Geothermal Data Management System

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Agenda

- About Landsvirkjun
- Project Aim
- Solution Overview
- Next Steps
- Q&A Session





About Landsvirkjun

Mission:

«Landsvirkjun's role is to maximise the potential yield and value of the natural resources it has been entrusted with, in a sustainable, responsible and efficient manner.»

- Hydro and Geothermal and Wind Power generation
- Hydro production, 1953 MW in 14 stations
- Geothermal production, 63 MW in 2 stations
- Third Geothermal Plant under construction
- Geothermal wells similar to O&G \rightarrow Steam
- +130 wells, declining output → 1 new every 1-2 years
- Total worth of LVs geothermal wells on the order of 100s of MUSD
- LV focus both on plant construction and operation
- All employees and most consultants and contractors based in Iceland







Project Aim

Information system for wide range of data in geothermal operations

Challenges

- Geothermal research and operations data stored in various places
 - Petrel, Power plant SCADA system, Share Point, various files and databases (MySQL, Oracle, PostGRES, SQLite, Excel)
- Key information systems outdated
- A good information system fulfills the requirements of the field operators, the power plant development team and the R&D division.
- Need to facilitate cooperation (both in-house and outside)
- A thorough requirements analysis for a new information system carried out



Requirements Analysis

Schlumberger Solution scored highest in quality and cost, both with and without Avocet Dashboard

Schlumberger chosen with aim to develop a long-term relationship with a dedicated partner

- Data Integration and Validation
 S
- Well established solution
- Field capture to analysis workflow

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solution quality

Est.

- Standardization
- Ties to geothermal industry
- Tools to incorporate own analysis and plug-ins



Est. cost

Geothermal Data Management System



Solution Scope

System and data integration from field data collection to geospatial analysis





Proposed Solution Architecture

System and data integration from field data collection to geospatial analysis

Solution Architecture





Data from legacy data systems into Avocet

Build key calculations into Avocet and OFM

Link OFM to Avocet and set up preliminary analysis

GIS from OFM and Avocet

Create common item hierachy and nomenclature

Integration of Data from legacy systems

Well Production and Injection Wellhead Pressure & Temperature, Orifice Configuration etc.

Flow Rate, Enthalpy, Thermal Power, Electric Power, etc

Data Verification, Operator Remarks, etc.

iter 🗰 G nve Filter 🌾 D sload 🔍 E	Group By Delete Excel	 New Save X Delete 	Duplicate Ditem Info	Edit Validations Edit Validations Show Active Validations Only Recalculate Screen Actions	Recalculate History	 James Lip Pressure Water Tracer and Orifice Steam Separator Toggle 	 Water and S Expand All Collapse All Methods 	team 1	Tracer 🖪 GB	5 Map	190		
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Chemical Analysis Sampling Data

Water, Steam and Gas Analysis

Data Verification, Operator Remarks, etc.

Filter Group By Save Filter To Delete Filter To Delete Filter Control	New Duplicate	Call Control C	Recalculate History	 Load Data Save Data / Call Watch Watch Process 	Eo G	5 Map							
eothermal Fluid Chemi		(hart										
Datetime Sample Number Well Nead Pressure Sampling Enthalpy Pressure Pressure Temperature Water Analysis	17/07/2013 16:30:00 803108 14.5 barg 1.658 kl/kg 35.6 kg/s 14.3 barg 200.2 *C		Separat Enthalpy Flow Pressure Tempera Steam Flow Carbon J	or ture		(inthalpy [kl/kg] ◆ Flow [1000 1180 1160 1140 1120 1100 1080 21/09/2006 22/04/	kg/s] ** pł	21/11/	Fotal Dissol	ved Solids (TDS)) [mg/kg	1
рН	8.62		Hydroge	n Sulfide, H2S									_1
pH Temp.	22.6 *C		Hydroge	in, H2	ł	listory	Errors Navigator						
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Total Suspended Solids (TSS)	1.400 mg/kg		Flow			.3.90				8.6/	23.20		
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Dissolved CO2	15.0 mg/kg		Т-рН										
Dissolved H25	75.51 mg/kg		Carbon I	Dioxide, CO2		.6.30				8,91	21.30		
Sulphate, SO4	12.20 mg/kg		Bicarbor	ate, HCO3		.7.20				8.9	17.60		_
Phosphate, PO4	mg/kg		Hydroge	n Sulfide, H2S	1	7.10				3.0.	20.70		
Ammonia, NH3	mg/kg		Hydroge	m, H2		7.50				8.9	23,20		
Nitrate, NO3	mg/kg		Methane	. CH4	-	.6.20	203.00						
				•	3 6								•



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Facility Measurements

Power Plant Production Parameters

Weather Conditions, Air Quality, Sound Intensity

Steam Transmission, Fluid Discharge, Groundwater Level, etc

As Of Date 4 14/08/2013 III Saved Lists Active Station Reset to default Nave	Te s Te s R pation	Iter Group By ave Filter Collecte eload Collecte	New Duplicate Save Duplicate Save Delete	Edit Validations Show Active Validations Only Recalculate Screen Actions	Recalculate History	GIS Map Map				
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Facility Measurements Wind Speed		Wind Speed	4.4 m/s					07/08/2013	1.013.0	14.2
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Air Quality	asure	Observer Name	ÓÞJ/HMS					09/08/2013	1,005.9	8.8
Discharge							-	10/08/2013	1,003.8	11.3
Geothermal Station		•			<u></u>			11/08/2013	1.009.3	6.4
Groundwater		Chart						12/08/2013	1.007.0	14.0
Sound Intensity		Chart				1.1.1.1		13/08/2013	1.003.0	15.4
Steam Transmission		- Dry Bulb Tempe	rature [*C] — Wet Buib	Temperature [°C] Presssure [mbar] — Dew Point Ter	mperature [°C]		14/08/2013	996.0	15.2
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Well Logs

Pressure, Temperature, Flow Rate (PTS)

Gamma, Neutron, Resistivity, Spontaneous Potential

Caliper, Cement Bond (CBL)

AvocetVM	Client.Screen	is.Common.Ge	Errors	Chart						History
hatotime 07/1	3/2000 15:10:00		*Te	mperature l'	CI VPressure	e Ibarol				Datetime 🔺
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Depth [m] 🔺	Temperature [°C]	Pressure [barg]	1400							26/08/2009
0.00	248.63								1	26/08/2009
5.00		38.83								26/08/2009
7.00	248.68		1200							26/08/2009
10.00		38.88							1	27/08/2009
15.00		38.90	1000							27/08/2009
15.50	248.76		1000							27/08/2009
20.00		38.93							1	27/08/2009
22.50	248.80		800							27/08/2009
25.00		38.95	Ξ						1	27/08/2009
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65.00		39.11	10	16	60	110	160	210	260	07/12/2009
				1						27/09/2012



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Well Configuration Trajectory

Casings

Schematics



Geothermal Data Management System



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Key calculations in Avocet and OFM

List Names Variables System Functions Plugin Functions User Functions	SatPXsi SatTXsi SteamPHsi SteamPTsi SteamPTsi SteamTSsi	Keypad DELETE CLEAR SELECT WHERE AND OR NOT
Add	Steam Table	< 7 8 9 / > 4 5 6 x 2 - es









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Link OFM to Avocet to setup preliminary analysis





	Power Station Annual Report Krafla Turbine 1													
	Note: Please select Krafla Turbine 1 or Krafla Turbine 2 under the completions or under item: type 'Unit' from the navigation													
	Year	Turbine Electric Power MW	Turbine HP Pressure barg	Turbine HP Steam Rate kg/s	Turbine LP Steam Pressure baig	Turbine LP Steam Rate kg/s	Power Production TJ	Turbine Thermal Efficiency	Turbine Mechanical Efficiency %	Condenser Pressure mmHg(DC)	Condenser Temperature Deg. C			
	1981	10.37	6.69	32.58	0.86		0.33			95.29	30.22			
	1982	13.61	6.76	36.71	0.80	4.27	0.43	12.53	57.28	110.98	28.65			
	1983	29.06	7.23	46.83	0.89	6.04	0.63	\$4.40	63.27	98.04	30.84			
	1984	23.64	6.88	62.70	0.99	10.41	0.76	14.35	60.66	80.69	36.94			
	1985	23.87	6.88	53.19	0.95	7.80	0.75	15.08	63.38	80.01	37.86			
	1986	25.50	6.40	65.77	0.95	8.03	0.80	15.58	65.72	81.05	37.52			
	1987	27.53	6.55	58.68	0.99	7.23	0.87	16.23	69.42	54.01	38.32			
	1988	27.79	6.74	51.68	1.17	8.09	0.88	18.08	76.88	85.52	37.73			
	1989	28.87	6.83	47.95	1.05	13.05	0.91	18.52	79.80	87.66	38.91			
0	1990	29.53	7.16	50.24	1.09	12.56	0.93	18.55	78.92	87.71	39.77			
1	1991	25.71	7.34	52.34	1.16	10.51	0.84	17.31	72.32	82.43	38.25			
2	1992	27.62	7.22	61.13	1.08	12.14	0.87	16.87	71.27	84.52	37.62			
3	1993	28.73	7.28	54.05	1.04	12.47	0.91	16.77	69.49	77.66	38.61			
4	1994	28.24	7.29	50.43	1.06	10.44	0.89	18.00	74.18	76.04	38.13			
5	1995	29.55	7.26	47.35	1.05	10.05	0.93	19.85	81.24	73.07	38.25			
6	1996	29.04	7.26	46.97	1.05	8.96	0.92	20.11	83.72	81.34	39 14			
7	1997	28.65	7.27	45.51	1.40	12.05	0.90	19.32	81.04	82.71	39.05			
8	1998	25.68	7.34	45.05	1.26	11.35	0.84	18.31	76.65	85.30	39.03			
9	1999	29.51	7.32	48.71	1.25	11.15	0.93	19 39	83.97	99.15	41.54			
0	2000	29.24	7.31	58.35	1.65	14.85	0.92	16.75	70.40	50.38	41.87			
1	2001	35.23	7.45	62.63	1.22	14.96	0.96	15.05	64.16	62.82	42.59			



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Common item hierarchy and nomenclature

Common Item Hierarchy and Nomenclature

/ |

Sub-system

Sub-system

Sub-system

-12

Sub-system

Function

- 6

-

Product

Water

Water

Active

✓

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Well

Organization Viewer

All Screens

Well Production and Injection Start Datetime + End Datetime + Operation Area 01/01/1900 Well Production 01/01/9000 Mývatn Operation Area Start Datetime ₽ End Datetime ₽ Site Facility Measurements 01/01/1900 01/01/9000 Biarnarflag Site Chemical Analysis 01/01/1900 01/01/9000 Krafla Site Wells and Facilities Start Datetime End Datetime Power Station 01/01/1900 01/01/9000 Krafla Power Station Bore Start Datetime + End Datetime + System Completion 01/01/1900 01/01/9000 KRA Other wells Condenser Start Datetime + End Datetime + Cooling Tower 01/01/1900 01/01/9000 KRA Cold water production Start Datetime End Datetime -10 Discharge AE-01 01/01/1900 01/01/9000 Lake AE-02 01/01/1900 01/01/9000 Mixer Start Datetime 01/01/1900 01/01/9000 KRA Drainage well Pipeline 01/01/1900 01/01/9000 KRA General research Separator Start Datetime + End Datetime + System Spring 01/01/1900 01/01/9000 KRA R&D data system + End Datetime + Station Start Datetime 01/01/1900 01/01/9000 KRA Measuring stations Streams 01/01/1900 01/01/9000 KRA Sampling point Sub-system KRA Weather Stations 01/01/1900 01/01/9000 Surface Start Datetime + End Datetime + System 01/01/9000 01/01/1900 KRA Steam systems Unit Start Datetime Well 01/01/1900 01/01/9000 KRA Injection wells 01/01/1900 01/01/9000 KRA Steam collecting system and wells



Future Work

- Start capturing manual field data through Avocet web
- Define views for partner collaboration
- Connect OFM to other data sources
- Standardized reporting to field operations
- Extended functionality for geothermal applications
- Design Dashboard for KPI monitoring

