



ANNUAL REPORT YEAR 1

Biological Utilization of Geothermal Gas

Date of annual report: 10. Nóv. 2010

Project ID: 09-01-017

Coordinator: Guðmundur Óli Hreggviðsson, University of Iceland

Start date: 1. June 2009

Duration: 2 years

Partners: University of Iceland, Prokatín ehf, Mannvit Engineering

1 General status of the project

As reported in the progress report 1, the milestones 1.1. and 1.2. were both completed in the spring of 2010. Also now, by the end of October 2010 also milestone 1.3. has been reached. Therefore all milestones and deliverables for year 1 have now been reached and completed according to plan.

The project has been delayed in total of about 4 months due to construction time and minor technical difficulties with pumps and sensors etc. Testing of the facility without gas was done in the first week of October and gas treatment testing started in second week of October. The formal start date is now seen as 1. December 2010.

1.1 Project progress/time schedule:

The project will therefore continue according to the original Project Plan as described in Annex I. The task are basically the same and do not need any modifications. Therefore we now can define the deliverables and milestones for year 2. This is shown below.

Short description of the work plan

Subtask 1. Pilot plant at Hellisheiði

Main emphasis is put on building a several thousand liter pilot plant at the Hellisheiði power plant. The pilot plant will obtain geothermal gas directly from the power plant and the gas will be processed by a biological process for the production of biomass (single-cell protein) and solid sulfur and sulfuric acid. The pilot plant will be run for 1-2 years and is estimated that during the operation of the facility, up to 50 tones of biomass and 100-300 tones of sulfur / sulfuric acid will be produced. The operation will be a feasibility study for a future full-scale factory.

Subtask 2. Use of Biomass for Feed

There is much interest in the availability of new protein sources for feed due to shortage of fish meal for feed. We will collaborate with the Norwegian feed producer Ewos to evaluate by analysis and testing the use of our single-cell protein in feed for animals and fish farming. We will also collaborate with Matís ohf and the Icelandic company Arctic Tilapia ehf for experiments using the single-cell protein for cultivation of the tropical Tilapia fish which is a species with characteristics suitable for experiments of this kind.

Subtask 3. Utilization of Sulfur

Previous studies have indicated that soil in Iceland is generally deficient in sulfur and is a limiting factor in growing grass and vegetables. Currently, the fertilizer imported to Iceland annually contains over 1000 tones of sulfur and indications are that agriculture could benefit from even larger amounts of sulfur. Potential use of the biological sulfur produced at the pilot plant as a fertilizer will be investigated in this project. Contacts have been established with the

Agricultural Univ. of Iceland and the Soil Conservation Service of Iceland (Landgræðsla ríkisins) for collaborations regarding experiments for use of the biological sulfur as fertilizer and protective agent mainly as a fungicide. Plans have been made for experiments regarding the use of sulfur as fungicide in the growth of barley plants by the Icelandic biotech company Orf Genetics Special and emphasis will be put on working with farmers of organic agriculture.

Deliverables and Milestones indicating progress: Year 1. All completed.

The submission of a Progress report:

Milestone 1.1: Construction of 2000 L pilot bioreactor tank finished.

Milestone 1.2: Report on sulphur market situation and main uses of sulphur prepared.

The submission of an Annual report:

Milestone 1.3: Bioreactor has been put in operation and at Hellisheiði power plant and tested with real geogas on site.

Deliverables and Milestones indicating progress: Year 2.

The submission of a Progress report:

Milestone 2.1: Successful operation of pilot plant at Hellisheiði for at least 2 months.

Milestone 2.2: Productivity in terms of kg/h of biomass and sulphur measured and documented.

Milestone 2.3: Certificate of analysis for representative samples on tonne scale in place.

Milestone 2.4: Feed formulation and fish-feeding tests started.

The submission of an Annual report:

Milestone 2.5: Results from evaluation of the SCP-meal by feed producers.

Milestone 2.6: Results from evaluation of the sulphur as fertilizer by vegetable growers and by the Land Conservation Service.

Milestone 2.7: Shipments of real and representative samples of SCP-meal and organic sulphur to potential buyers.

Milestone	Date of delivery		Report
	2010	2011	
2.1.	4Q		
2.2.		1Q	
2.3.		1Q	
2.4.		2Q	Progress 2
2.5.		2Q	
2.6.		3Q	
2.7.		3Q	Annual 2

2 Project Management

The project will be managed by the coordinator and his cooperation partners, primarily Prokatin ehf, which mission is the same as the objectives of this project and concentrating all its efforts on this problem in close cooperation with Orkuveita Reykjavíkur.

The cooperation between Univ. of Iceland and the partners involves supervision of students involved in the project by the applicant Dr. Guðmundur Ó. Hreggviðsson. The daily operations of the pilot plant at Hellisheiði will be under responsibility of Dr. Arnþór Ævarsson, CEO of Prokatin and Dr. Jakob Kristjánsson. The board of Prokatin, including representatives from Reykjavik Energy, Mannvit Engineering and Arkea, the mother company of Prokatin, take part in major decisions in the progress of the project. Chemical engineer Ásgeir Ívarsson at Mannvit Engineering supervises the operations of engineers in the projects. Progress in the project is regularly review by all involved parties for further decision making. Reykjavik Energy has allocated up to 50 millions ISK for construction of the pilot plant at Hellisheiði power plant and other share-holders of Prokatin are also contributing to the GEOGAS projects. Effort will be made to establish international collaborations, especially EU funded programs. The project partners have extensive experience of participation in research programs within the EU research framework.

Cooperative partners

University of Iceland,

Dr. Guðmundur Óli Hreggviðsson, Ph.D. in molecular biology from Edinburg Univ., UK. Docent in Microbiology at Univ. of Iceland. Department manager at Matís/Prokaria.
M.Sc. student: *Guðný Inga Ófeigsdóttir*, B.S. Biochemistry Univ. of Iceland.

Prokatin ehf

Dr. Arnþór Ævarsson CEO, Ph.D. educated in Biotechnology and Biophysics at Univ. of Lund, Sweden and Univ. of Washington, USA. Previously director of intellectual property and business development at Prokaria. Published about 20 scientific papers and a number of issued patents.
Dr. Jakob Kristjánsson, Chairman, Ph.D. in biochemistry from Brandeis Univ. USA. Previously docent and research professor at Univ. of Iceland. Founder and president of Prokaria. Published over 100 scientific papers and a number of issued patents.

Mannvit Engineering

Ásgeir Ívarsson, M.Sc. Chemical engineering, Chalmers Univ. of Technology, Sweden.
Rúnólfur Maack, M.Sc. Mechanical eng. Denmark Univ. Of Technology. Deputy CEO foreign operations.

Reykjavik Energy

Hólmfríður Sigurðardóttir, Cand Scient Soil Biology Univ. of Aarhus, MBA from Univ. of Reykjavik. Manager of innovation and development.

3 Student involvement

One student has been directly participating in this project as part of her study. Guðný Inga Ófeigsdóttir is doing a Masters project as part of this project under the supervision of the coordinator. A matching grant was also awarded to the applicant from Reykjavik Energy Research fund (UOOR) for part of this work and supporting this student.

4 Publications and disseminations

Michael Monit, 2009. **Bioprocess design: The GEOGAS Project – Bioremediation of geothermal gases and SCP production with HOX/SOX bacteria.** Lokaritgerð í MS námi við RES orkuskóla á Akureyri og HÍ.

Andri Stefánsson, 2009. **Blöndun brennisteinssýru við niðurrennslisvatn frá Hellisheiðarvirkjun –** Skýrsla Raunvísindastofnunar RH-01-2009.

Hildur Vésteinsdóttir og Jóhann Örlygsson. 2009. **Nýting jarðhita í líftækni - brennisteinsoxandi bakteríur.** Rit auðlindadeildar RA09:10. Háskólinn á Akureyri.

Guðný Inga Ófeigsdóttir. 2009. **Production and utilization of biomass with microbes.** Rannsóknaverkefni MS nema (12 ein) við Líf – og umhverfisvísindadeild. Háskóli Íslands. Ritgerð, 31 bls.

Guðmundur Óli Hreggviðsson. 2010. **Nýting efna í jarðhitagasi.** Erindi á Ráðstefnu Umhverfis- og orkurannsóknasjóðs OR, 14. maí.

Guðmundur Óli Hreggviðsson. 2010. Biological Utilization of Geothermal Gas. Erindi á ársfundi GEORG - GENERAL ASSEMBLY, 21. maí.

Guðný Inga Ófeigsdóttir, Arnþór Ævarsson, Jakob K. Kristjánsson og Guðmundur Óli Hreggviðsson. 2010. **Nýting brennisteins í lífrænni ræktun.** Áfangaskýrsla til Umhverfis- og orkurannsóknasjóðs OR, 11 bls.

5 Cost statement

Consortium:
Name of Project: **Biological Utilization of Geothermal Gas**

ISK '000	Year Month	Year 1 2009/2010												Total Y1	
		1	2	3	4	5	6	7	8	9	10	11	12		
Financing															
GEORG funding		350										600	300	1.250	3%
Participants own contributions		500	500	500	500	500	500	500	500	500	500	500	500	6.000	
Participants, in kind costs		107	100	150	150	150	150	150	150	150	150	150	1.707		
Facilities, equipm. & other resources												1.000	1.000		
Other national compet. grants		933	600	933	933	933	933	833	833	833	833	833	10.263		
Other intern. Grants, e.g. FP7													0		
Other sources (e.g. Philanthropic)		2.500	2.500	2.500		2.500	2.500	2.500	2.500	2.500	2.500	2.500	25.000		
Total other financing		1540	3700	4083	4083	1583	4083	3983	3983	3983	3983	4983	43.970	97%	
Total financing														45.220	
Operational Costs															
Average Personnel Costs		Unit cost											Man-months		
Participant:															
Univ. Icel. Applicant	GÓH	500				250					250		500	1,0	
Univ. Icel. M.Sc.Student	GIÓ	266	260	260	270	270	270	270	270	270	270	260	3.200	12,0	
Prokatin ehf - Partner	AÆ	530	265	415	530	530	530	265	265	265	530	530	4.920	9,3	
Prokatin ehf - Partner	JKK	470	150	150	150	150	200	150	150	200	300	300	2.500	5,3	
Mannvit Eng. - Partner	ÁÍ	600	500	500	500	500	500	800	800	800	800	800	7.800	13,0	
Total			1.175	1.325	1.450	1.700	1.500	1.450	1.485	1.535	1.885	1.900	1.890	16.225	41
Operational exp.			900	1.000	1.000	1.000	1.000	2.000	2.000	2.800	2.000	2.000	2.000	18.700	
Total			900	1.000	1.000	1.000	1.000	2.000	2.000	2.800	2.000	2.000	2.000	18.700	
Contracted services													0		
Total			0	0	0	0	0	0	0	0	0	0	0	0	
Travel expenses													0		
Total			0	0	0	0	0	0	0	0	0	0	0	0	
Others													0		
Total			0	0	0	0	0	0	0	0	0	0	0	0	
Overhead			500	600	600	600	600	600	700	700	700	700	700	7.600	
Total			500	600	600	600	600	600	700	700	700	700	700	7.600	17%
Total operational cost			2.575	2.925	3.050	3.300	3.100	3.050	4.085	4.235	5.385	4.600	4.590	43.225	

Justification & explanations

The main project here is really the only operational activity of Prokatin and therefore the GEORG project is not booked separately in the company's accounting system.

The total operating costs of Prokatin in 2009 was ISK 32.640.000. Half of from 1.june is counted as cost of GEORG project

The total operating costs of Prokatin for first half of 2010 is ISK 28.900.000 - all is counted as cost of GEORG project

The salary costs are listed as close to real paid salary and time-input.

Other operational costs are estimates as part associated to the student's part of the project.