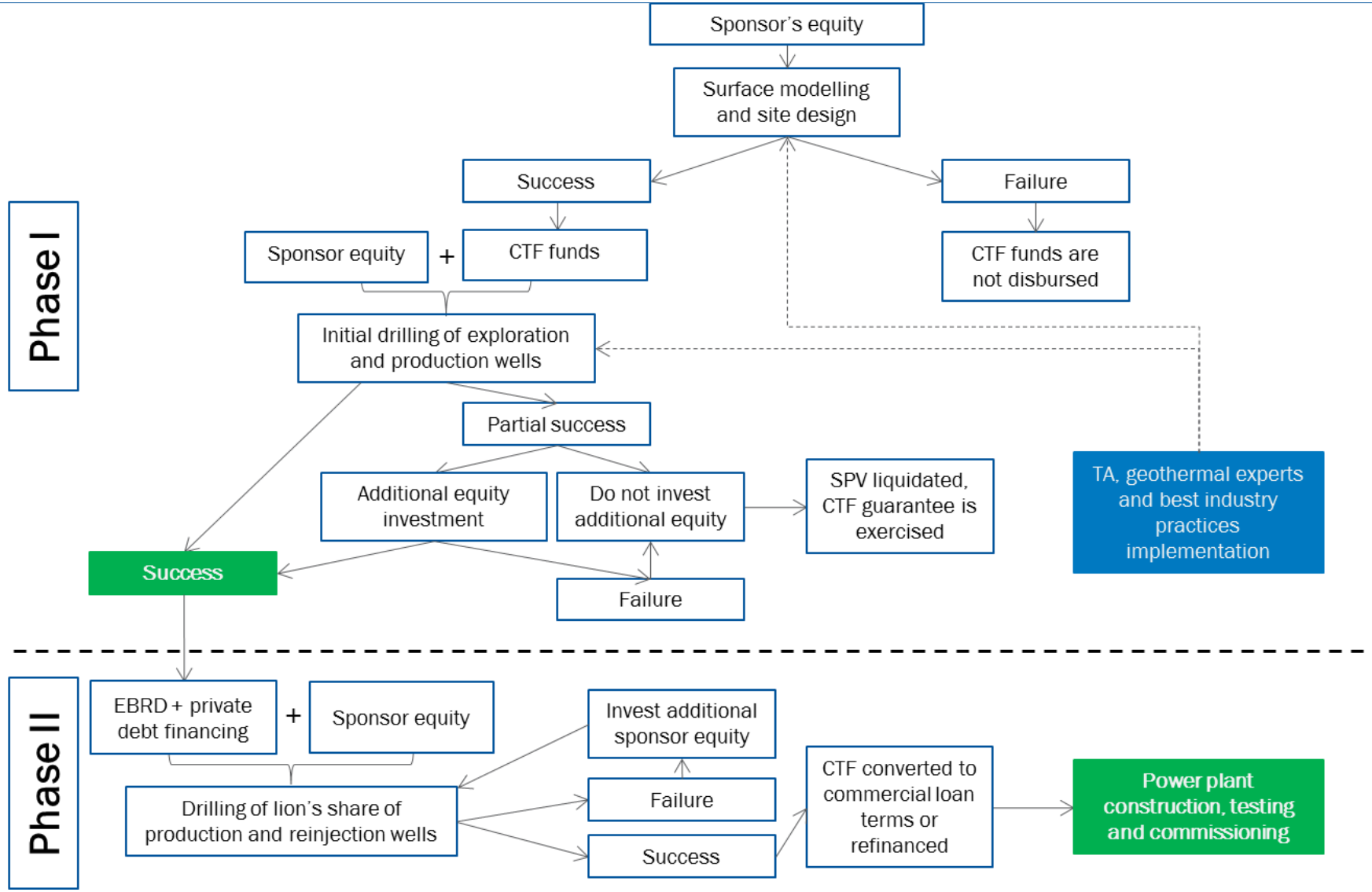
Geothermal resource development

Financial source

- Sponsor
- Sponsor + PLUTO
- Sponsor + EBRD + Private sector

For more information: http://www.ebrd.com/pages/project/psd/2014/46809.shtml

Contingency flowchart



Non-condensable gases (NCGs)

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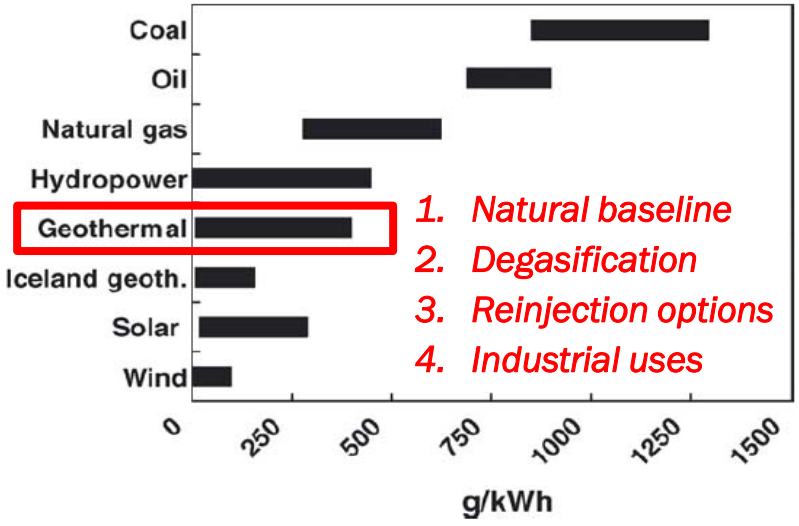
- GPP projects must address the release of CO_2, even though emissions are *relatively low* compared to fossil fuel-based power plants
- Potential solutions to NCGs
  - Reinjection (in binary and combined cycle GPPs)
  - Sale of the CO_2 to potential industrial and agribusiness clients
  - Accurately modelling the background & degasification processes
- EBRD framework includes technical assistance to address the issue in its GPP investments

Assessing the use of CO_2 from natural sources for commercial purposes in Turkey

- Initial technical characterisation of the CO_2 supply available for commercial use in Turkey
- Mapping of the existing CO_2 value chain & identification of bottlenecks in supply and demand
- Assessment of the current market & legal/regulatory framework
- Financing and grant options to expand industrial use of CO_2 from geothermal resources

Greenhouse gas emissions from various types of power plants



Source: Hunt 2000.

NCG abatement strategies

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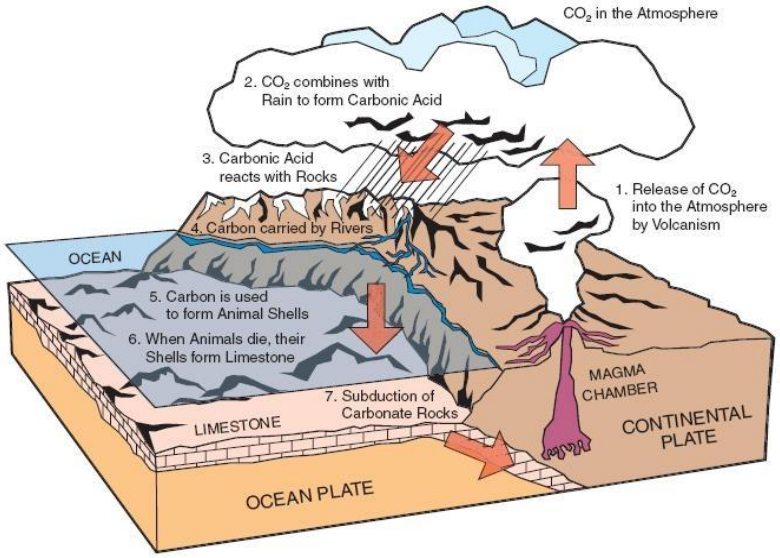
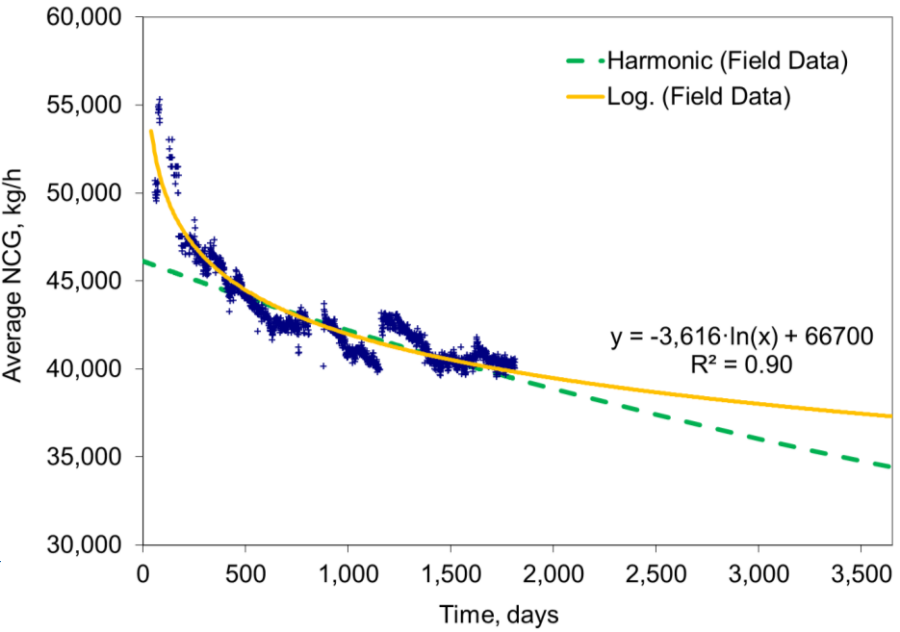




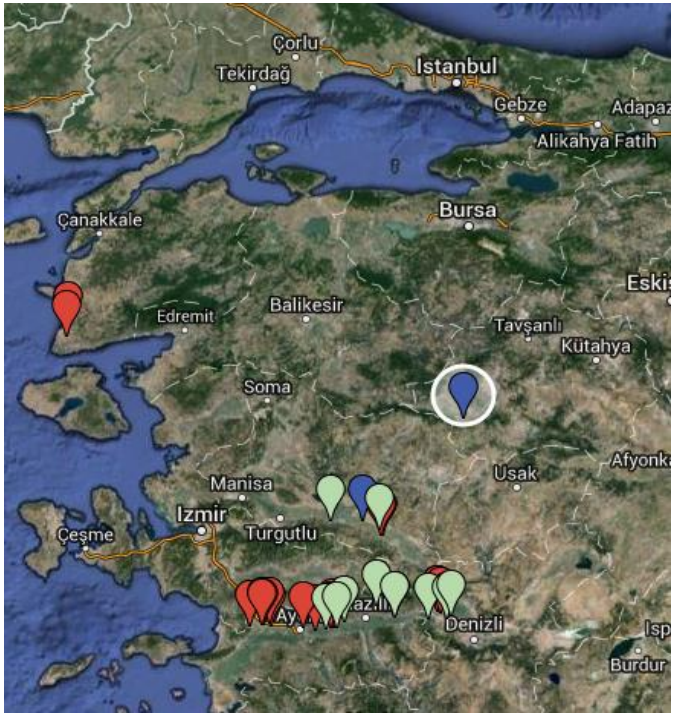
1. ***Natural baseline:*** *measure natural CO_2 background emissions in 5 areas prior to GPP development*
2. ***Degasification:*** *regression analysis of data from existing liquid-dominated resources suggests 40 to 70% decline over plant lifetime*
3. ***Industrial uses:***

4. Economically-viable reinjection options?

CO_2 technology	Application	Selection criteria			Relative Final Score
		Uptake	Economic potential	Long term contribution to CO_2 reduction	
CO_2 to fuels carriers	Renewable methanol	Low	Med	Low	Med
	Formic acid	Low	Med	Low	Med
	Algae cultivation	Low	High	Med	Med
Enhanced commodity production	***Urea production and yield boosting***	Low	High	Low	Med
	Enhanced geothermal systems	Low	Low	High	Med
Enhanced hydrocarbon production	***Enhanced oil recovery (EOR)***	Low	High	Med	High
	Enhanced coal bed methane (ECBM)	Low	Med	High	Med
CO_2 for food production	***Greenhouses***	High	High	Low	High
	Beverage carbonation	Low	High	Low	Med
CO_2 mineralisat.	Concrete curing	High	Low	Med	Med
	Carbonate mineralisation	Unknown	Low	Med	Low

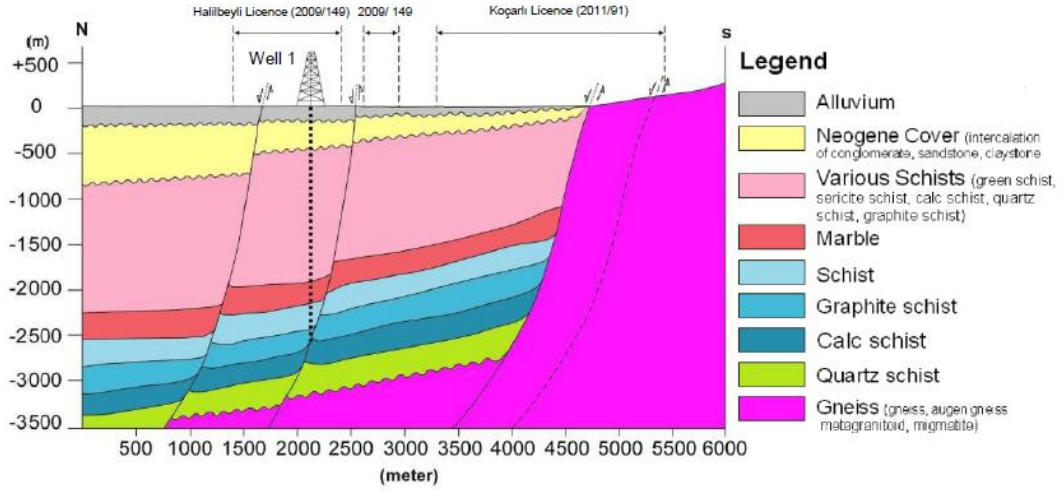
Potential Projects: Simav Graben – Eyre GPP

- Supporting geothermal development in the ***Simav graben*** (inner Aegean region in Turkey), with no existing GPP
- ***District heating*** from geothermal resources is quite common in the area
- Many greenhouses in the area ***use waste CO_2*** from ***the existing wells*** to produce tomatoes
- There are ***no geothermal power production sites nearby***
- One 380 m gradient well, showing a gradient of ***57 °C/km***.



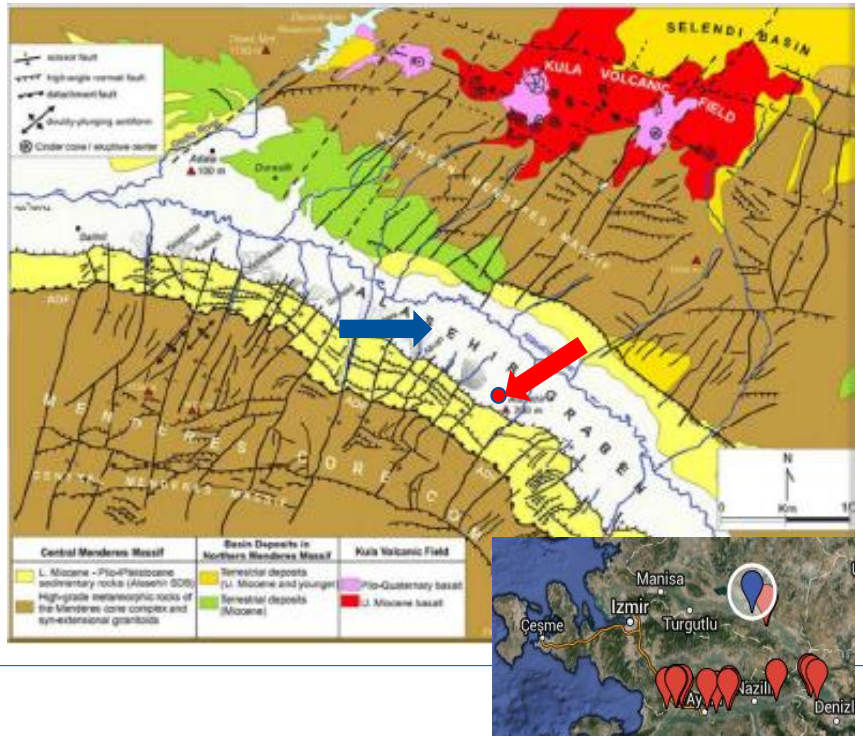
Potential Projects under the PLUTO: Halilbeyli GPP

- *South of the Büyük Menderes Graben*, in the inner Aegean region in Turkey
- Most GPPs concentrated in the north of the Büyük Menderes Graben); potential of its southern part remains unknown
- One *1,170 m* slimhole well has been drilled, showing a temperature gradient of *50 ℃/km*
- Estimated temperature at a depth of *3,200 m* depths is around *170 ℃*
- The drilling of a "Wildcat" ***production well*** will start in late May



Potential Projects: Gediz Graben – Yeşilova GPP

- *North of the Gediz graben*, where only two operating plants exist despite good temperature gradients (110 °C/km)
- Geothermal area under development; existing (partially collapsed) well at *2133 m*
- The *PT surveys* carried out down to *1950 m*; unfortunately, significant portion of the mud loss zone was covered with fill
- The *maximum temperature of 222 °C* was measured at1950 m
- Promising project but currently on hold due to shift in priorities by developer, focusing on developed licenses



EBRD support for geothermal development

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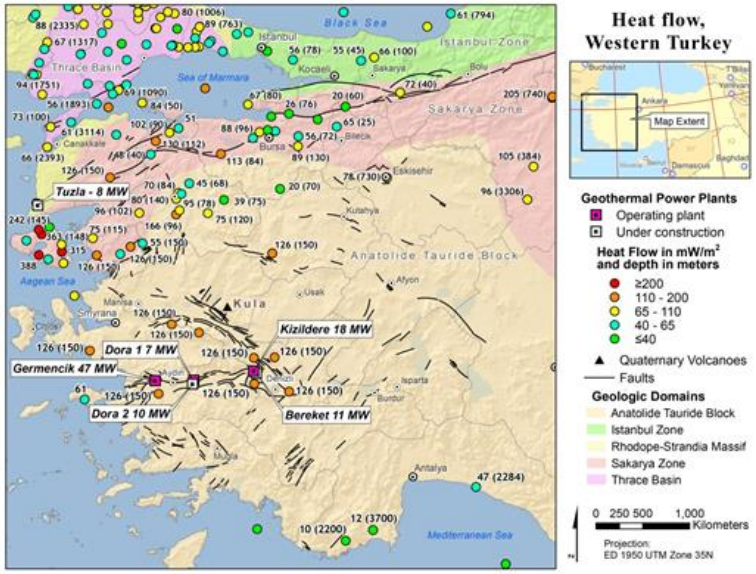
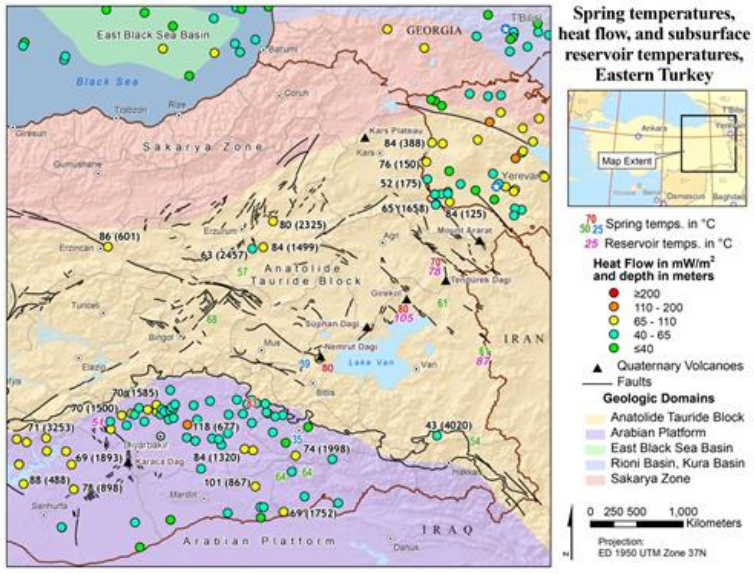
PROJECT FINANCE

- ***Direct project finance:*** 170 MW in the Aydın-Germencik province
- ***Intermediary financing*** existing projects through local banks
- Engaging blue-chip developers in Turkey to support future ***greenfield projects***



POLICY DIALOGUE

- Support MoENR in further developing legislative frameworks & ***licensing procedures***
- Defining centralised approach on key issues such as ***sustainable resource management***
- ***Raising awareness*** on existing challenges and industry best practices to mitigate early stage risks and accelerate deployment



http://www.ebrd.com/news/2015/ebrd-supports-turkeys-shift-to-renewable-energy.html

For more information

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Global overview – Iceland

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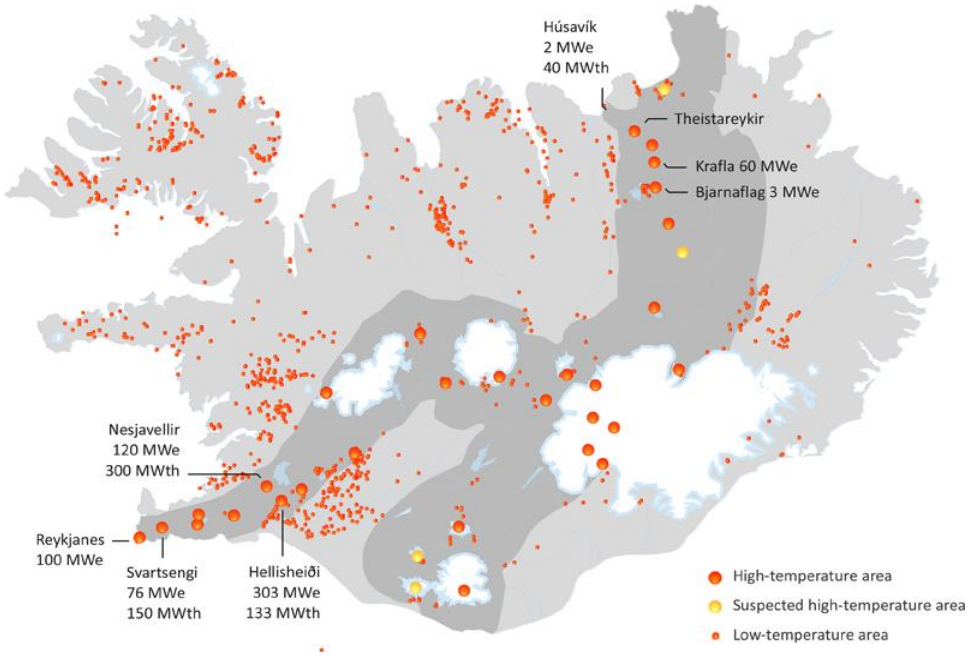

ISOR, 2015.

Total Electricity Production, 2012 – (share of geothermal)	18 TWh - (29%)
Installed Capacity, 2014	665 MW_e
Growth, 2010-2014	15.6%
Share of Global Installed Geothermal Capacity, 2014	5.2%

History

- *1928*: 1st district heating system installed in Reykjavík
- *1967*: Energy Fund created for **cost-sharing** in drilling and exploration (convertible loans for up to 80% of unsuccessful drilling costs)
- *1999*: *Master Plan for Geothermal and Hydropower Development in Iceland* initiated
- *2006*: Market opened to private developers; to date, 100% of power generation has been developed by public companies/utilities
- *2007*: Private developers HE Orka, Orkusalan enter the market
- *2009*: Iceland Deep Drilling Project becomes hottest producing geothermal well in the world by harnessing **supercritical hydrous fluids** (over 450°C)