EGS Potential Assessment and Mapping

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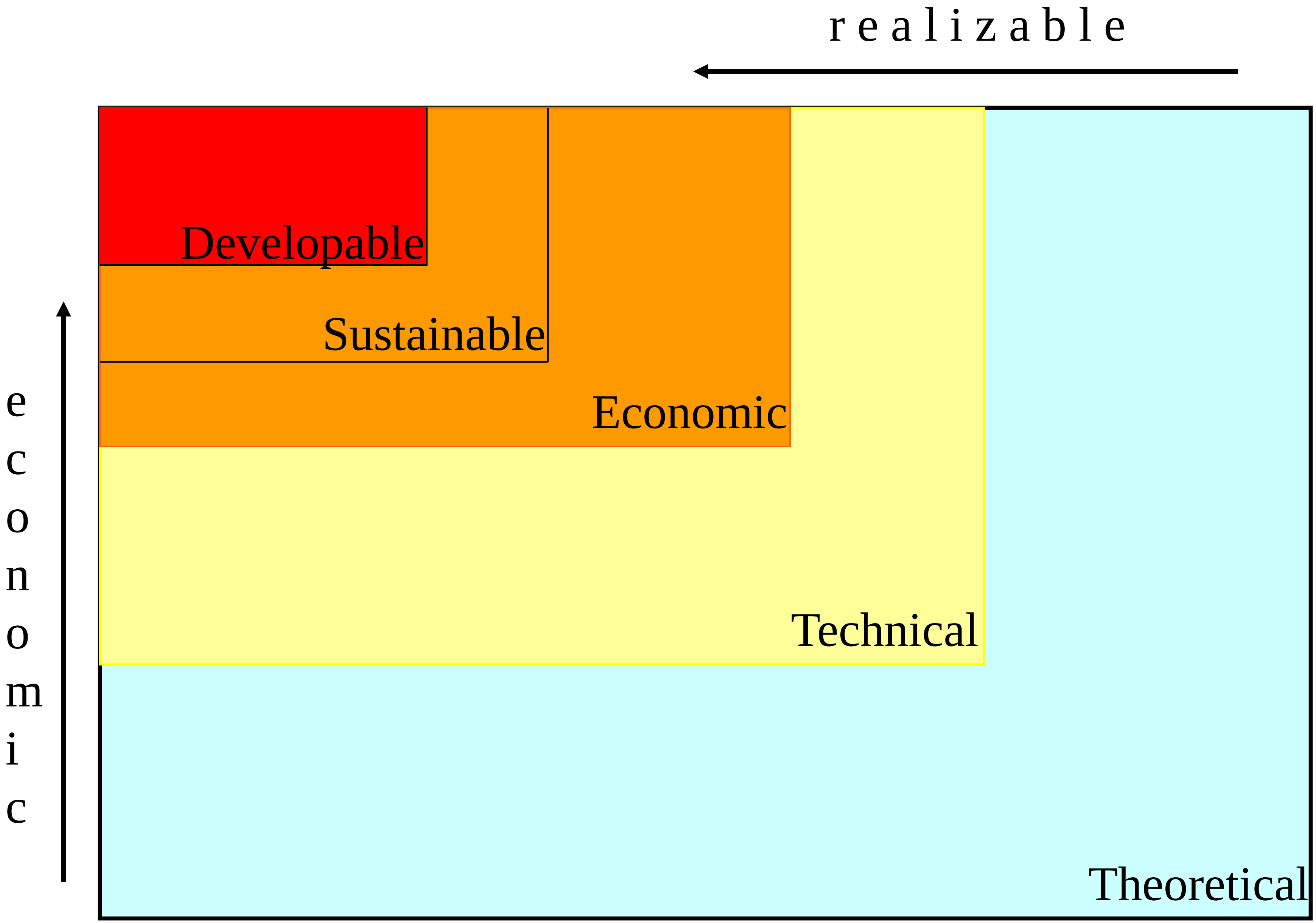
Potential definitions



Rybach, WGC 2010

Realizable

Realized ⇐ Competitive ⇐ Prospective ⇐ Possible someday

Challenges: Land access, competitive costs, technologic progress & proximity to markets

Path to Deployment in Markets

Uneconomic ⇒ Usable in Future ⇒ Economic

Supplies (2009)

Installed Electricity		Direct use	
GW electric	Capacity Factor	GW thermal	Capacity Factor
10.7	74.5%	51	27.5%

Developable economic geothermal reserves

Economically useable with existing technologies

Current development wells generally drilled to less than 3.5 km

Expected Deployment EJ / year
ELECTRICITY (resources to 10 km)

by 2050 (90% CF)	by 2100 (90% CF)
4.56 EJ / year Ref. 20 (Goldstein, et al 2010)	7.5 EJ / year (1% growth pa)
45 EJ / year Ref. 22 (Krewitt, et al 2009)	32.4 EJ / year (4% growth pa)

Expected Deployment EJ / year
DIRECT USE (resources to 10 km)

by 2050	by 2100
7.57 EJ / year Ref.20 (Goldstein, et al 2010)	12.4 EJ / year (1% growth pa)
	53.8 EJ / year (4% growth pa)

Total technically usable
EJ / year thermal
ELECTRICITY

Low Estimate	High Estimate
1,094 EJ / year Ref. 20 (Goldstein, et al 2010)	5,000 EJ / year Ref. 21 (Simms, et al 2007)

Total technically usable
EJ / year thermal
DIRECT USE

Low Estimate	High Estimate
9.5 EJ / year Ref. 20 (Goldstein, et al 2010)	312 EJ / year Ref. 20 (Goldstein, et al 2010)

Estimated technically useable geothermal energy with foreseeable technologies

Theoretically useable geothermal energy with future technologies – no economic considerations

42,670,000 EJ stored heat energy from 15° Celsius to 3 km depth under continents, Reference 23. (EPRI, 1978)

The above-stated estimate is the sum total of stored heat in EGS (34.14 x 10^6 EJ) and hydrothermal (8.53 x 106 EJ) resources

55,900,000 EJ stored heat energy from surface to 5 km depth under continents, Reference 20 (Goldstein, et al 2010)

The above-stated estimate is an interpolation between Reference 24 (Tester, 2005) and Reference 23. (EPRI, 1978)

139,500,000 EJ stored heat energy from surface to 5 km depth under continents, Reference 20 (Goldstein, et al 2010)

The above-stated estimate is an interpolation between Reference 25 (Rowley, 1982) and Reference 23. (EPRI, 1978)

110,400,000 EJ stored heat energy from surface to 10 km depth under continents, Reference 24 (Tester, et al, 2005)

403,000,000 EJ stored heat energy from surface to 10 km depth under continents, Reference 22 (Rowley, 1982)

5,400,000,000 EJ stored heat energy to from surface 50 km depth within the earth, Reference 26 (Dickson and Fanelli, 2003)

12,600,000,000,000 EJ stored heat energy within the earth, Reference 26 (Dickson and Fanelli, 2003)

Goldstein (2011)

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A Protocol for Estimating and Mapping Global EGS Potential

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Keywords

Engineered Geothermal Systems. Enhanced Geothermal Systems. EGS resource estimation, global geothermal resource inventory, Google Earth, Keyhole Markup Language, KML

parable to one another globally. The maps, estimates and source data will be made freely available for public use and presented in common data formats such as the Keyhole Markup Language (KML) for Google Earth.

Endorsed by the IEA GIA Executive Committee in September 2011

A Protocol for Estimating and Mapping the Global Potential for EGS

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David Blackwell, and Charles Baron

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Technical Process

- **Key inputs**
  - **Surface temperature**
  - **Depth of sediment**
  - **Sediment rock properties (thermal conductivity, heat generation)**
  - **Basement rock properties (thermal conductivity, heat generation, specific heat, density)**
  - **Surface heat flow (or borehole temperatures and rock properties)**

- **General Process**
  - **Divide geographic region into a grid of ‘cells’ (5’ x 5’)**
  - **Estimate ‘Temperature at Depth’ from surface temperature, heat flow and rock properties**
  - **Estimate ‘Theoretical Potential’ from ‘Temperature at Depth’, ‘Base Temperature’, rock properties and ‘Recovery Factor’**
  - **Estimate ‘Technical Potential’ as a proportion of ‘Theoretical Potential’**
  - **Generate maps and tables**

Technical Process

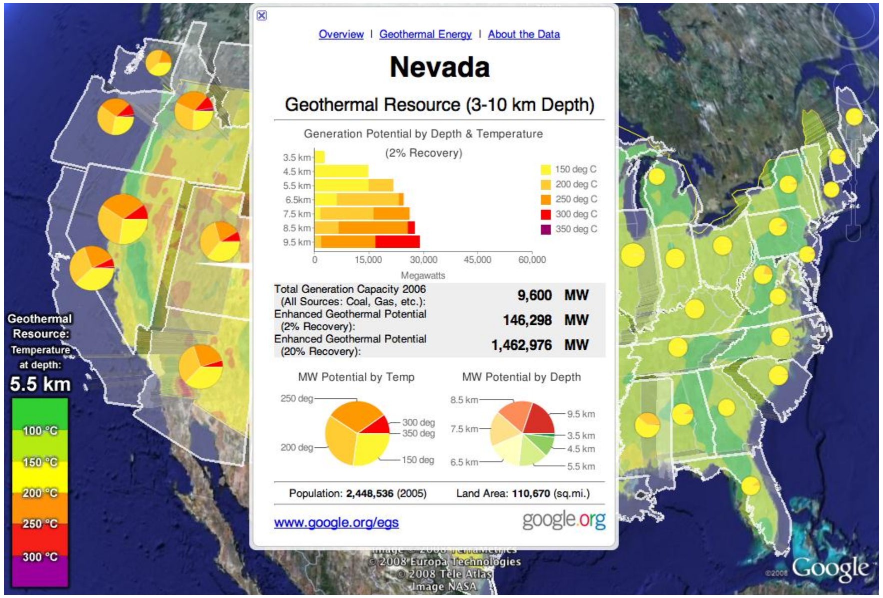
- **Key outputs**
  - **‘Temperature at Depth’ maps and tables down to 10,000 m**
  - **Estimates and maps of ‘EGS Theoretical Potential’ in basement to 10,000 m**
  - **Estimates and maps of ‘EGS Technical Potential’ in basement to 7,000 m**
  - **Tables of cumulative Potential over geographic regions and depth intervals**

Example Comprehensive Resource Info

Current Version
- Temp at Depth
- Resource by Temp and Depth
- Total Capacity
- Relative Share of Resource by Temp and Depth

Could be Expanded To:

- Replace “Resource” with “Potential”
- Thermal Gradients by 5’ x 5’ cell
- Potential by cell
- Accessible vs. Inaccessible land
- Mean surface temperature



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