Asset management guideline for low enthalpy geothermal assets

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Agenda

- Why an Asset Integritiy Management guideline?
- Objectives and context of the study
- Typical Geothermal Plant considered
- Survey and Visit outcome
- How does the Guideline looks like?
  - Operational, Organisational & Technical Integrity
- Detailed guidance to ease implementation
- Technical Integrity
- Conclusions

Asset management guideline

Why a Guideline/template

- The benefits of proactive asset management can include, but are not limited to the following:
  - improved financial performance;
  - informed asset investment decisions;
  - managed risk;
  - improved services and outputs;
  - demonstrated social responsibility;
  - demonstrated compliance
  - improved organisational Management
  - improved efficiency and effectiveness,
  - management of technical and operation integrity
  - ensure safer assets, greater control

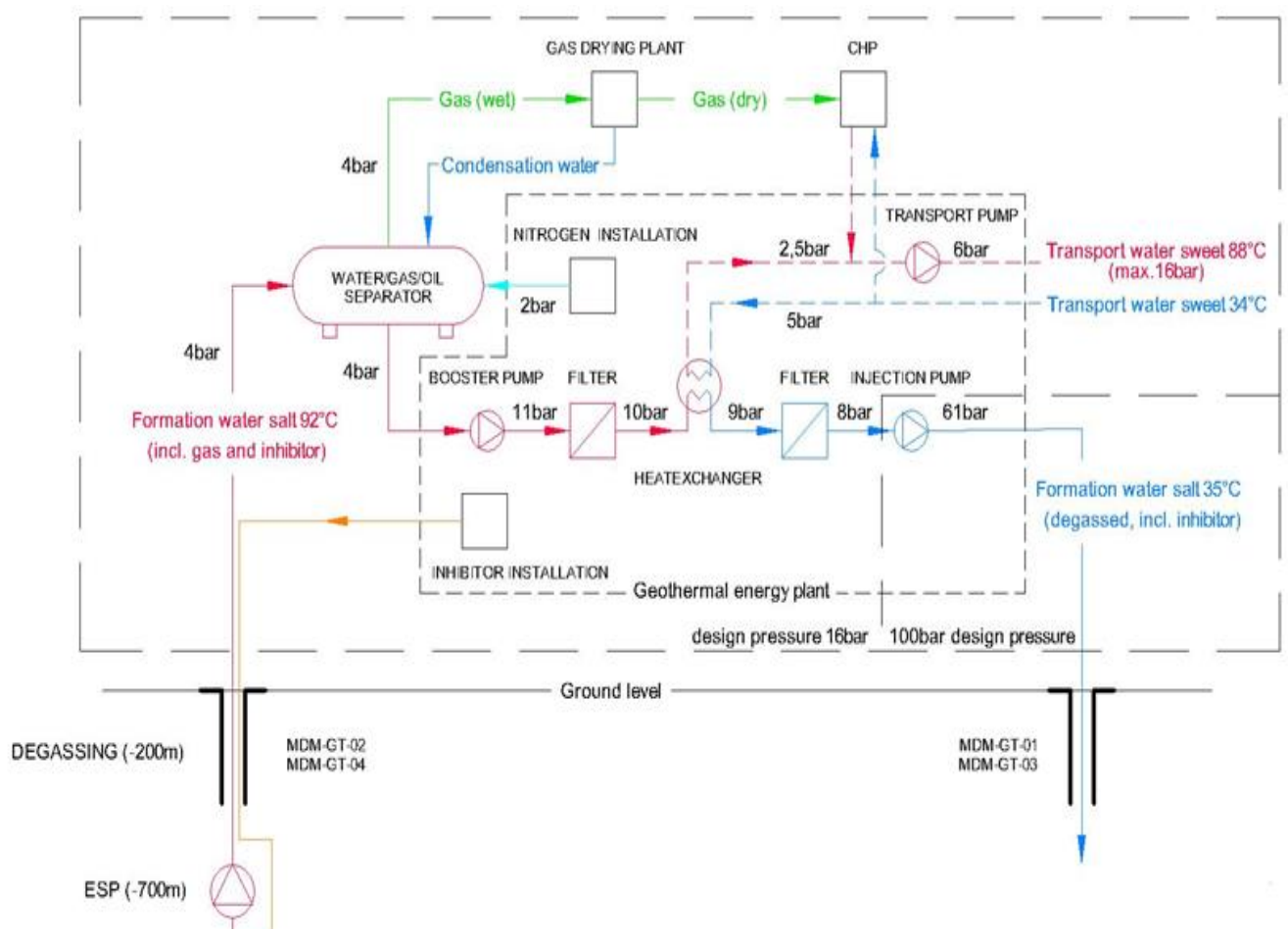
Geothermal asset

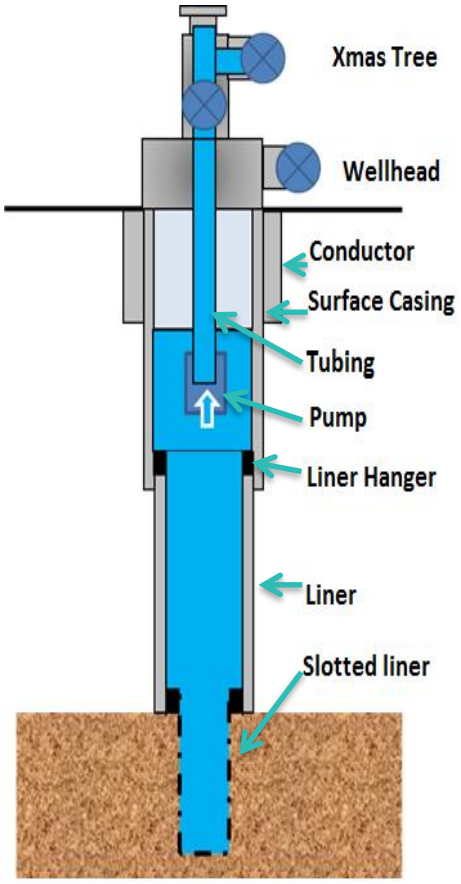
Objectives and Context at glance...

- Develop a Draft Asset Management Guideline/practices Framework enabling the Dutch Geothermal Industry to develop asset management plan for geothermal low enthalpy asset plants
- Define standardise good asset management practice covering the full life cycle,
- Define the content of asset management plans for geothermal energy systems,
- Cover the entire asset life cycle from concept to abandonment,
- Create lean asset management plans which maximise production and safety whilst optimising cost
- Guideline developed from oil and gas practices and other Relevant Literature
- End usage: district heathing and greenhouses
- Account for Single ownership to small consortia; different business models
- Account for diversity of Geothermal plants, such as:
  - Potential hydrocarbons in formation water ; gas or oil
  - CO2 can be produced from the geothermal wells (up to 8mol%)
  - high dissolved salt content can be observed

Geothermal asset

Typical system considered in the guideline





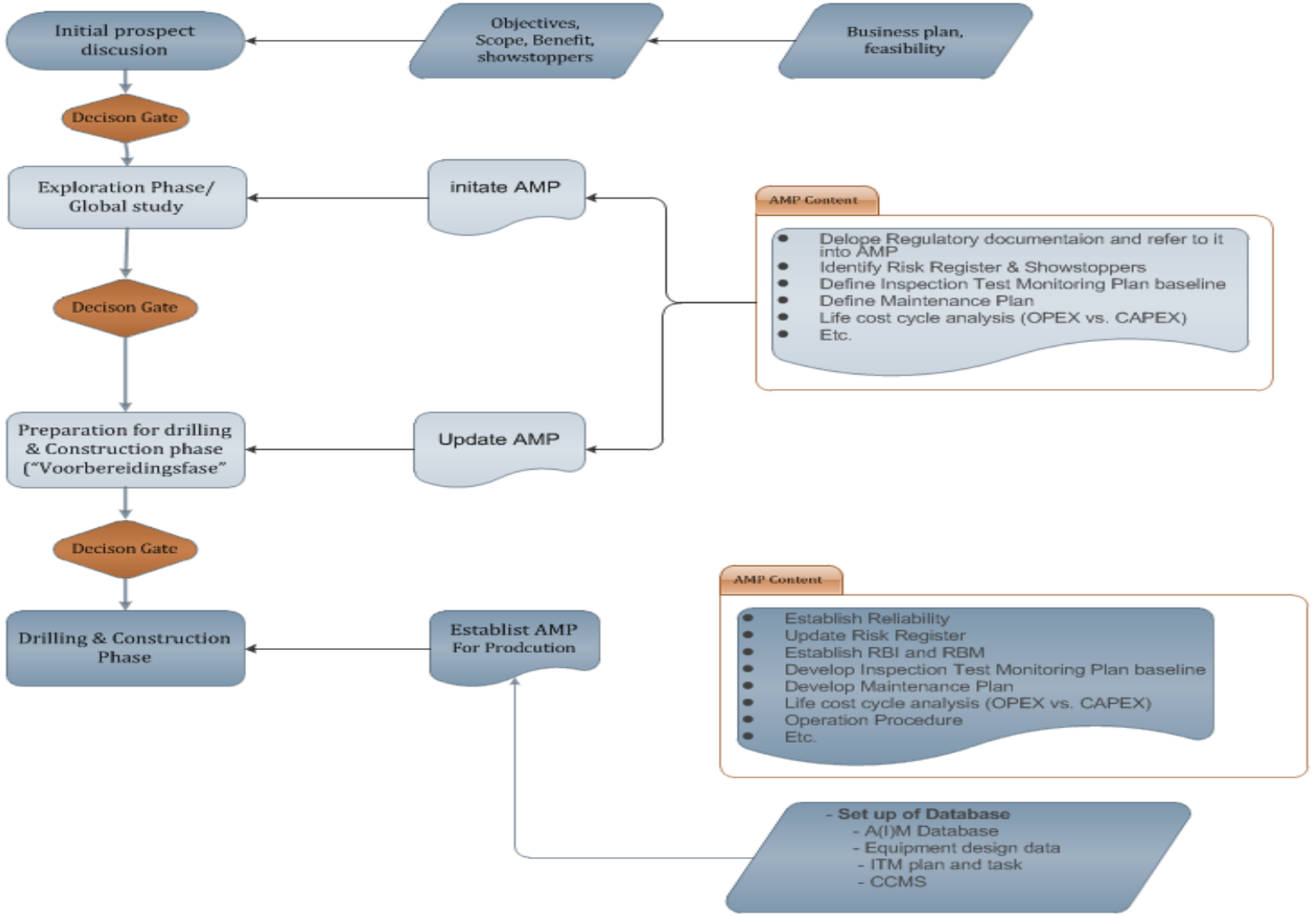
Asset management guideline

Survey & on Site Visit Feedback

- Survey:
  - 6 participants; Asset Mgt. current Practices
- Survey & Visit
  - Equipment: Inspection, Monitoring, Testing and Maintenance (IMMT) Practices
- Survey outcome
  - 83% have have IMMT program review, Compliant with Regulation, Risk management (but may be not RBI)
  - Potential Improvement :
    - Training, Third party Control, Roels and responsibility, Mgt of Change, Consistency in IMMT proceudre developement and implementaion
  - Diversity
    - Operation organisation: Turnkey Contractor to self, also combination of ourselves and third parties
    - Small inspection & maintenace ourself
- Equipment outcome Survey
  - Visual inspection mainly
  - Some measurements mentioned
  - Little details
- Visit Outcome
  - Current Asset mgt Practices. i.e
    - Inspection/ preventive maintenance pratices
    - Technical and operational Integrity anomalies experienced
    - Organisation/Procedure
  - Inspection and maintenance frequency for some equipments
  - Used in Technical Integrity Management section

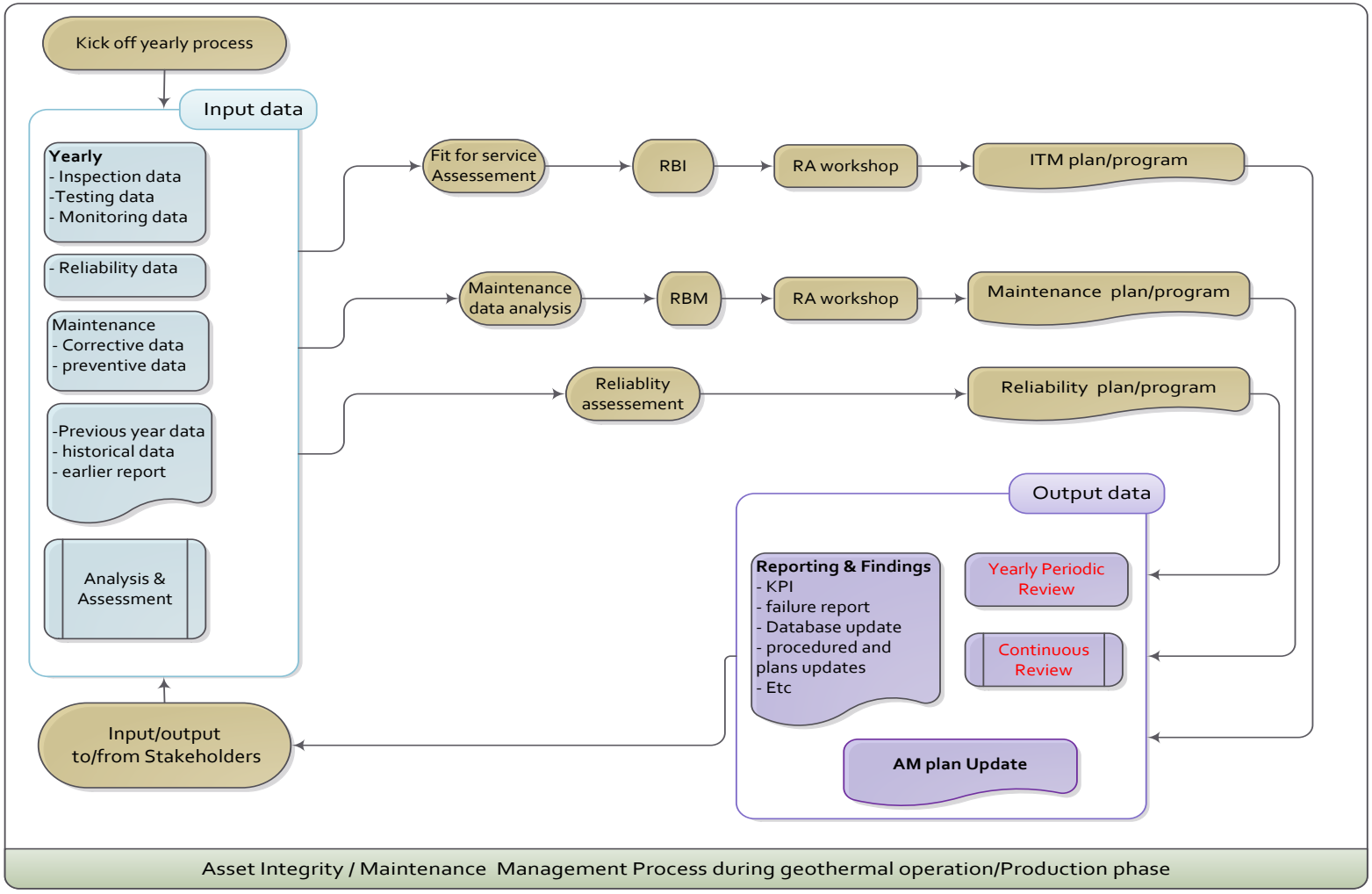
Asset management guideline

A classic asset project management process – Pre operation



Asset management guideline

A classic asset integrity management process – Operation phase



Asset management guideline

How does it look like? 1/2

- A guideline setting requirements and recomendations
- ... But written as a Plan /Template to be completed (tables)
- The guideline sugggests:
  - Operational and organisational integrity management systems
  - Reliability management
  - Technical integrity management

- **Operational & Organisational Asset Integrity Management**
  - Organisational Roles, Responsibilities, Authorities
  - Leadership Commitment and Policy
  - Supply Chain Management and Knowledge Network
  - Competence and Training
  - HSE and Emergency Response
  - Management of Change
  - Incident, Preventive and Corrective Action Management System
  - Lessons Learned
  - Storage of Information – Documentation / Database
  - Performance Evaluation
  - Monitoring, Audit & Review

3.6.8 Lessons Learned

Lessons learned from assurance activities or from incidents should be captured and communicated within the operator's organisation and across the wider industry as necessary (see section 3.6.5). Learning from problem and exchanging data and information across developing industries are crucial to the overall long-term viability and efficiency of the geothermal asset.

Table 3-17 Lessons Learned List for all Phases

Component	Lesson Learned description	Recommended Action	Project Phase	Distribution list	Status
Relevant component	*Describe the change*	*Describe action*	*Exploration development, Construction, Commissioning, Operation and*	*List who should be informed*	*Open, ongoing, closed*

Typical guideline section example:

Short text, table to filled in, table explanation...self-explained

Asset management guideline

Detailed guidance to ease implementation...develop an Asset Plan

Best practices for pre-operation phases

Define Design Basis
Design life of the asset, reservoir data, production target/requirements, etc.
Define preliminary Asset and Organisation philosophy
Define and describe information and philosophy such as production level, fluid composition, type of wells, surface equipment's, drilling information and constraints, reservoir information, Corrosion risk, etc.
Identify Risk & Opportunity and the show stoppers for each scenarios
Material selection for geothermal wells and surface
Define qualification testing required for the project and associated cost
Establish Preliminary Integrity Management requirements by considering CAPEX versus OPEX
that includes material selection, operation philosophy, equipment selection, consequences on Maintenance Inspection, spare and repair workovers required for different options, etc.
Seek and address lessons learnt from other projects to inform design decision making
Identify resource requirements for the various project stages
Address Economic viability of the assets for the key scenarios

Prescriptive life cycle Information requirement

Requirements & Recommendations	Information
Maintainable and up-to- date documentation and database system	*The design documentation will be the primary means by which engineers are informed of key requirements and design assumptions*
Design and set a documentation format and system easing retrieval and analysis of data & information	*Clearly defined criteria to develop and revise documents, to limit documentation and ease access to information in the future*
Review by Technical Authority	*The design documentation should be reviewed and endorsed by relevant technical authorities to ensure that the design basis remains aligned with Objectives*
Identify a document/data Controller	*Allocated responsibilities and authorities to review and issue documents, to withdraw and retain obsolete documents*
Documentation data systems account for tracking of changes	*Arrangements to ensure that documentation is revised and updated according to MoC section 3.5.6*
Security and back up of the Data	*Security of the data shall also be considered against ransomware or any other virus; a backup of the information and system shall be set up.*
Ensure business continuity via a business continuity plan	*IT system can be hacked, asset partly damaged (e.g. fire, explosion), key personnel can leave company. As a result, significant knowledge and experience can be lost. Operation can be disrupted for several weeks or months with significant impact. Operator should have a business continuity plan to address such threats.*

Audit: recommend frequencies...prescriptive

Item #	Description	Recommended minimum frequency
1	Review and Audit of AMP effectiveness and compliance	*Once a year during Operation, Once per project phase*
2	Review and Audit of Inspection, Monitoring, Testing and Maintenance plan, records and execution	*Once a year, Twice yearly for records*
3	Review and Audit of Operation and integrity processes and procedure	*Once a year*
4	Review and Audit of suppliers	*Twice for key suppliers during project duration; every year for supplier involved in Operation*

Asset management guideline

Technical integrity 1/3

- System description and operational parameter;
- KPI : monitoring Parameter
- Generic threats and risk assessment to support RBI and RBM
- The “what, how and when” related to inspection/monitoring/testing and maintenance technical programme;
- Indicative inspection and maintenance frequencies
- Long term inspection, testing and maintenance frequencies
- Periodic review: compliance and asset integrity assessment

Performance Indicator Description	Acceptance Criteria & Anomaly Limits
Additives Monitoring	*To be defined as per asset design, i.e. the following shall be defined for each KPI whenever possible.* *1) Upper Safe Design limit* *2) Upper Safe Operating limit* *3) Upper Normal Operating limit* *4) Normal Operating Limit* *5) Lower Normal Operating limit* *6) Lower Safe Operating limit* *7) Lower Safe Design limit* *Note that beyond 1) or below 6) equipment will operate with Design Margin / known safe then uncertain operating conditions.* *Between 2/3 and 5/6, this is called the Troubleshooting zone*
Corrosion inhibitor content	
Corrosion inhibitor availability	
H2S Scavenger (Residual H2S Concentration)	
Scale inhibitor (continuous/intermittent)	
Bactericide / Biocide (continuous/intermittent)	
Fluid Parameter Monitoring	
Iron Ion content	
Oxygen Scavenger (Residual O2 concentration)	
Fluid Additives	
O2 in Water Injection (ppb Oxygen equivalent)	
CO2 (mol% in gas phase)	
H2S (ppm in gas phase)	
Water Calcium (Ca) content	
Water Sodium (Na) content	
Water Chloride (Cl) content	
Water pH Value	
Bubble Point	
Methane (CH4) mol%	
Physical Parameters Monitoring	
Gas/water Ratio	
Gas production	
Injection pressure	
Injection temperature	
Production Pressure	
Production temperature	
Production Flow	
Electricity consumption per Phase	
Degasser pressure	
Degasser, Flow rate	
Water/Oil/Gas Separator, pressure	
Water/Oil/Gas Separator, Temperature	
Usage of Gas - Preferred option - WKK (capacity)	
Usage of Gas - Alternative option - Heating (capacity)	
Usage of Gas - Alternative option - Flare (capacity)	
Heat Exchanger, Flow Capacity	
Heat Exchanger, Temperature In	
Heat Exchanger, Temperature Out	

Typical monitoring parameters change with the asset profile

Asset management guideline

Technical integrity – 2/3

Basic Corrosion Monitoring Regime/Frequencies

Technique	Notes
Corrosion Monitoring	
LPR corrosion probe pH monitoring	At a convenient location in the surface piping or on a bypass loops. Ideally, real-time connection to control room. Otherwise, manual reading or download of data daily. Acts as an alert for problems with the inhibition system.
Corrosion coupon	At a convenient location in the surface piping. Typically retrieved 6-monthy.
Process measurements (pressure, flow rates, temperature)	Standard process measurements
Sampling	
Inhibitor residuals (biocide residual, scale inhibitor residuals etc. if applicable)	Measure at commissioning of the system to set initial dose rates. Review at 6 or 12 monthly intervals. Sampling point should be as far downstream as practical, e.g. at injection wellhead.
CO2	For systems with Separator, measure the off-gas. May be by on-line monitor or by sampling (e.g. 6-monthly). It is important that a consistent sampling location and technique is used. LEGE Asset Practice : monthly assessment
Water chemistry (see Appendix D)	Sampling and laboratory analysis, e.g. 6 or 12 monthly LEGE Asset Practice : monthly
Bacteriological sampling and analysis	Only required as routine with lower salinity waters able to support microbial activity.

Indicative inspection Frequencies

Equipment	Inspection Frequency	Reference/ Source	DAGO Practice
Inspection			
Piping & Valves	12 months for GVI/CVI Max 48 months for Maintenance Depending	API 570 – February 2016	Wall thickness 2 time year
Booster Pump & Injection Pump	Routinely CVI (read gauges, leak, vibration etc.) Maintenance monthly/annually/by hours of service depending on parts	Typical Manufacturer specification	6 times per year
Heat Exchanger	GVI	DAGO	Daily check

Basic reliability data collection template

Component	*Name and tag*	Operation time in service of Components (hrs)	*From start to last update of the data in days*
Number of failures	*Number of failures during time in service*	Non production time (hrs)	*Any shutdown time during production/ operation*
Number of Maintenance order	*Number of Maintenance tasks during Operation*	Cumulated Maintenance time (hrs)	*Cumulated Maintenance time during time in Service in days*
Failure type	Failure description	Repair time	Downtime
Short description of failure types list : corrosion, mechanical failure, etc.	Describe if failure occur during normal or abnormal operation, describe failure mode, failure cause, failure effect, failure criticality n term of safety or production	*Only time to repair.*	*Time from failure to restart - include supply of part time, failure investigation, repair time, time for re-testing and commissioning.*

Asset management guideline

Technical integrity – 3/3

Inspection & Maintainance Planning

Table 3-32: Inspection & Maintenance Planning template

				Inspection					
Systems	Component or part	Description	Procedure reference	M. 1	M. 2	M. 3	M. 4	M. 5	M. n
		Inspection							
Piping	All piping	General GVI	*Doc number*	*S*	*S*	*F*	*P*	*P*	*P*
	flanges	CVI		*S*		*P*		*P*	
	As per Assessment findings	NDE							
	Piping section, Wels, etc.	Internal Examination							
	All piping	Wall thickness							
	Corrosion under Isolation	NDE							
		Testing							
Piping	Internal	Pressure							
		Maintenance							
Piping	all	Painting							
	Flanges	Seal							

Note:

- S: Done and successful; F: Done and failed; P: Planned. New Abbreviation to be added as required.
- Time line can be Month, Year, or Week depending on equipment. First two lines for piping system are an example.
- It is suggested to develop an Excel Spreadsheet to keep historical recording and show planned activities.
- Additional equipment to be added as per LEGE Asset.

Asset management guideline

Conclusion & recommendation

- An asset guideline/plan template …practical to implement for end user
- Asset Plan developement Guidance
  - Intend to be prescriptive enough to guide
  - But Scalable to small and bigger plants
- It covers all project life cycle
  - Asset Integrity Plan is developed progressively at each phase
  - Risk based approach : Project Risk, RBI and RBM
- Cover Organisational, Operational and technical Asset management
- Technical Guidance
  - Pre-operation project risk typical list
  - Operation Risk typical list
  - Inspection tools for different equipment
  - Inspection Test and mainteance program guidance for Surface and Well Asset
  - Regulation recap
  - Reliability data collection
- A Tool to communicate
  - to different stakeholders,
  - to share knowledge on a common basis

Thank you.

Questions?

Arnaud Barré - integrity operation manager , norway

Survey

N#	Questions	Yes %	Analysis
6	Do you review and change your Inspection, Monitoring, Testing and Maintenance program on yearly basis?	83%	Is it risk based?
7	Do you have a documentation system for archiving Inspection, Monitoring, Testing and Maintenance record, and associated assessement?	83%	but **no specific feed back**
11	Did you evaluate the Inspection, Monitoring, Testing and Maintenance of your Geothermal well and surface equipments at Concept and feasibility stage?	83%	some only at production or operation phased. OPEX?
13	Are applicable laws, regulations, permits and other governmental requirements anticipated and met, and are the resulting operating requirements documented and communicated to those affected?	83%	still learning curve (noise/ integrity isuses) ; Overlook some issues ; one participant fully compliant. Exchange needed (eg. JIP)
15	Do you have a system to follow up the risk mitigation and anomalies found in your asset	83%	Control in place
12	Did you evaluate the Inspection, Monitoring, Testing and Maintenance of your Geothermal well and surface equipments at Design and construction phase, ie prior starting production?	75%	some only at production or operation phased. OPEX?
18	Do you have a process to control changes in your Equipment or operation procedure and their impact on the overall system (Component replacement, operationg condition changes, etc)?	75%	improvement possible (consistency and regularity)
5	Are roles and responsibility for Asset Integrity Program activity documented?	67%	In general exist but need to be improved or updated
14	Do you risk assess your asset on regular basis?	67%	improvement possible. **Some partially or future activity**
9	Do you have an Incident Investigation and Analysis process in place?	58%	May be part of Emergency prepardeness? One respondent said partially
16	Are your operating, maintenance, and inspection procedures developed, implemented, and consistently used	58%	improvement possible (consistency and regularity)
1	Do you have dedicated employee to manage the Geothermal Asset integrity?	50%	Diversity! From Trunkey Contractor to self to 5 engineer , also combination of ourself and third parties
2	Do you perform Inspection, Monitoring, Testing and Maintenance of Well and surface equipement yourself?	50%	ourself or third party (e.g. Subsurface)
4	Do you have a training program for the employees coordinating/executing Asset Integrity Program activity?	50%	Training: turnkey - to mainly "on the job" training
8	Do you have a Community Awareness and Emergency Preparedness in place?	50%	Emergency preparedness ok. Comunity awareness can be improve but discussion in place. New energy so important to ge "buy in"
10	Do you have a processs to select , evaluate performance of Third-Party Services?	50%	From "of course" to no or improvement
3	If answer to question 2 is no, what do you perform or subcontract : Inspection, Monitoring, Testing and Maintenance of Well and surface equipment yourself?	N/A	smaller inspection & mainteancne ourselves