EUSUSTEL WP3 Report – Geothermal power production - Appendix A

Table A1.

- Energy:

	Conventional steam plants	**Binary cycle plants**
1) Range of unit size [MW]	3-120	1-3
Range of project size [MW]	At least 1 000	30-200
2) Nominal efficiency		
i) For electricity generation only [%]	Irrelevant*	
ii) For combined heat and power [%]	Irrelevant*	
3) Efficiency at partial load	Irrelevant*	
4) Flexibility towards fuel, fuel resource availability, plant siting and infrastructures (e.g. cooling water needs, high voltage, grid gas pipes, etc.)	-Free "fuel" -Plant has to be located near the source -Steam/water pipes needed	-Free "fuel" -Plant has to be located near the source -Steam/water pipes needed -Cooling water needed
5) Flexibility towards exploitation:		
i) Cold start [minutes from 0% to 90% of nominal power]	1 min	
ii) Warm/lukewarm start [minutes from 0% to 90% of nominal power]	1 min	
iii) Uncontrollable variation in load [% from nominal power]	<1%	

- Ecology and resource use:

1) Exhaust [average in lifetime, incl. construction & transport]:	**Conventional steam plants**	**Binary cycle plants**
i) CO_2 [kg/kWh$_{electricity}$]	0.004 – 0.74 [18]	0 (closed loop)
ii) SO_2 [kg/MWh$_{electricity}$] – note the unit, kg/MWh	H_2S – 0.5-6.8 [2]	0 (closed loop)
iii) NO_x [kg/kWh$_{electricity}$]	0 [2]	
iv) PM_{10} [kg/kWh$_{electricity}$]	0 [2]	
v) NMVOC [kg/kWh$_{electricity}$]	No data	
vi) Methane [kg/kWh$_{electricity}$]	No data	
vii) N_2O [kg/kWh$_{electricity}$]	0 [2]	

viii) C_{14} [kg/kWh$_{electricity}$]	No data	
ix) Hg [mg/kWh$_{electricity}$]	0.045-0.9 [2]	0
2) Thermal exhaust [TJ/GWh$_{electricity}$]		
i) Into air	No data	
ii) Into water source	No data	
3) Liquid waste		
i) Total liquid waste [kg/kWh$_{electricity}$]	6-70 [2]	Up to 400 [2]
ii) Total nitrogen into water source [kg/kWh$_{electricity}$]	No data	
iii) Total phosphor into water source [kg/kWh$_{electricity}$]	No data	
iv) Total chlorides into water source [kg/kWh$_{electricity}$]	No data	
v) Total sulfates into water source [kg/kWh$_{electricity}$]	No data	
vi) Others ($KMnO_4$, iron, organic materials, solid materials)	No data	
4) Solid waste [tons/MWh$_{electricity}$]		
i) Flue dust	0	
ii) Slurry	No data	
iii) Hazardous waste	No data	
iv) Radioactive waste – ^{222}Rn	3700-78000 becquerel/kWh$_e$	0
v) Other solid waste	No data	
5) Safety and health impacts		
i) Population affected by worst perceived accident during operation [nr of persons]	No data	
ii) Number of deaths over the fuel cycle [persons/MWh$_{electricity}$]	No data	
iii) Other effects	No data	
6) Visual impact and noise	Some but manageable	
7) Footprint and use of resources		
i) Primary material moved for construction [kg/kW$_p$ of nominal power	Rock	
ii) Secondary material moved for construction [kg/kW$_p$ of nominal power	None	
iii) Main materials uses for construction (five) [kg/kW$_p$ of nominal power]	No data	
iv) Primarily material moved for usage e.g. fuel [tons/ MWh$_{electricity}$]	Water (can be reinjected)	None

v) Secondary material moved for usage e.g. fuel [tons/ $MWh_{electricity}$]	None
vi) Critical materials in construction and usage (materials that may become a limiting factor for the technology) [kg/kW_p of nominal power]	None
Total ecological score	

- Economy (without subsidies, price level for 2003):

	Conventional steam plants	**Binary cycle plants**
1) Investment cost [euro/MW]	640 000-2 400 000 Euro/MW or 16-80 euro/MWh[1] [16]	800 000-2 000 000 Euro/kW net without drilling (4)[2]
2) Availability [hours per year]	3942-7884[3] [2]	
3) Operational time [hours of nominal power/year]	3942-7884[4] [2]	
4) Reliability [%]	Very high	
5) Technical life span [years]	>30	
6) Construction time [years]	1-2 [4]	
7) Fuel cost [euro/MJ]	0	
8) Operation and Maintenance (O&M) cost [euro/$MWh_{electricity}$]	No data	
9) Waste handling and dismantling [euro/ $MWh_{electricity}$]	No data	
Total economic score		

* Efficiency is often discussed when talking about energy conversion. It appears to be a very important parameter to consider when comparing different energy sources, but we argue that it is irrelevant. Efficiency is only useful when comparing different techniques that utilize the same energy resource; for example two different turbine types for a hydro power station or two different generator types for a wind power station. The efficiency of generation of electricity from geothermal steam is between 10 and 17 % which is at least three times lower than for example the efficiency of nuclear or fossil-fuelled plants [X2, p. 41 and 45]. But as you cannot replace the geothermal power plant with a coal or nuclear power plant to use the hot geothermal steam or water, a comparison of efficiencies between them is completely useless. The only thing that matters is how much power a given energy resource can give to a commercially viable cost, within legal, environmental and other constraints.

[1] USD/EUR=1.25
[2] 1000-2500 US$/kW, USD/EUR=1.25
[3] Corresponds to a capacity factor of 45-90%
[4] Corresponds to a capacity factor of 45-90%