Appendix ALife Cycle Inventory data for the Chiusdino 1 power plant

Table A.1 - DESCRIPTION		
Name	Chiusdino 1	
Location	43°09'37.0"N 11°03'49.9"E	
Construction start date	dec-2010	
Expected life	30	yrs
Geothermal reservoir	Metamorphic	
Reservoir depth	3-4,5	km
Land occupation	11000	m^2
Type of geothermal resource	Steam	
Production technology	Natural draft	
Electrical generation technology	Flash and condensation	
Cooling system	Evaporative towers	
End use of energy	Electricity	
Installed capacity		
Electrical	20	MWe
Operating capacity		
Electrical	18	MWe
Expected annual decay rate	0	% per year
Net annual production		
Electricity delivered to the grid	151,2	GWh
Capacity factor	8400	h
Out of order	18	h/yr
Average pressure at well head	15,74	bar
Average temperature at well head	199,61	°C
Overall flow rate	36,1	kg/s
Condenser temperature	25	°C
Reinjection		
Temperature	25	°C
Pressure	Atmospheric	
Liquid phase, % of total from wells	30%	
Gas phase	0%	
Composition of the geothermal fluid		
Dissolved gasses (NCG) mass fraction	4,00%	
CO_2	5100	kg/h
CO	0,4	kg/h
CH_4	79	kg/h
H_2S	90	kg/h

NH_3	11,6	kg/h
Hg	5,6	g/h
Trace elements		
As	0,042	mg/l
B	-	mg/l
Sb	-	mg/l
Se	-	mg/l
Rn	-	Bq/m^3
NCG emissions treatment system (AMIS)		
H_2S removal efficiency	99,80%	
Hg removal efficiency	82,20%	
NH_3 removal efficiency	87%	
CO_2 removal efficiency	0%	
B removal efficiency	99%	
As removal efficiency	99%	

Table A.2 - CONSTRUCTION		
DRILLING		
Production wells	5	
Average depth	3818	m
Reinjection wells (equivalent)	2	
Average depth	3000	m
Drilling time	146	days per well
Diesel fuel consumption for generator set (total)	1970950	l
Diesel fuel consumption - construction works, per well	309734	l
WELLS CASING AN CEMENTING		
Production wells		
Steel	1458476	kg
Portland cement	1737190	kg
Bentonite	832324	kg
Silica sand	503976	kg
Lignosulfonates	11454	kg
Perlite	38180	kg
NaOH	1282848	kg
HCl	328348	l
Oli and lubricants	91632	kg
Excavations	1925	m^3
Drilling mud	2103718	kg

Reinjection wells (equivalent)		
Steel	228971	kg
Portland cement	272972	kg
Bentonite	130600	kg
Silica sand	79047	kg
Lignosulfonates	0	kg
Perlite	5814	kg
NaOH	188426	kg
HCl	13358	l
Oli and lubricants	14457	kg
Excavations	293,1364589	m^3
Drilling mud	320351,4	kg
DRILLING PLATFORM		
Occupied surface	10000	m2
Portland cement	1230000	kg
Aluminum	9000	kg
Steel	43000	kg
Sand	1937000	kg
Plastic	1250	kg
Excavation	1790	m3
Fills	2150	m3
STEAM ADDUCTION PIPELINE		
Total length	2758	m
Steel for supports and fundations	163736	
Steel fot tubing	313398	kg
Portland cement	493,682	m3
Aluminum	12962,6	kg
Rock whool	130177,6	kg
Excavations	468,86	m3
Fills	468,86	m3
CONDENSATE PIPELINE		
Total length	5000	m
Plastics	36565	kg

POWERHOUSE EQUIPMENT		
Turbine and Alternator		
Number of turbines	1	
Rated Power	20	MW
Type	Ansaldo TUVA 20 MW 2nd generation	
Expected Life*	25	years
Number of alternators	1	
Rated Power	23	MWA
Type	Ansaldo	
Expected Life*	>25	years
Cast iron	13400	kg
Copper	4000	kg
Iron-nickel-chromium alloy	1000	kg
Rock wool	4400	kg
Chromium steel 18/8	9800	kg
Steel, low-alloyed	600	kg
Steel, unalloyed	76400	kg
Compressor		
Number of compressors	1	
Capacity	5	t/h
Type	Modified Tosi model	
Expected Life*	25	yrs
Aluminum	5680	kg
Cast iron	12120	kg
Steel, unalloyed	8080	kg
Copper	16200	kg
Condenser		
Number of condensers	1	
Rated Power	20	MW
Type	Ansaldo/ENEL	
Expected Life	30	yrs
Chromium steel 18/8	68250	kg
Intercooler		
Chromium steel 18/8	18000	kg

Cooling towers		
Number of cells	3	
Type	Hamon cooling tower	
Main material	PSRV	
Expected Life	25	yrs
Steel piping	8190	kg
Plastic piping	81900	kg
Fiberglass	90220	kg
Copper	150	kg
Cast iron	450	kg
Gas treatment system		
Type	AMIS 1 unit	
Main material	Stainless steel 316L	
Size (max flow rate)	5000	kg/h
Expected Life*	25	years
Sorbent (Selenium for Hg)	4000	kg
Catalyst (Titanium for H2S)	9000	kg
Aluminum	500	kg
Chromium steel 18/8	11500	kg
Building		
Portland cement	637500	kg
Diesel fuel for construction works	195500	l
Excavations	8500	m3
Plastic pipes	637500	kg
Fills	17944960	kg
Aluminum	810	kg
Steel, low-alloyed	170000	kg
Accessories		
Copper	30000	kg
Plastic pipes	15000	kg
Chromium steel 18/8	150000	kg
Steel, low-alloyed	220000	kg

* Major maintenance and refitting every 4 years

Table A.3 - OPERATION & MAINTENANCE		
Emissions-to-Air		
CO_2	5100	kg/h
CO	0,4	kg/h
H_2S	18,4	kg/h
CH_4	79,3	kg/h
NH_3	1,5	kg/h
Hg	1,1	g/h
As	2,8	mg/h
Se	0,4	g/h
Machinery maintenance		
Lubricants	25000	kg
Waste mineral oil	25000	kg
Iron-nickel-chromium alloy	5375	kg
Chromium steel 18/8	3500	kg
Waste steel	8875	kg
Fluid treatment		
NaOH	2500000	kg/yr
Table A.4 - END OF LIFE		
Wells Abandonment (per well)		
Expected time	10	days
Diesel fuel consumption	25000	l
Portland cement	25000	kg
Inert	5000	kg
Steel	0	kg
Water	0	l

Appendix B Life Cycle Inventory data for the Potenza Pietragalla wind farm

Table B.1 DESCRIPTION		
Name	Potenza Pietragalla	
Location	40.776954, 15.837555	
Construction start date	2005	
Expected life	30	years
Land occupation	1500000	m^2
Production technology	HAWT Repower MM92	
Electrical generation technology	• Generator at summit. • MV a tground . • HV at substation	
End use of energy	Electricity	
Installedcapacity		
Electrical	18	MWe
Operating capacity		
Electrical	18	MWe
Expected annual decay rate for the electrical power supplied	0	% per yr
Net annual production		
Electricity delivered to the grid	25,2	GWh
Capacityfactor(at 18 MWe)	1400	h
Out of order (per year)	50	h
Resource characteristics		
Mean power density (at 100 m)	1041	W/m2
Maximum average wind speed (at 100 m)	9,32	m/s
Table B.2- CONSTRUCTION		
PITCHES AND LOGISTIC SURFACES		
Excavations	75000	m3
Fills	11250	m3
Steel	430272	kg
Cement	3339	m3
Occupied surface	20305	m2
Wood	324	m2
Diesel fuel for excavations	37500	l

CABLE-DUCTS		
Total lenght	15000	m
Aluminum	19660	kg
Copper	6560	kg
Optical fibre	15000	ml
Excavations	7015	m3
Fills	1960	m3
Diesel fuel for excavations	3510	l
Occupied surface	7500	m2
HAWT		
Number of HAWT	9	
Rated power	2	MW
Description	Repower MM92	
Expected life	25	years
Diesel fuel for construction works	14400	l
Tower		
Steel	146500	kg
Copper	6480	kg
Blade		
Steel	1620	kg
Fiberglass	6480	kg
Nacelle		
Steel	56520	kg
Copper	5600	kg
Fiberglass	2780	kg
Hub		
Steel	17000	kg
VIABILITY		
Excavations	24784	m3
Fills	700800	kg
Asphalt	8190	m3
Diesel fuel for construction works	13000	l
SUBSTATION		
Steel	36800	kg
Fills	1220	m3
PEAD tubing	1260	kg
Cement	970	m3
Pre-cast concrete	16,4	m3
Copper	5000	kg
Aluminum	1500	kg
Diesel	1000	l
Occupiedsurface	2620	m2

Table B.3 - OPERATION & MAINTENANCE		
Lubricatingoil	202500	kg

Waste mineraloil	202500	kg
Steel, chromium 18/8	999000	kg
Steel, lowalloyed	540000	kg
IronScrap	1539000	kg
Diesel for O&M	54000	l
Table B.4 - END OF LIFE		
Machinerydisassemblement		
Time (per HAWT –estimate)	10	days
Diesel for O&M (per HAWT – estimate)	25000	l
Steel (per HAWT - 95% recycled)	221640	kg
Copper (per HAWT - 95% recycled)	12080	kg
Fiberglass (per HAWT - 100% recycled)	22220	kg
Cement (per HAWT - left on site)	371	m3
Iron for foundation works (per HAWT - 95% recycled)	47808	kg

Appendix C Life Cycle Inventory data for the Serre Persano Photovoltaic Power Plant

Table C.1 - DESCRIPTION		
Name	Serre Persano	
Location	40°34'08.5"N 15°06'10.5"E	
Construction start date	2013	
Expected life	30	yrs
Land occupation	770000	m^2
Electrical generation technology	Photovoltaic generator, inverter for subfield, elevation downstream substation	
Module NA F130 G5	53760	
Module NA F135 G6	103796	
Inverter Santerno SUNWAY TG760 1000V TE	24	
End use of energy	Electricity	
Installed capacity		
Electrical	21,00126	MWe
Operating capacity		
Electrical	19,53117	MWe
Expected annual decay rate	0,07	% per year
Net annual production		
Electricity delivered to the grid	29,50407179	GWh
Capacity factor	1281	h
Out of order (per year)	0	h
Resource characteristics		
Global annual radiation on the normal surface	2131	kWh/m2
Table C.2 - CONSTRUCTION		
PITCHES AND LOGISTIC SURFACES		
Excavations	54000	m3

Fills	1080	m3
Occupied surface	770000	m2
Diesel for excavations	30000	l
METAL CARPENTRY		
Steel	10023790	kg
Aluminum	2594686	kg
Diesel for construction	18135	l
PHOTOVOLTAIC MODULES		
Module NA F130 G5	53760	
Module NA F135 G6	103796	
ELECTRICAL CONNECTIONS		
Copper	63125	kg
Aluminium	1516	kg
Excavations	2954	m3
Sand	29546	kg
Cement	1181	kg
Plastic	18381	kg
Diesel for construction	1477	l
INVERTER		
Inverter Santerno SUNWAY TG760 1000V TE	24	
DELIVERY CABIN		
Precast concrete	41000	kg
Portland cement	272176	kg
Diesel for construction	1176	l
Plastic pipes	1470	kg
Fills	581760	kg
Steel	43052	kg
Aluminum	1743	kg
Copper	5880	kg
Table C.3 - OPERATION & MAINTENANCE		
Diesel for cleaning machine	56270	l
Decarbonised water	16881000	kg
Table C.4 - END OF LIFE		
Diesel for disassembly	341	l
Electricity, medium voltage	159716	kWh
Used cable	29935	kg
Aluminum scrap for melting	511899	kg
Inert material and fill	2451729	kg

Appendix D Synthesis tables of ILCD and Recipe Impact analysis

Table D.1 ILCD MidPoint 2011+ method results

	GEO	GEO-AS	GEO-NA	W	PV	NEM
Acidification [molc H+ eq]	3,04E-03	1,92E-03	1,14E-02	6,30E-05	1,50E-04	2,34E-03

Climate change [kg CO_2 eq]	4,77E-01	3,01E-01	4,59E-01	1,34E-02	2,66E-02	4,84E-01
Freshwater ecotoxicity [CTUe]	2,09E-03	2,50E-03	8,96E-04	7,41E-04	5,85E-03	5,14E-03
Freshwater eutrophication [kg P eq]	1,18E-05	1,41E-05	2,30E-06	2,88E-06	1,81E-05	9,04E-05
Human toxicity, cancer effects [CTUh]	6,58E-04	4,31E-04	2,38E-03	1,72E-05	6,49E-05	5,09E-04
Human toxicity, non-cancer effects [CTUh]	1,89E-03	2,26E-03	1,21E-03	8,09E-04	1,78E-02	7,62E-03
Ionizing radiation E (interim) [CTUe]	2,80E-02	3,26E-02	1,35E-02	7,33E-03	6,22E-02	1,05E-01
Ionizing radiation HH [kBq U235 eq]	2,31E-03	2,77E-03	2,53E-04	4,28E-04	1,64E-03	2,71E-03
Land use [kg C deficit]	1,74E-04	2,08E-04	4,60E-05	1,76E-04	2,33E-04	9,31E-04
Marine eutrophication [kg N eq]	2,71E-03	3,24E-03	1,19E-03	9,41E-04	7,45E-03	7,05E-03
Mineral, fossil & ren resource depletion [kg Sb eq]	1,13E-06	1,36E-06	1,85E-07	2,27E-07	1,50E-06	7,19E-06
Ozone depletion [kg CFC-1 eq]	6,15E-03	7,37E-03	1,68E-03	5,17E-03	6,53E-03	1,47E-01
Particulate matter [kg PM2.5 eq]	1,97E-05	2,36E-05	1,42E-05	3,90E-05	1,79E-05	1,21E-05
Photochemical ozone formation [kg NMVOC eq]	2,41E-08	2,89E-08	4,00E-09	3,36E-09	8,91E-09	3,37E-07
Terrestrial eutrophication [molvc N eq]	9,10E-05	1,09E-04	4,92E-05	3,29E-05	8,03E-05	8,33E-04
Water resource depletion [m^3 water eq]	9,22E-05	1,11E-04	5,00E-05	3,39E-05	8,41E-05	8,48E-04

Table D.2 Recipe 2016 method results at midpoint level

	GEO	**GEO-AS**	**GEO-NA**	**W**	**PV**	**NEM**
Terrestrial acidification (kg SO2 eq)	2,27E-03	1,42E-03	8,58E-03	4,15E-05	9,68E-05	1,58E-03
Global Warming (kg CO2 eq)	4,77E-01	3,01E-01	4,59E-01	1,34E-02	2,66E-02	4,84E-01
Freshwater ecotoxicity (kg 1,4-DB eq)	2,09E-03	2,50E-03	8,96E-04	7,41E-04	5,85E-03	5,14E-03
Freshwater eutrophication (kg P eq)	1,18E-05	1,41E-05	2,30E-06	2,88E-06	1,81E-05	9,04E-05
Fine particulate matter formation (kg PM2,5 eq)	6,58E-04	4,31E-04	2,38E-03	1,72E-05	6,49E-05	5,09E-04

Human toxicity carcinogenic (kg 1,4-DB eq)	1,89E-03	2,26E-03	1,21E-03	8,09E-04	1,78E-02	7,62E-03
Human toxicity non-carcinogenic (kg 1,4-DB eq)	2,80E-02	3,26E-02	1,35E-02	7,33E-03	6,22E-02	1,05E-01
Ionising radiation (kBq Co-60 eq)	2,31E-03	2,77E-03	2,53E-04	4,28E-04	1,64E-03	2,71E-03
Land use (m2 yr crop eq)	1,74E-04	2,08E-04	4,60E-05	1,76E-04	2,33E-04	9,31E-04
Marine ecotoxicity (kg 1,4-DB eq)	2,71E-03	3,24E-03	1,19E-03	9,41E-04	7,45E-03	7,05E-03
Marine eutrophication (kg N eq)	1,13E-06	1,36E-06	1,85E-07	2,27E-07	1,50E-06	7,19E-06
Fossil resource scarcity (kg oil eq)	6,15E-03	7,37E-03	1,68E-03	5,17E-03	6,53E-03	1,47E-01
Mineral resource scarcity (kg Cu eq)	1,97E-05	2,36E-05	1,42E-05	3,90E-05	1,79E-05	1,21E-05
Stratospheric Ozone depletion (kg CFC-11 eq)	2,41E-08	2,89E-08	4,00E-09	3,36E-09	8,91E-09	3,37E-07
Ozone formation, Human health (kg Nox eq)	9,10E-05	1,09E-04	4,92E-05	3,29E-05	8,03E-05	8,33E-04
Ozone formation, Terrestrial ecosystems (kg Nox eq)	9,22E-05	1,11E-04	5,00E-05	3,39E-05	8,41E-05	8,48E-04
Terrestrial ecotoxicity (kg 1,4-DB eq)	2,10E-01	1,98E-01	2,67E-01	3,09E-02	1,82E-01	3,18E-01
Water consumption (m^3)	1,60E-01	1,92E-01	3,38E-02	2,18E-02	1,90E-01	3,15E+00