

# Opportunities & Challenges for Geothermal Development: EBRD's Support in Scaling-up Investment in Turkey

Adonai Herrera-Martínez

Associate Director, Energy Efficiency & Climate Change

Energy Efficiency and Climate Change (E2C2)



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# Green Economy Transition (GET) – *Business model for geothermal scale-up*

Various financing approaches that suit small and large projects alike

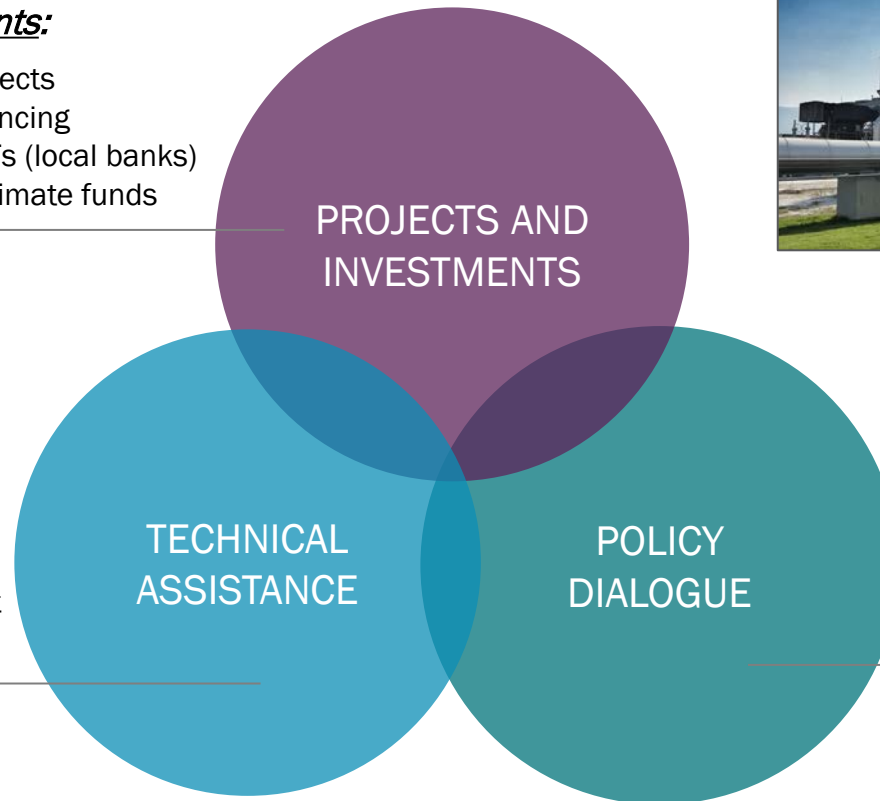
## Tailored financial instruments:

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



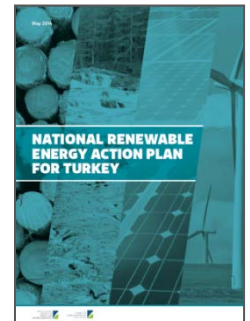
## Industry best practices:

- 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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## Tuzla GPP (2010)

- Capacity: 7.5 MW
- Investment size: \$22m
- Ormat ORC

## Gümüsköy GPP (2012)

- Capacity: 13.2 MW
- Investment size: \$50m
- TAS ORC

## Pamukören GPP (2012)

- Capacity: 45 MW
- Investment size: \$63m (\*\*)
- Atlas Copco ORC

## Babadere GPP (2014)

- Capacity: 7 MW
- Investment size: \$33m
- Atlas Copco ORC

## Germencik GPP (2015)

- Capacity: 170 MW
- Investment size: \$800m
- Dual flash + Ormat 3 binary

EBRD has participated in financing eight geothermal power projects so far, seven of which are in Turkey (479 MW)

## Mutnovsky IPP (1997)

- Capacity: 40 MW
- Investment size: \$150m
- Feature: first IPP<sup>(\*)</sup> in the Kamchatka region
- Dual flash technology

1 Kamchatka

## Kızıldere III GPP (2017)

- Capacity: 160 MW
- Investment size: \$800m
- Triple flash + Ormat 2 binary

## Umurlu II GPP (2016)

- Capacity: 12 MW
- Investment size: \$53m
- Exergy ORC

## Alaşehir II GPP (2015)

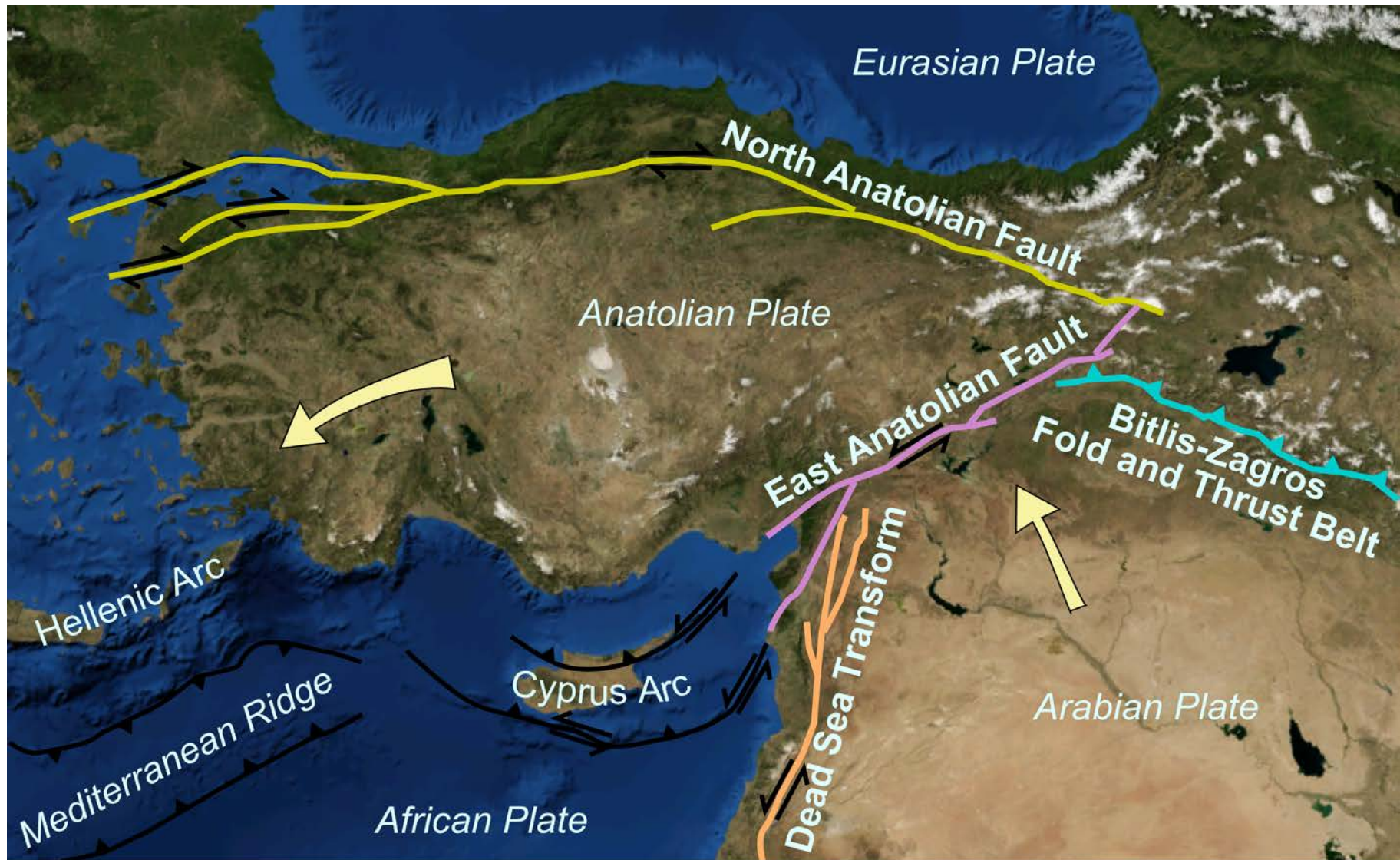
- Capacity: 24 MW
- Investment size: \$100m
- Ormat ORC



# Plate Tectonics: Turkey & Middle East



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# Geothermal power in Turkey: *Historical Development*

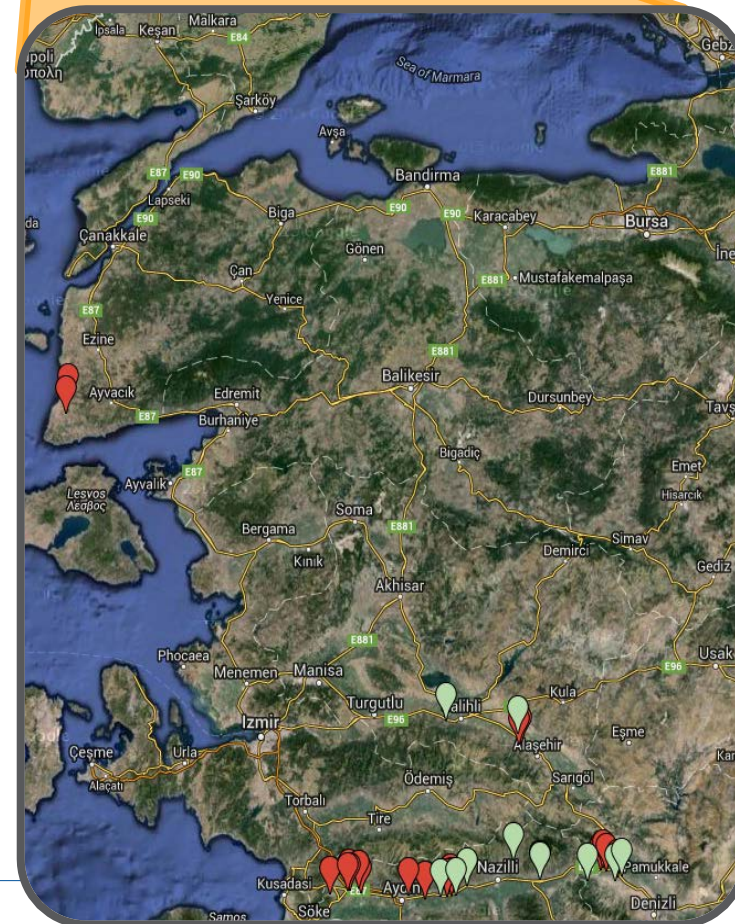
## *Public-sector driven*

- **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

## *Private-sector driven*

Geothermal Resources and Applications Map





# PLUTO: Early Stage Priate Sector Geothermal Development Framework



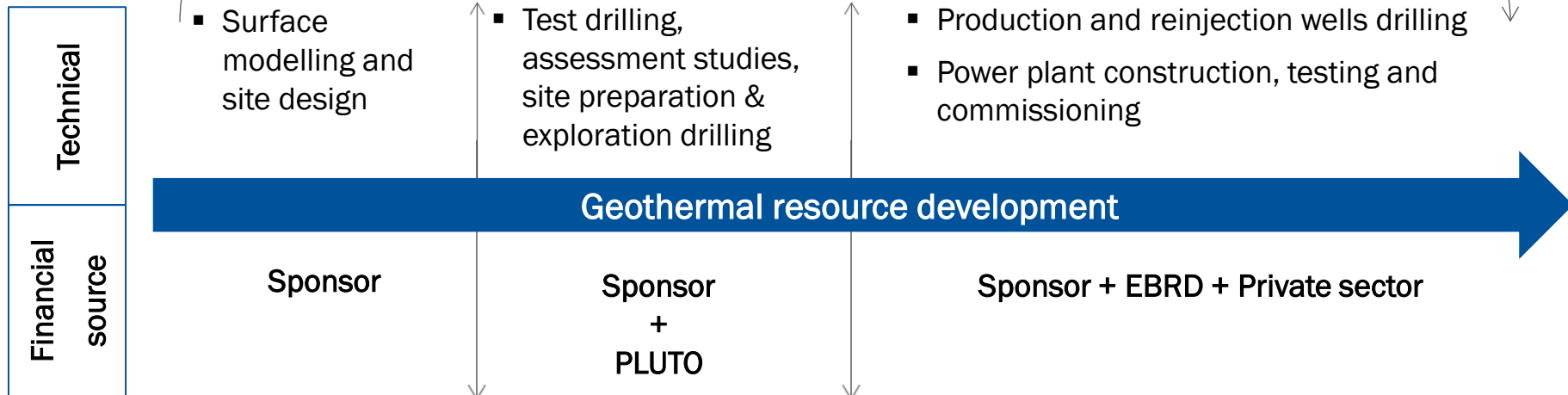
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Currently developing a framework to *support private sector early stage development*.

- 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

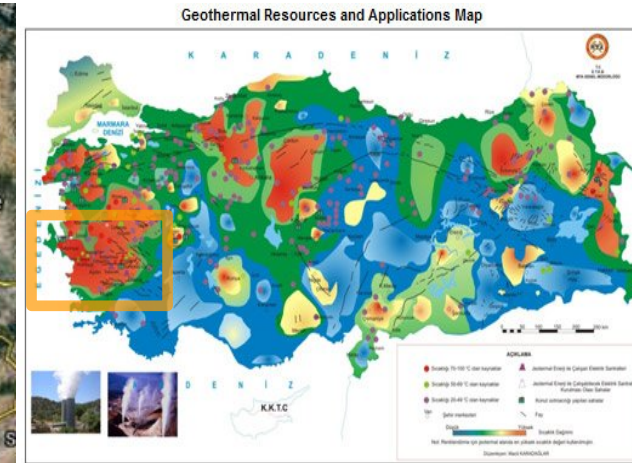




# Challenge in Turkey: Sustainable Reservoir Management



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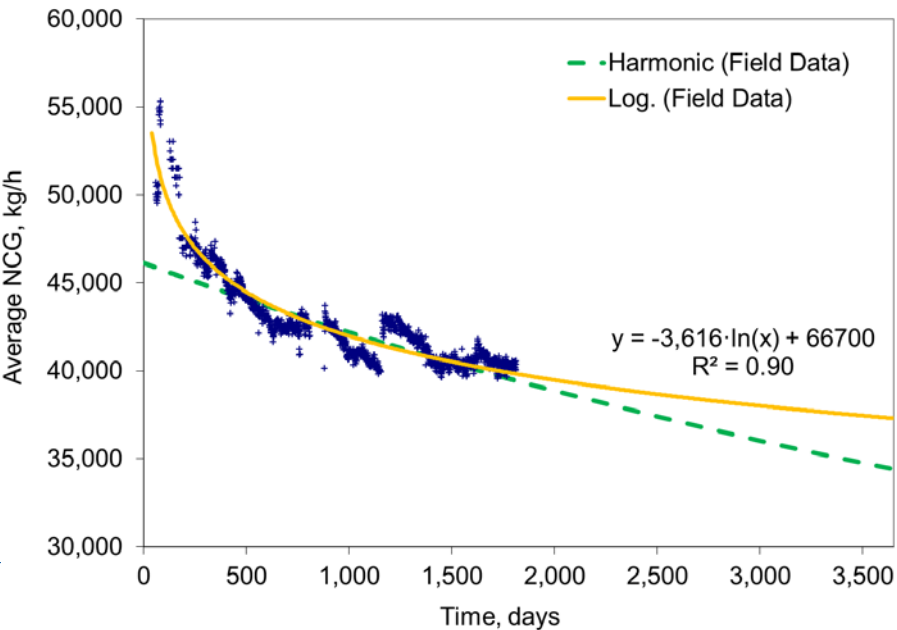
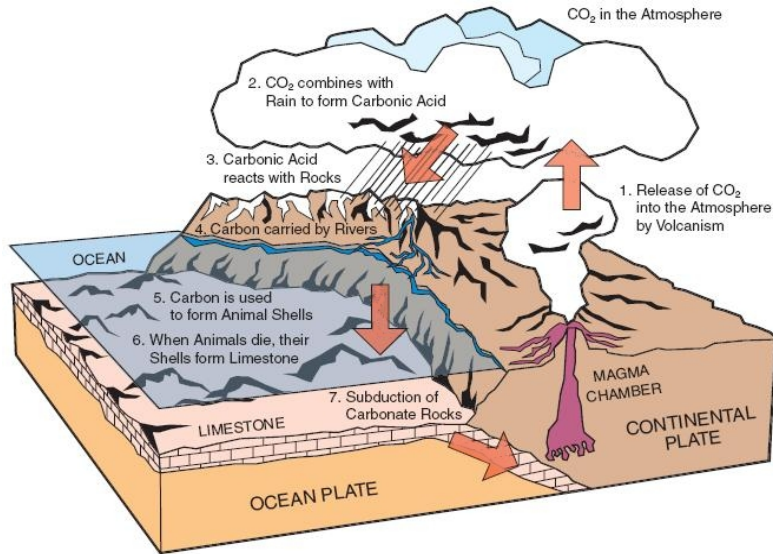


- Development concentrated in Büyük Menderes Graben (above)
- Need for coordination among different plants drawing resources from the same reservoir
- Over-exploitation of geothermal resources may result in depletion and other environmental problems, and in a decline in power output (e.g. The Geysers in the US)
- Full re-injection and resource monitoring are essential for sustainable reservoir management
- *Thus, conference sessions on: Sustainable resource management, Drilling & Exploration, Pumps and Water Loop and Power Plant Technology*

# NCG abatement strategies



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1. **Natural baseline:** measure natural CO<sub>2</sub> 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 <sub>2</sub> technology          | Application                               | Selection criteria |                    |   | Relative Final Score |
|-------------------------------------|---|--------------------|--------------------|---|----------------------|
|                                     |   | Uptake             | Economic potential | Long term contribution to CO <sub>2</sub> reduction |                      |
| CO <sub>2</sub> to fuels carriers   | Renewable methanol                        | Low                | Med                | Low   | Med                  |
|                                     | Formic acid                               | Low                | Med                | Low   | Med                  |
|                                     | Algae cultivation                         | Low                | High               | Med   | Med                  |
| Enhanced commodity production       | <b>Urea production and yield boosting</b> | Low                | High               | Low   | Med                  |
|                                     | Enhanced geothermal systems               | Low                | Low                | High  | Med                  |
| Enhanced hydrocarbon production     | <b>Enhanced oil recovery (EOR)</b>        | Low                | High               | Med   | High                 |
|                                     | Enhanced coal bed methane (ECBM)          | Low                | Med                | High  | Med                  |
| CO <sub>2</sub> for food production | <b>Greenhouses</b>                        | High               | High               | Low   | High                 |
|                                     | Beverage carbonation                      | Low                | High               | Low   | Med                  |
| CO <sub>2</sub> mineralisat.        | Concrete curing                           | High               | Low                | Med   | Med                  |
|                                     | Carbonate mineralisation                  | Unknown            | Low                | Med   | Low                  |





## For more information

Dr. Adonai Herrera-Martínez

Associate Director

Energy Efficiency and Climate Change  
EBRD, Kanyon Ofis, Istanbul, Turkey

[MartineA@ebrd.com](mailto:MartineA@ebrd.com)

Tel: +90 212 386 1100

# Geothermal power in Turkey



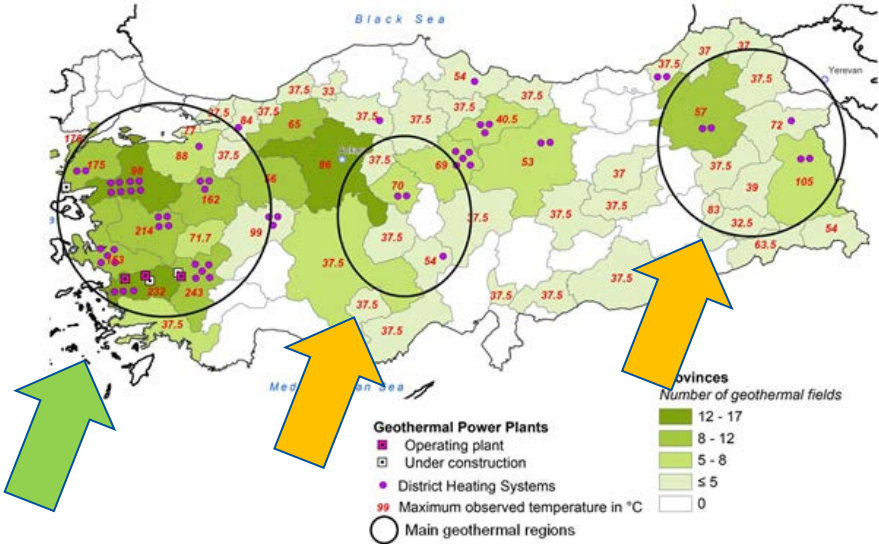
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## Turkey

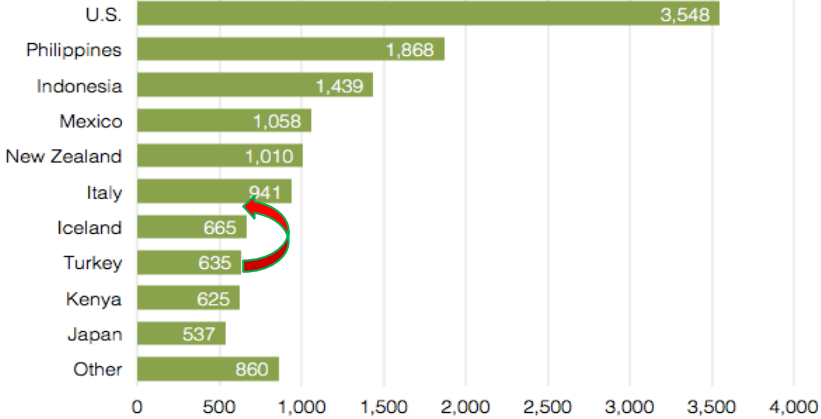
Installed geothermal capacity:  
c.  $900 \text{ MW}_e$  in 30 units (Sept 2017)  
or ~20% of the  $4.5 \text{ GW}_e$  estimated potential

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

Geothermal fields, power plants, districting heating systems, and maximum observed temperature by province



Top 10 - Installed Geothermal Capacity (MWe) - Jan. 2016



|  |                |
|--|----------------|
| Total Electricity Production, 2017 - (share of geothermal) | 360 TWh - (1%) |
| Installed Capacity, Sept. 2017                             | 900 MWe        |
| Growth, 2010-2017  | 1,000%         |
| Share of Global Installed Geothermal Capacity, 2017        | 7%             |

# Indicative cost pyramid for geothermal energy projects

