Integrated SET Plan Actions Nr.1&2

ISSUES PAPER on
DEEP GEOTHERMAL ENERGY

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2 Our general views on geothermal energy

2.1 Vision

In a Danish context we have the government goals set for 2030, 2035 and 2050 leading Denmark towards a fossil-free future. These goals provide us with guidelines and milestones, and it fuels the development of the necessary systems to facilitate this transition.

In our vision the development and implementation of multi-sourced energy systems are pivotal to a structured approach to having a modern DHC system. Intrinsic to this vision is not getting hung-up on individual technologies, but having a consistent approach to developing technologies across a board range incl wind, sun, biomass, waves, geothermal etc.

In addition to the energy sources we also have to embrace storage technologies as pivotal to having efficient systems. Daily and seasonal fluctuations must be forecasted, and we shall have backbone systems that can store energies and deliver these when demand requests it – from a usage point-of-view, but also from a system-economics point-of-view e.g. storage when economically advantageous.

2.2 Obstacles and opportunities

2.2.1 Obstacles

The obstacles are primarily centered around two issues, 1) habitual thinking and 2) political reluctance to change.

Force of habit

We must break the shell of comfort and start thinking out-side our comfort zones (The Danish DH companies are profoundly adapt of this, and learnings must be distributed ww). When analyzing novel solutions, and making prognosis of the consequences of novel technologies and/or processes we base the prognosis on known facts. We should be prepared to leave our comfort zones, and embrace the risks as game-changers that we cannot possible make prognosis on or predict the outcome.

There is bound to be costly flops, however, through being adapt at discovering failure, not using 'blame' as culture element and through though project management, we stand to gain.

Political reluctance

Having political goals is perhaps the single greatest motivator – however, the motivation must be followed be flexible regulation and legislation to adapt seaming hopeless technologies in a type of incubator environment where the boundaries (technological, economical etc) can be discovered in a practical context.

The 'political' systems must be flexible to allow technologies to interact on a levelised playing field, where subsidies and taxation doesn't cloud the picture of the efficiency of the technologies in an overall picture.

Political initiatives must be able to stand their ground against lobbying and other types of scheming which at the same time shall unfold in an open, unbiased debate.

Separation of activities

District heating is experiencing a shake-up of systems and processes that is almost unprecedented due to the move towards CO2 neutrality and fossil-free energy. However, this shake-up has made DH distribution companies evaluate their role in society – they have taken on more responsibility and have acquired a leading interest in everything from production of energy (sun, wind, biomass etc), energy (heat (and sometimes electricity)) production, distribution, maintenance of assets, and not least billing. This has led to situations where the DH company takes on a responsibility for which it has no knowledge and know-how, leading to costly mistakes (as best) or down right failures (when worst). A fitting analogy is that no DH company produces their own natural gas, they procured a product on market terms, and added value through distribution and (stable) supply.

DH companies must acknowledge their position within the system, respect boundaries, and not least develop new value for their consumers through innovative measure such as remote billing, and optimised delivery of heat products.

2.2.2 Opportunities

We have the opportunity now based on accepting of the outcome of COP21 and other political initiatives to make changes – and we must as industry raise to the challenge. Initiatives such as 'City Solutions Platform' facilitated by Clean, is one such initiative which breaks down barriers and looks at things in holistic perspective.

Another important asset not to be forgotten is to incubate small and SME companies which have technology, technic and process to make significant (positive) changes to our DH systems. These must be given a path whereas financial investment is not an insurmountable obstacle to idea realization.

So in essence these is not just one opportunity, there is a flourish of ideas which must be given the financial aid to blossom without the often adjoining bureaucracy of documentation etc. The Danish EUDP system is one such system which walks the delicate balance between opportunity and bureaucracy.

Despite the changes to the EU Horizon 2020 system from the previous Frame programs, the system is viewed from an industry-perspective as being overly costly in terms of management.

3 Proposed targeted R&I actions

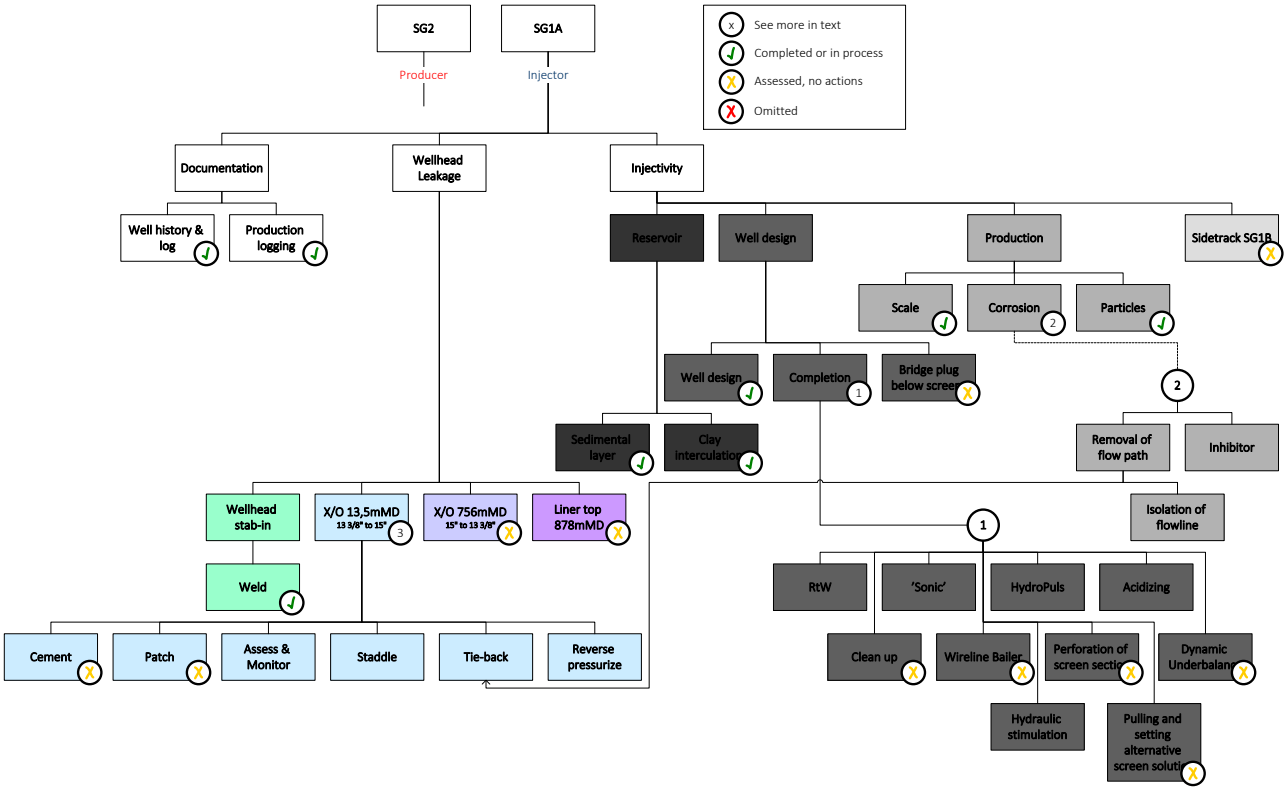
Ross is positive towards the suggested R&I targets, however, we can also say that in a Danish context we are already addressing many of these concerns.

3.1 Advanced Research Programme

3.1.1 Action 2: Improving deep geothermal production technologies: reservoir stimulation and management

See 3.2.1

Furthermore, we are currently working with two of the Danish geothermal systems and mapping their pains.



The mapping about is a snapshot of things ongoing right now, and is to mention that deep geothermal has a past, a present and a future.

3.1.2 Action 3: Improving deep geothermal production technologies: New materials

See 3.2.1

3.1.3 Action 4: Costs reduction of deep geothermal drilling technologies: develop novel drilling technologies

Ross has been funded by EUDP under DEA to conduct such as a project;

Phase 1 - Note

Phase 2 - Note

3.1.4 Action 5: Improve exploration technologies

Geological survey of Denmark and Greenland has recently launched a website dedicated to deep geothermal energy http://dybgeotermi.geus.dk/, and while there are areas with potential for improvement, this site is a milestone for having tools to guide our time and investments into geothermal energy.

3.2 Industrial Research and Demonstration Programme

3.2.1 Action 2: Improving deep geothermal production technologies: innovation in monitoring and operation

Ross is currently working on one such project proposal with Geological survey of Denmark and Greenland (POC State geologist Lars Henrik Nielsen). The aim is to understand 'geothermal brine' and the conditions which leads to scaling and corrosion, and the effects of extracting of heat on the brine and the brine cycle.

Project 'Geotherm';

GEOTERM – Tasks and project partners

Scientific research *Geological / Geophysical Team*	Production *Technical Team*	Distribution *District heating consumers*
• GEUS, AU • Qeye Labs • GFZ, BRGM, LU	• Geoop • FORCE Technology	• HOFOR • Margretheholm anlæg • Sønderborg og Thisted anlæg

WP1 Project Management (GEUS)

Pre-drilling assessment and Extraction

WP2 Quantitative seismic interpretation
(GEUS)

- Assessment of advanced seismic reflection methodology for locating sedimentary reservoirs.
- Transfer of quantitative seismic interpretation methodologies from hydrocarbon industry.
- Focused towards specific challenges of geothermal reservoirs: reservoir properties and rock physics.
- Testing on existing high quality 3D and 2D seismic data sets with wells.
- ***Partners:*** *GEUS, Qeye Labs, AU*

WP3 Reservoir properties – diagenetic and geochemical modelling
(GEUS)

- Analysis of coupling between mineralogy, hydrogeochemistry and changes in petrophysical properties and relation to sandstone diagenesis
- Numerical diagenetic modelling of physical properties as function of temperature and pressure during burial.
- Model validation against existing seismic data to qualify pre-drill estimates of reservoir quality.
- ***Partners:*** *GEUS, BRGM, GFZ, LU*

WP4 Resource assessment and energy extraction
(AU)

- Modelling of flow and energy extraction as a function of reservoir properties.
- Numerical geothermal reservoir simulation for sustainable geothermal production.
- Dynamic models for resource assessment.
- Conceptual models with realistic complex geology and various configurations of production and injection wells.
- ***Partners:*** *AU, GEUS, GFZ, BRGM*

Maintenance and Business case

WP5 Aggressive geothermal brines, microbiology, corrosion and scaling
(FORCE Technology)

- Chemical analysis of formation brines in relation to reservoir mineralogy at existing geothermal plants.
- Trouble-shooting on material and operational problems in existing geothermal energy plants, and assessment on material selection in corrosive brines with dissolved gasses and on scaling, de-scaling.
- Assessment of potential risk of microbiological induced corrosion due to recirculation of water.
- Qualification and corrosion testing of new materials and dissemination of technology to industry.
- ***Partners:*** *FORCE technology, GEUS, existing geothermal plants, Geoop*

WP6 Geothermal business case
(Geoop)

- Development of robust business case with commercial risks and economic investment scenarios.
- Elaborated from full sequence of geological assessment, project engineering, drilling, maintenance, service and intervention during lifecycle.
- Ideal for investment decisions and negotiations with stakeholders.
- ***Partners:*** *Geoop, HOFOR, existing geothermal plants*

Funding is sought from Innovationsfonden under the Danish ministry for Research

3.2.2 Action 3: Launch an EGS flagship programme

Not relevant in DK context.

4 Framework conditions policy measures

4.1 Innovative and Market uptake Programme

4.1.1 Action 3: Mitigate geological risk associated with geothermal

We fully acknowledge the risks associated with extraction of energy for the earth. However, geothermal energy and other renewable sources must be commercially competitive, and the price of energy needs to be unsubsidised.

Instigation of measure such as an insurance scheme on national, regional and EU will only fuel 'bad' projects which will be characterised by doubtful management (without proper competence and/or knowhow), poor organisation and/or project portfolios which paint a rosy picture of a project without addressing the real, underlying pains.

5 Ross' commercial target

The targets below are the areas where Ross is commercially active and where we expect to see development on both short and long term basis.

Geothermal energy – Low enthalpy

Heat account for 50% of the energy consumption [Source EU]. However, electricity has a far greater attention due to distribution and sale of electricity across boarders as a commodity, and the generation of electricity from WTG, PV panels and minor technologies (wave, tidal etc) taking the political attention from our energy sources (due to skillful lobbying not least).

Geothermal energy is part of a stable energy supply due to its properties of being independent of wind and weather and seasonal changes. In addition, geothermal energy is virtually unlimited as it harvest energy from the Earth's core.

Geothermal energy has the property to become a base load in most heating systems.

Thermal storage

OECD [Source OECD] has described the challenge as "Energy storage technology can be defined as a system that absorbs energy and stores it for a period of time before releasing it to supply energy or power services. Breakthroughs are needed in energy storage technology to optimise the performance of energy systems and facilitate the integration of renewable energy resources."

This is "essential to bridge temporal and geographical gaps between energy demand and supply" (same OECD source).

We see thermal storage as essential for heat storage, we acknowledge the need for electricity storage, however, the efficiency of integrated heating system (in a regional context) will increase exponentially with thermal storage systems bridging the full temporal spectrum from hour to seasonal.

Low and ultralow district heating

We are approaching 4G DH [Source 4DH] systems – and with the development of efficient piping from producer to consumer, we have an 'enabler' to see a widespread implementation of DH in district / regions / countries which have previous been viewed as uneconomical for the development of DH systems.