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GEOTEHRMAL ENERGY- PROFESSIONAL IMPLEMENTATION

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Outline of presentation

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The UNFC-2009 scheme

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Hungarian case studies (existing projects)

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- Szentes

} Porous reservoir

- Veresegyház
- Miskolc

} Limestone reservoir

CHPM2030 project (EGS) classification

Conclusions: merits and pitfalls of the UNFC-2009

Why do we need a new clasification methodology ?

- With no globally agreed geothermal standards, codes existing prior to the development of UNFC-2009.
- The renewable energy industry (e.g. geothermal) has become a fully commercialized sector, in which several oil and gas majors have already started to play a significant role. These players have voiced a need for a common platform to assess and compare in a transparent way the potential of their renewable and non-renewable energy portfolios.
- Need for a complex, objective evaluation methodology→ direct impact on financing

Basic definitions I.

The resource classification process consists of defining a Project estimating the quantities of energy that can be recovered and delivered as Geothermal Energy Products.

The **Project** includes all the systems and equipment connecting the Geothermal Energy Source to the Reference Point(s) where the final Geothermal Energy Products are sold, used, transferred or disposed of.

The **Reference Point** is a defined location in the production chain where the quantities of Geothermal Energy Product are measured or assessed. The Reference Point is typically the point of sale to third parties .

Basic definitions II.

The **Project Lifetime** will be the minimum of the economic limit, design life, contract period and entitlement period, as defined below:

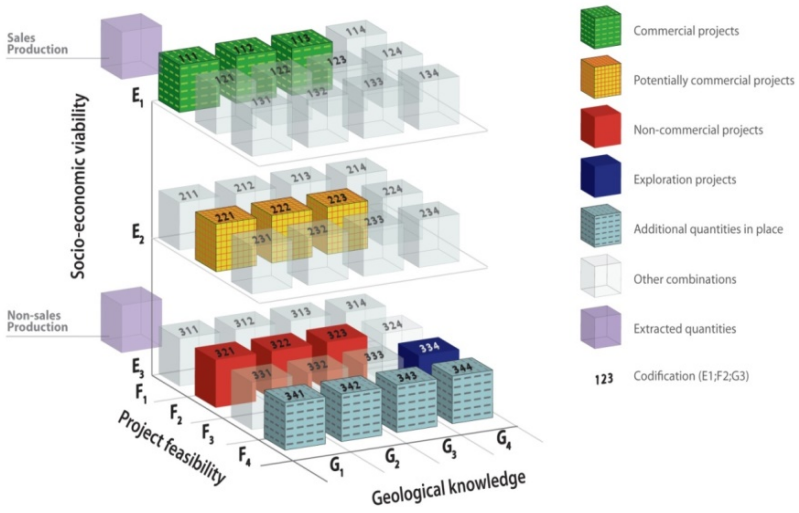
- The **'economic limit'** may be the time when the expected extraction rate declines to a level that makes the Project uneconomic.
- The **'design life'** of a Project is the expected operating life of major physical infrastructure.
- The **'contract period'** for a geothermal Project is the term of all existing, or reasonably expected, sales contracts for the Geothermal Energy Products.
- The **'entitlement period'** is the term of all licences and permits which provide rights to access the Geothermal Energy Source.

The Geothermal Energy Source may be expected to last much longer than the Project Lifetime, but any future extracted quantities beyond those estimated for the Project would be assessed and classified as subsequent or additional Projects.

Basic premises

- Where a project produces multiple Geothermal Energy Products, there may be different Reference Points for each product stream (heat, electricity, mineral resources, etc.)
- Depending upon the specific Project, it could be necessary to report other additional quantities affecting the overall energy conversion process. Other examples concern those systems in which the geothermal apparatus works together with other energy sources or thermal cascading systems.
- In general, any reported energy quantity shall be disclosed together with a clear description/definition of the corresponding point of evaluation.

The UNFC-2009 scheme



Generic, principles-based system

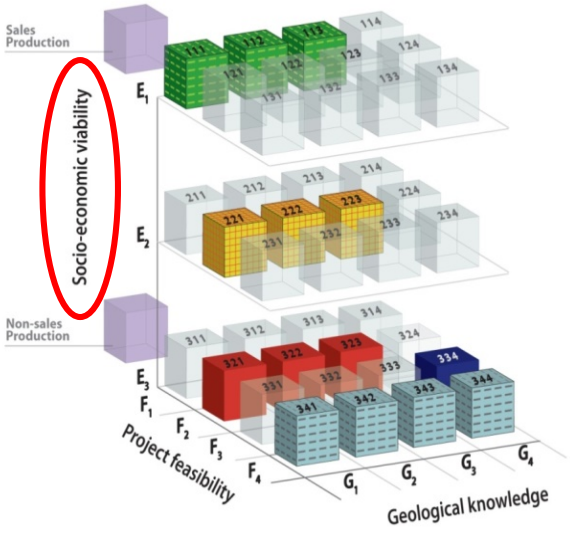
E-axis: 'Economic and social viability' (degree of favourability of social and economic conditions in establishing commercial viability of project, e.g. market prices, relevant legal, regulatory, environmental conditions)

F-axis: 'Field project status and feasibility' (maturity of studies and commitments necessary to implement project)

G-axis: ' Geological knowledge' (level of confidence in the geological knowledge and potential recoverability of the quantities)

E-categories

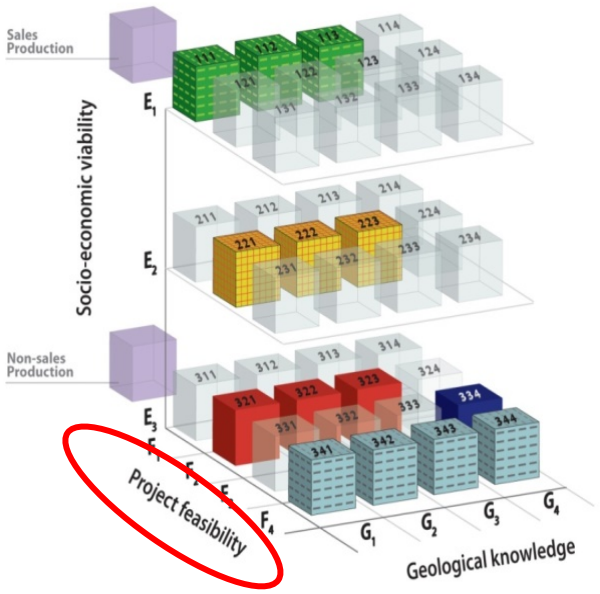
Means degree of favourability of social and economic conditions in establishing commercial viability of project (market prices, relevant legal, regulatory, environmental and contractual conditions, etc.)



- E1: Extraction and sale economically viable
- E2: Extraction and sale economically viable in the foreseebale future (5 yrs)
- E3: Extraction and sale not expected to be economically viable in the foreseebale future, or too early stage for evaluation

F-categories

Means project status and feasibility / technology (maturity of studies and commitments necessary to implement project)



F1: feasibility of extraction confirmed (ongoing production)

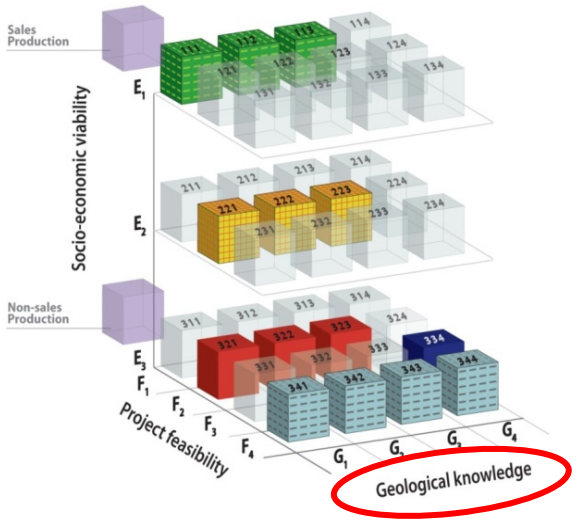
F2: preliminary studies exist, but feasibility of extraction subject to further evaluation (e.g. first well drilled)

F3: exploration phase, limited technical data (e.g. pre-drilling exploration)

F4: no project development identfied (in-situ quantities)

G-categories

Means geological knowledge (level of confidence in the geological knowledge and potential recoverability of the quantities)



G1: Quantities associated with a high level of confidenece (low estimate – P90)

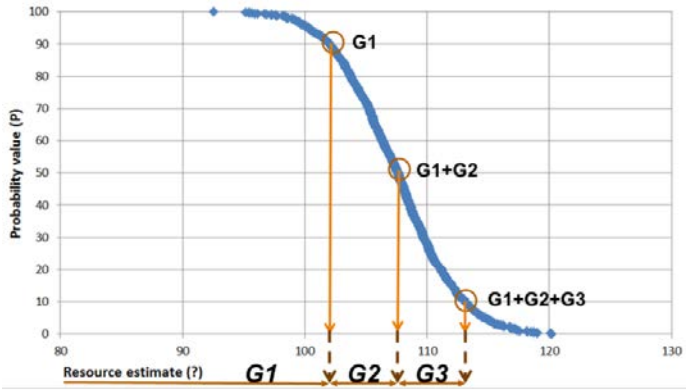
G2: Quantities associated with a moderate level of confidenece (best estimate – P50)

G3: Quantities associated with a low level of confidenece (high estimate – P10)

G4: Potential based on indirect evidence

Monte Carlo simulation: repeated calculations with stohastically changing parameters (e.g. reservoir volume, temperature, etc.)

Confidental data can be incorporated into a probability distribution!

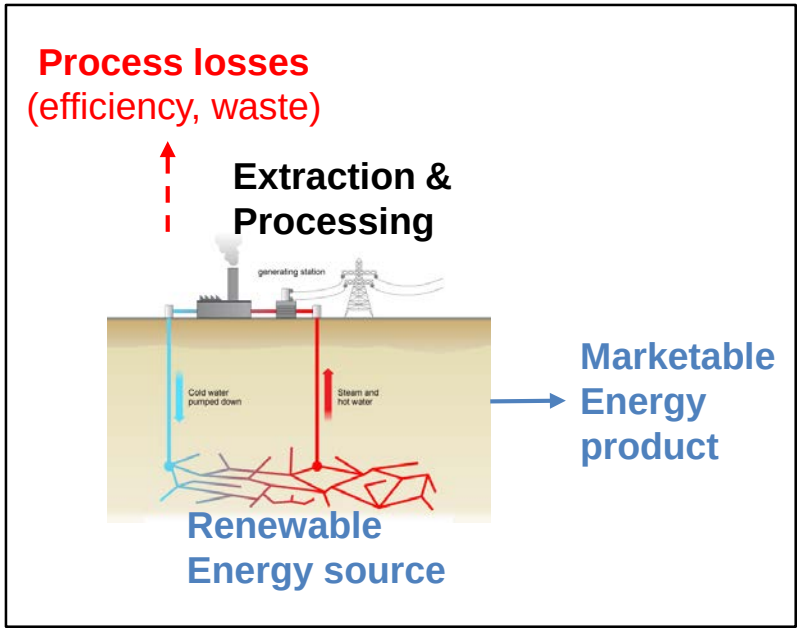


The classification process

1) defining a project, link between a geothermal energy source (equivalent to the terms ‘deposit’ or ‘accumulation’ used for solid minerals and fossil fuels) and the product (heat, electricity)

„Project” can be:

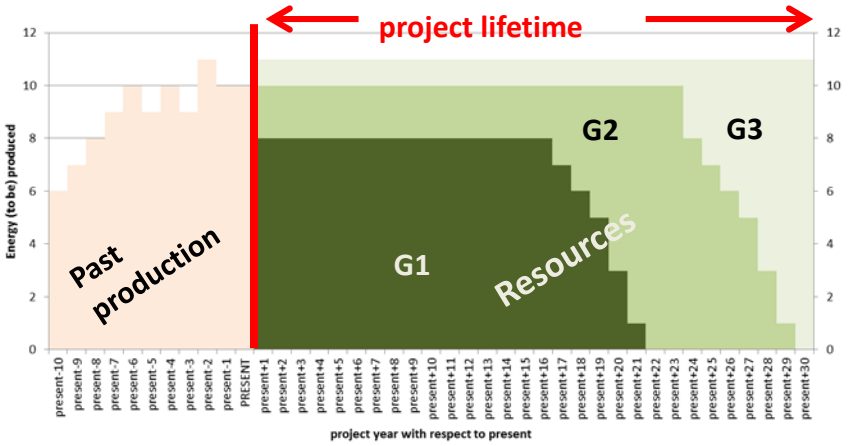
- Existing geothermal energy utilisation
- Expansion of an existing project
- Greenfield development
- Project in pre-drilling exploration phase
- Conceptual Project
- Regional evaluation of a geothermal play



The classification process

2) estimating the quantities of energy that can be recovered and delivered as ‘products’ by the given project from the effective date of the evaluation forward (till the end of the project lifetime/limit), measured or evaluated at the reference point (a defined location in the production chain).

Estimation method / quantification (e.g. scenario, probabilistic) is NOT PART of the classification exercise! – no standard method uniformly accepted



3) classifying the quantified geothermal energy resource based on the criteria defined by the E, F and G (sub)categories

Project examples

Hódmezővásárhely

- HU's oldest geo-DH system
- operating since 1954,
- 8 production, 2 re-injection wells
- Upper Miocene porous reservoir
- partial reinjection
- 2725 flats, 130 public consumers
- municipality owned company

Szentes

- Árpád-Agrár Zrt. large agricuture company
- 14 production wells
- Upper Miocene porous reservoir
- no reinjection
- heating of 30 ha greenhouses and plastic tents, 3,5 ha of poultry yards and stables + crop drying

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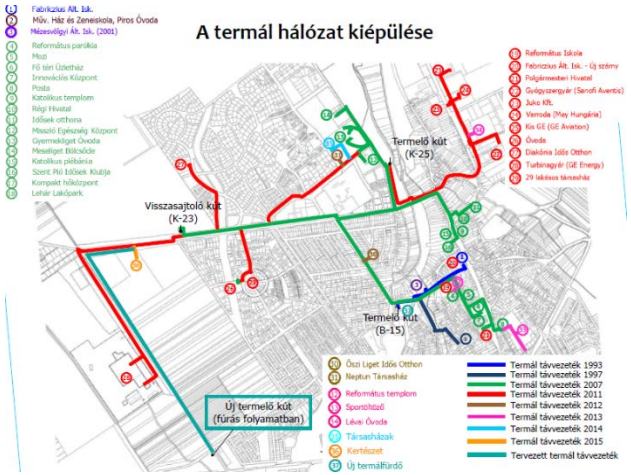
Project examples

Veresegyház

- Gradually expanding thremal water town heating cascade system
- 3 production 1 re-injection well
- Triassic carbonate reservoir
- partial reinjection
- Heating of public and private houses + industrial users
- municipality owned company



Miskolc

- HU's largest geo-DH system (55 MW_{th})
- 2 production, 3 reinjection wells
- Triassic carbonate reservoir
- full reinjection
- district heating of large panel blocks, historical city center, university buildings
- PPP (90% Pannergy, 10% municipality)

MC-based estimation of recoverable heat (volumetric method)

	Input parameters					Calculated parameters			
	A	B	C	D	E	F	G	H	I
	Reservoir area (km^2)	Reservoir thickness (km)	Porosity (V/V	Reservoir temp. (˚C)	Recovery factor	**Total volume (km^3)**	**Pore volume (km^3)**	**Porosity heat content (PJ)**	**Recove-rable heat (PJ)**
Calculation formula						A*B	C*F	4.187*G*(D-30)	**(H*E)**
Hódmezővásárhely									
Min	12,5	0.080	0.06	58	0.1				
Max	15,5	0.150	0.18	108	0.2				
"p90"	*12.8*	*0.087*	*0.07*	*63*	*0.11*	1.21	0.109	20.5	**2.88**
"p50"	*14*	*0.115*	*0.12*	*83*	*0.15*	1.6	0.185	38.7	**5.69**
"p10"	*15.2*	*0.143*	*0.17*	*103*	*0.19*	2.01	0.29	70.5	**10.85**
Veresegyház									
Min	15	0.043	0.01	80	0.2				
Max	20	0.116	0.07	85	0.3				
"p90"	*15.5*	*0.051*	*0.016*	*80*	*0.21*	0.88	0.02	4.5	**1.11**
"p50"	*17.5*	*0.08*	*0.04*	*83*	*0.25*	1.39	0.051	11.2	**2.78**
"p10"	*19.5*	*0.109*	*0.064*	*85*	*0.29*	1.93	0.099	21.8	**5.47**
Szentes									
Min	45	0,135	0.05	103	0.1				
Max	57	0,255	0,07	132	0.2				
"p90"	*45.9*	*0.137*	*0.054*	*104*	*0.11*	6.89	0.405	142	**19.26**
"p50"	*51*	*0.195*	*0.06*	*117*	*0.15*	9.9	0.59	213	**31.29**
"p10"	*56.2*	*0.251*	*0.067*	*130*	*0.19*	13.08	0.8	299	**48**
Miskolc									
Min	50	0,069	0.01	90	0.2				
Max	60	0,099	0.07	105	0.3				
"p90"	*51.0*	*0.073*	*0.016*	*91*	*0.21*	4.28	0.074	20.9	**5.12**
"p50"	*55.1*	*0.084*	*0.040*	*98*	*0.25*	4.63	0.18	52.3	**12.9**
"p10"	*59.0*	*0.095*	*0.064*	*104.*	*0.29*	4.96	0.29	84.4	**21.48**

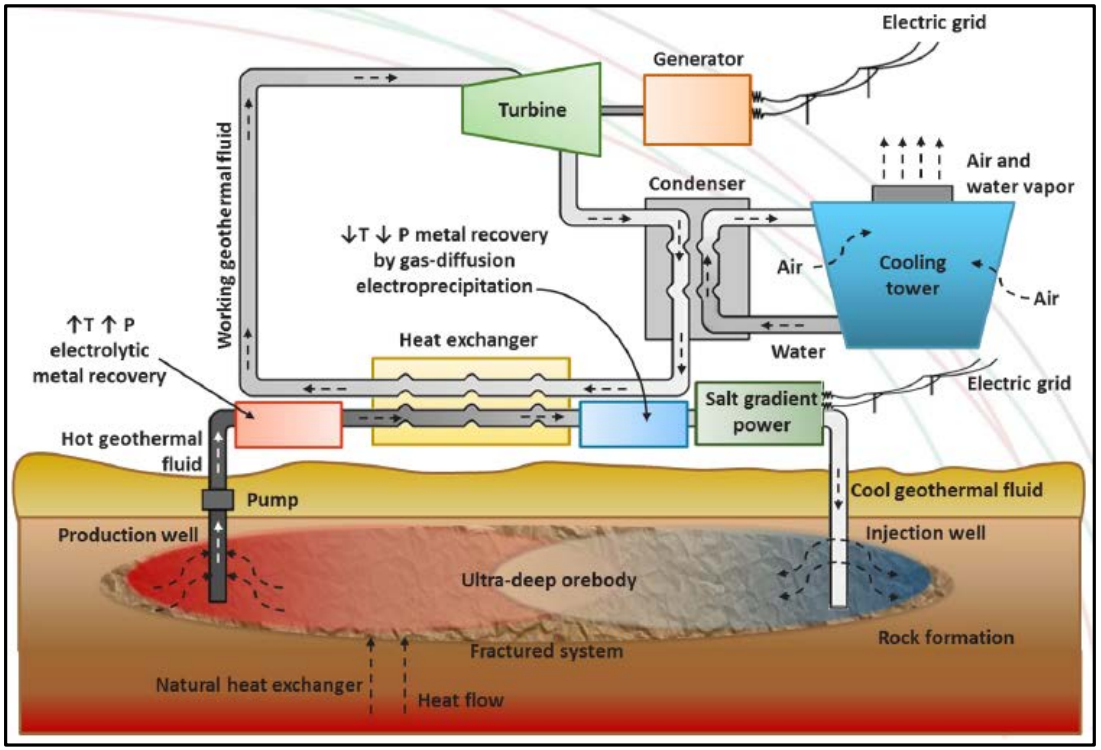
All projects: E1.F1.G1/2/3

Category	UNFC-2009 Definition	Reasoning for classification
E.1.	Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions	• existing heat market • all production licenses available and guaranteed within reasonable timeframe – 5 yrs • very positive and quantified effects on the reduction of gas consumption and heating costs as well as and decreased CO_2 emission,
F.1.	Extraction is currently taking place.	• projects have been operating for 5-25 yrs • technically feasible use (district heating, communal hot water supply, individual space heating - agriculture) with well established technology
G.1.	Quantities associated with a known deposit that can be estimated with a high level of confidence (High confidence / low estimate)	A volumetric Monte Carlo assessment has indicated a 90% probability of (H) 2,88 PJ, (V) 1,11 PJ, (SZ) 19,26 PJ, (M) 5,12 PJ of recoverable geothermal energy
G.2.	Quantities associated with a known deposit that can be estimated with a moderate level of confidence (Moderate confidence / best estimate, incremental to G1)	A volumetric Monte Carlo assessment has indicated a 50% probability of (H) 5,69 PJ, (V) 2,78 PJ, (SZ) 31,29 PJ, (M) 12,9 PJ of recoverable geothermal energy. Therefore G2 are (H) 2,81 PJ, (V) 1,67 PJ, (SZ) 12,03 PJ, (M) 7,78 PJ
G.3.	Quantities associated with a known deposit that can be estimated with a low level of confidence (Low confidence / high estimate, incremental to G2)	A volumetric Monte Carlo assessment has indicated a 10% probability of (H) 10,85 PJ, (V) 5,47 PJ, (SZ) 48 PJ, (M) 21,48 PJ of recoverable geothermal energy. Therefore G3 are (H) 8,04 PJ, (V) 3,8 PJ, (SZ) 35,97 PJ, (M) 13,7 PJ

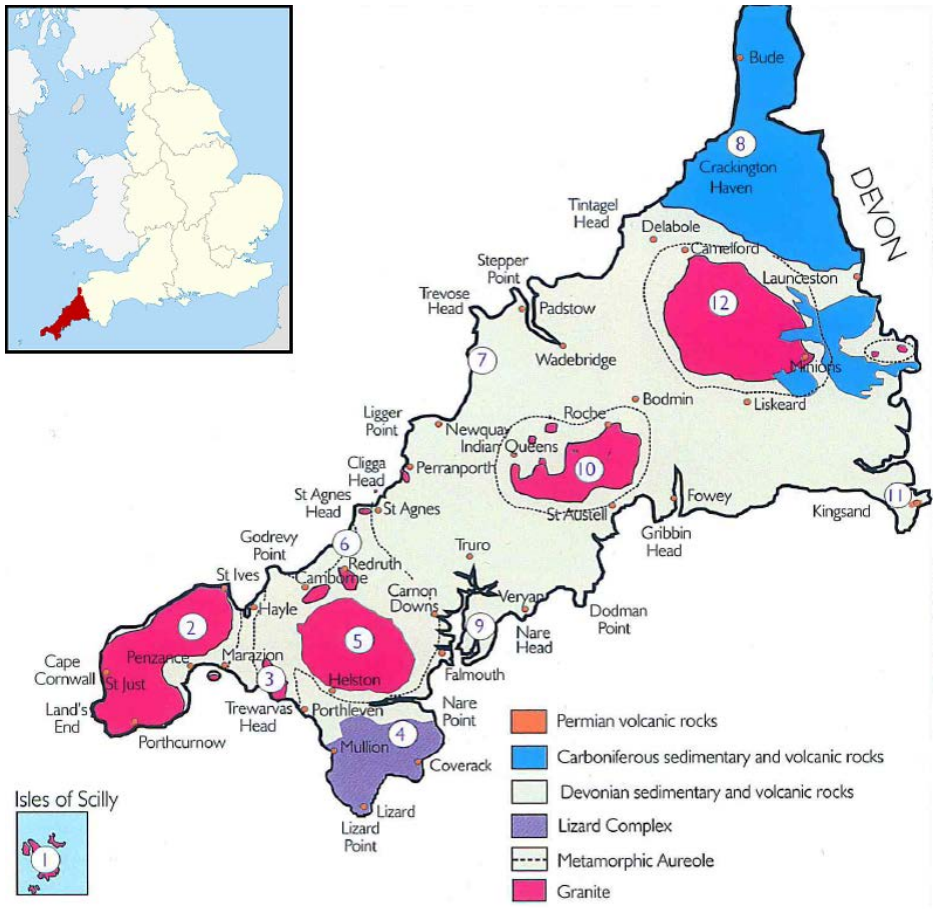
Combined Heat, Power and Metal (CHPM) extraction from ultra-deep ore bodies

Concept

- Identifying ultra deep metalliferous formations
- Enhance the interconnected fracture systems within the orebody (EGS)
- Leaching metals from the orebody and metal extraction from the geothermal brine
- Production of heat and electricity



Study area - Cornwall



Sn, Cu, Fe, Pb, As, S, Mn, Zn, W, U, Ag, Co, Ni, Bi, Sb, Mo, Au

UNFC-2009 Classification

Geothermal energy

Category	UNFC-2009 Definition	Reasoning for classification
E.2	Extraction and sale has not yet been confirmed to be economic but, on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic extraction and sale in the foreseeable future.	Heat available for exploitation and conversion to electricity not yet confirmed to be commercially viable. Project is however, expected to become commercially viable in the foreseeable future.
F.3.1	Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.	Pre-successful well drilling exploration complete (if a drilled well is 'dry' or unsuccessful, but further drilling is planned, this sub-category is still appropriate).
G.3	Quantities associated with a known deposit that can be estimated with a low level of confidence.	Low-confidence estimate

Metal

Category	UNFC-2009 Definition	Reasoning for classification
E.3.2	Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	Economic viability of extraction cannot yet be determined due to insufficient information (e.g. during the exploration phase)
F.4.2	No development project or mining operation has been identified	The technology necessary to recover some or all of the these quantities is currently being researched, but no successful pilot studies have yet been completed
G.4.2	Estimated quantities associated with a potential deposit, based primarily on indirect evidence	Low-confidence estimate (high estimate)

Conclusions: pro-s and cons of UNFC-2009

Pro-s

- ✓ Universally accepted classification system
- ✓ Proven that can be applied to geothermal projects
- ✓ Geothermal under a joint umbrella with minerals, fossil fuels and other renewables – comparable portfolio

Con-s

- Vague classes: cannot accommodate significant differences among projects, partly due to the complexity of the E-axis (all environmental, regulatory, market access, social and political features)
- Detailed technical and non-technical data owned by the project company are needed for the classification - often not available for an independent evaluator

High quality, authorized evaluators are needed!