Common framework of Energy Profiles for islands

Version:
1.2

Production:
M. AL SHAKARCHI, Island-NEWS manager – ARER (Réunion island - France)

Validation committee:
Mr. MUNGUR, Ag Principal Planner - Ministry of Public Utilities (Mauritius)
Dr ZOGRAFAKIS, Director - Regional Energy Agency of Crete (Crete – Greece)
Mr. MELIM MENDES, Director – Regional Energy and Environment Agency of the autonomous region of Madeira (Madeira – Portugal)
M. IBRAHIM, Energy project leader – General Council (Mayetta – France)
Dr RAKOTONIAINA, Professor – Polytechnic University of Antananarivo (Madagascar)
Mlle GILBOIRE, Project leader for Réunion Island Energy Observatory - ARER (Réunion - France)

Validation date: December 3rd, 2006

Table of content

Introduction

This document presents a common framework for the definition of island energy profiles. This framework is produced within Island-NEWS network (Natural Energy Ways toward Self-sufficiency for ISLANDS). Therefore, it serves the inter-island cooperation for energy self-sufficiency strategies and can be used by any energy actor. Besides islands, this framework can be useful for all regions worldwide.

This document deals with methodological aspects. A virgin energy profile is also available to make network members' task easier.

An energy profile makes an inventory of primary productions and imports, of secondary productions and energy sector consumptions as well as of final energy consumptions. It also presents a synthetic energy balance sheet.

This framework is partially inspired by the works of the International Energy Agency (IEA) as well as those of The General Office of Energy and Raw Materials (DGEMP, France). Islands particularities introduce a few changes:

- inventory of all renewable energy sources under all form of usage (fuel, electricity, heat,…)
- inventory of production and consumption of heat (cogeneration included)
- simplification of questions related to:
    - climate corrections
    - final non-energetic consumptions

In this methodology document, we will deal with the composition of an energy profile in the following order:

- primary productions and imports
- secondary productions and energy sector consumptions
- final energy consumptions
- synthetic energy balance sheet

It is decided to use ktoe as the unit for energy (kilo ton oil equivalent). Annexes gather definitions, calculation methodology, equivalences and table of units and conversions.

Primary productions and imports

This chapter deals with energy supply:

- primary energy productions
- imports, exports and stock changes of all energies, primary and secondary

These aspects have to detail all energy forms.

Presenting the information with tables is enough. The tables presented here correspond to the following case: an island with only renewable local resources and importing/exporting only fossil energy or electricity. Table for other cases can be built with the presented information.

A map showing local production zones as well as import/export harbours would be very useful too.

For a precise definition of primary and secondary energies as well as a calculation methodology, please go to annex 1 and 2.

Local Resources (year XX):

ktoe	Production
Biomass and waste - solid	
Wood	
Forestry and paper processing residues	
Energy crops *For bio-ethanol* *For bio-diesel* *Other*	
Solid agricultural residues *Bagasse (from sugar cane industry)* *Pomace (from olive oil production)* *Other*	
Animal dejections	
Municipal solid waste (household)	
Biomass and waste - liquid	
Liquid agricultural residues *Melasse (from sugar cane industry)*	
Used vegetable oil	
Used engine oil	
Solar energy	
Hydro energy	
Wind energy	
Geothermal energy	

An inventory of production of biomass and waste is done by estimating physical quantities then applying an equivalence coefficient.

As for other energies, it is necessary to calculate the productions of the different form of usage (electricity and heat) in kWh and apply the following conversion factors: 0.086 toe/MWh; except for geothermal electricity which conversion factor 0.86 toe/MWh.

Fossil resources (year XX):

ktoe	Imports	Exports	Stocks	**Total Net**
Coal				
Hard coal				
Coke oven coke				
Patent fuels				
Lignite				
Oil				
Crude oil				
Heavy fuel oil				
Gasoline				
Diesel				
Kerosene, jet fuels and aviation gasoline				
LPG				
Natural Gas				
Electricity				

Secondary productions and energy sector consumptions

This chapter presents transformations from primary/secondary energy to secondary. Primary energy can also be consumed by final users without transformation (e.g. fuel wood).

Secondary energies are:

- refined petroleum products
- manufactured solid fossil fuels and gases
- charcoal and other solid forms of transformed biomass and waste
- biofuels
- biogas
- electricity
- heat

Cold will probably be considered as a secondary form energy.

Transformations taken into account are:

- refinery
- solid transformations of biomass and waste:
    - destructive distillation and pyrolysis of wood and other vegetal material
    - …
- liquid transformations of biomass and waste:
    - production of biofuels from vegetable
    - production of biofuels from used vegetable oil and used engine oil
- gaz transformations of biomass and waste:
    - digestion and anaerobic fermentation
    - gaz transformation of wood
- Combined Heat and Power plant (CHP plant)
- Centralised production of electricity
- Centralised production of heat
- Decentralised production of electricity
- Decentralised production of heat

Transformation of coal to manufactured solid fossil fuels and gases is not taken into account because it is considered that all imported coal products are used without transformation.

As far as centralised productions of electricity and heat are considered, it is necessary to take into account gross production, net production, own use and losses.

This chapter gives an inventory of the following information:

- transformation means:
  - type
  - power/capacity and approximate duration of use
  - age and planned end-of-life
- productions (see table at the end of chapter)
  - type
  - quantities
- distribution network
  - type
  - length

A map showing the geographic repartition of transformation means and distribution network would be very useful.

Refinery

Name	Capacity	Duration of use	Age and planned end-of-life

Consumptions and productions per petroleum product

Solid transformation of biomass and waste

Name	Capacity	Duration of use	Age and planned end-of-life

Consumptions and productions.

Biofuel production

Name	Capacity	Duration of use	Age and planned end-of-life

Consumptions and productions per type of biofuel

Biogaz production

Name	Capacity	Duration of use	Age and planned end-of-life

Consumptions and productions per type of biogas.

Centralised production of electricity and heat

Type	Name	Power	Duration of use	Age and planned end-of-life
CHP				
Coal power plant				
Gaz power plant				
….				
Hydropwer plant				
Wind farms				
Solar plants				
Geothermal power plant				

Consumptions and productions of electricity and heat:

- gross production
- own use
- losses

Decentralised production of heat and electricity

	Nb of installations	Area (m²)	Power	Duration of use	Age and planned end-of-life
Connected PV					
Isolated PV					
Solar thermal					

Consumptions and productions of electricity and heat

Distribution network

Fuel		
Stations	Number	Total capacity
Electricity		
HV	Length km	(voltage)
LV	Length km	(voltage)

Energy sector productions and consumptions

"- consuptions" unit = ktoe

"+ productions"

hatched cells not to be filled in

	Coal	Oil		Gas	Solid biomass		Liquid biomass		Gas bio	Hydro	Solar	Wind	Geotherm	Electricity		Heat	
		Crude	Refined		Raw	Transf	Raw	Transf	transf					prod	conso	prod	conso
Secondary production and energy sector consumption																	
Refinery																	
Solid transformation of biomass																	
Liquid transformation of biomass																	
Gaseous transformation of biomass																	
Co- generation																	
Own usse																	
Losses																	
Centralised production of electricity																	
Own usse																	
Losses																	
Centralised production of heat																	
Own usse																	
Losses																	
Decentralised production of electricity																	
Decentralised production of heat																	
TOTAL (P2)																	

Final energy consumptions

In this part, final consumptions are presented:

- industry
- agriculture
- commercial
- households
- transports
    - road transports
    - air transports
    - sea transports

Differentiating these sectors will not always be possible. In those cases, sectors can be associated: for instance commercial sector ans households.

Consumptions of all type of energies have to be taken into account.

Variations of consumptions over years (per sectors and per energy) are also useful information.

Energy Balance Table

The Energy Balance Table synthesises all consumptions, productions, imports, experts, stock changes presented in the previous chapters.

It presents neither non-energetic consumptions nor climate corrections.

The unit used is ktoe: kilo ton oil equivalent.

According to IEA convention, negative figures are consumptions and positive figures are productions.

"- consuptions" unit = ktoe "+ productions"	Coal	Oil		Gas	Solid biomass		Liquid biomass		Gas bio	Hydro	Solar	Wind	Geotherm	Electricity		Heat	
		Crude	Refined		Raw	Transf	Raw	Transf	transf					prod	conso	prod	conso
hatched cells not to be filled in																	
Primary production and supply																	
Primary production																	
Imports																	
Exports																	
Stock changes (+=destocking, -=stocking)																	
International bunkers																	
Total supply																	
Energy independency (P/D)																	
Primary supply																	
Secondary production and energy sector consumption																	
Refinery																	
Solid transformation of biomass																	
Liquid transformation of biomass																	
Gaseous transformation of biomass																	
Co- generation																	
Own usse																	
Losses																	
Centralised production of electricity																	
Own usse																	
Losses																	
Centralised production of heat																	
Own usse																	
Losses																	
Decentralised production of electricity																	
Decentralised production of heat																	
TOTAL (P2)																	
Final energy consumption																	
Households - commerce																	
Industry																	
Agriculture																	
Transports																	
road transport																	
air transport																	
sea transport																	
TOTAL (C1)																	
CONSOMMATION FINALE																	

Bibliography

Books:

OECD/IEA & Eurostat, *Energy Statistics Manual*, IEA PUBLICATIONS, Paris, 2004.

Observatoire de l'énergie (DGEMP), *Les énergies renouvelables en France 1970-2005*, Syndicat des Energies Renouvelables, Paris 2006.

Web sites:

DGEMP (Ministère de l'industrie), méthodes:
http://www.industrie.gouv.fr/energie/statisti/se_method.htm

Outils Solaires, productivité des capteurs solaires thermiques :
http://www.outilssolaires.com/Fabricants/prin-compare.htm

ANNEX 1: Definitions

Consumption

Final energy consumption: excluded distribution losses, excluded own use of the energy sector, excluded all non-energetic consumptions of materials coming from the transformation of primary energy.

Primary energy consumptions: final energy consumptions + losses + energy sector own use. Primary energy consumptions indicate the national energy independency rate.

Energy Independency Rate

Ratio primary energy production to total supply.
Ratio>100% means surplus and net export of energy.

Energy

Primary energy: raw energy, not transformed after extraction
Coking coal, bituminous coal and anthracite, sub-bituminous coal, lignite, peat
Crude oil, natural gas, solid land liquid biomass and wastes before transformation, hydropower, solar, wind-power, geothermal power)

Secondary energy: any energy derived from transformation of a primary or secondary energy.

Final energy: energy consumed by the final consumers (excluded energy sector)

Renewable energy sources (RES): solid/liquid/gaseous biomass and waste, hydropower, wind-power, solar (electricity and heat), geothermal power, sea power.
Primary forms of RES are:

- biomass and waste – solid form before transformation: wood, bagasse, plants for biofuels, green wastes
- biomass and waste – liquid form before transformation: used vegetable oil and used engine oil
- Solar: accounted for using a conversion factor of 0.086toe/MWh
- Hydropower: accounted for using a conversion factor of 0.086toe/MWh
- Geothermal power: accounted for using a conversion factor of 0.086toe/MWh for heat and 0.86toe/MWh for electricity

Final forms of RES are:

- biomass and waste – solid: fuel-wood, charcoal, green wastes
- biomass and waste – liquid: biofuels, filtered used oil
- biomass and waste – gas: biogas and gas from wood gasification
- Electricity
- Heat

Electricity and heat

Primary electricity: from nuclear

Primary heat: from nuclear

Co-generation (combined heat and power plant - CHP): joint production of heat and electricity from primary and secondary sources.

Secondary production of electricity: electricity production from primary and secondary sources

Secondary production of heat: heat production from primary and secondary sources

Centralised production of heat or electricity: large plants producing energy to be consumed by others

Decentralised production of heat or electricity: small units producing for own use

Gross value: production measured at plant terminals before own use and losses

Own use: auto-consumption of energy sector

Losses: losses in transformers and in the network

Calorific value

Quantity of heat from whole combustion of a given unit of combustible. This notion only implies to combustible.

- Gross calorific value (GCV): maximum theoretical value of heat, included steam produced during combustion
- Net calorific value (NCV): excluded heat from steam

Note: difference between GCV and NCV is around
Natural gas: 10%
LPG: 9%
Other petroleum products: 7-8%
Solid combustibles: 2-5%

ANNEX 2: Calculation methodology and equivalences

This part deals with calculation of energies in an energy balance table.
This is done by measuring specific value relative to each energy and by then applying an equivalence factor. As far as these factors are concerned, international conventions are used (IEA, DGEMP)

Calculation methodology

For energies that can be measured with physical units (mass or volume), it is sufficient to make a physical inventory of production, imports exports, stock changes and consumptions then to apply factors from the table on the next page. It is the case with fossil energies, biomass and waste.

For all other energies, it is necessary to measure heat and electricity production and then apply an equivalence factor.

For electricity, there are three cases:

- Electricity from nuclear plants: accounted for according to the production primary equivalence methodology, with a conversion ratio of 33% => 0.086/0.33 = 0.260606 toe/MWh;
- Electricity from geothermal power plants: accounted for according to the production primary equivalence methodology, with a conversion ratio of 10% => 0.086/0.10 = 0.86 toe/MWh;
- All other forms of electricity production (solar, wind-power, hydropower,…): accounted for with 0.086 toe/MWh

For heat, one equivalence factor is used: consumption: 0.086toe/MWh. The issue is to measure all produced MWh, especially with water solar heaters. Different options are possible:

- precise calculation by adding up every unit production
- average production per m² for each climate zone in the island, multiplied by panel surface in each zone
- average production per m² for the whole island, multiplied by total panel surface
- common value of production per m² for all islands with similar climate, multiplied by total panel surface

In 2005, average production in French overseas departments was 57 toe / 1000m².

For more details, see annex 4: productivity of thermal solar panels.

Equivalences

Énergy	Physical Unit	NCV (GJ)	NCV (toe)
Coal			
Coal	1 t	26	0,619
Anthracite	1 t	30	0.714
Lignite and recovered products	1 t	17	0,405
Peat	1 t	12,6	0.3
Coking coal	1 t	28	0,667
Patent fuels and briquettes	1 t	32	0,762
Crude oil and petroleum products			
Crude oil	1 t	42	1
Heavy fuel	1 t	40	0,952
Gazole	1t	42	1
Domestic fuel	1t	42	1
Petroleum coke	1 t	32	0,762
LPG	1 t	46	1,095
Gasoline and jet fuels	1 t	44	1,048
Natural and industrial gases			
Pure methane	1000 m3	45.8	1.09
Natural Gas	1000 m3	41,9	1
Biomass and waste – Solid			
Wood (30% humidity)	1 t	10,8	0,257
Dry wood	1 t	18,3	0.435
Charcoal	1 t	26	0,62
Straw	1 t	14,3	0,34
Colza	1 t	26	0.587
Palm	1 t		
Sunflower	1 t	20	0.478
Wheat	1 t	15,5	0.369
Corn	1 t	16	0.381
Sugar-beet	1 t		
Sugar cane	1 t	17	0.405
Bagasse	1 t	7,77	0.185
Almond prunings	1t	18,4	0,43792
Apple prunings	1t	17,8	0,42364
Apricot prunings	1t	19,3	0,45934
Barley straw	1t	17,5	0,4165
Cherry prunings	1t	19,1	0,45458
Corn cobs	1t	18,4	0,43792

Corn stalks	1t	18,5	0,4403
Cotton stalks	1t	18,2	0,43316
Durum wheat straw	1t	17,9	0,42602
Lemon prunings	1t	17,6	0,41888
Oats straw	1t	17,4	0,41412
Olive prunings	1t	18,1	0,43078
Orange prunings	1t	17,6	0,41888
Peach prunings	1t	19,4	0,46172
Pear prunings	1t	18	0,4284
Rice straw	1t	16,7	0,39746
Soft wheat straw	1t	17,9	0,42602
Sugarbeet leaves	1t	14,6	0,34748
Sunflower straw	1t	14,2	0,33796
Tangerine prunings	1t	17,6	0,41888
Tobacco stems	1t	16,1	0,38318
Vineyard prunings	1t	18,3	0,43554
Animal excrements	1 t		
Household waste	1 t	7,77	0,185
Biomass and waste – liquid			
Used vegetable oil	1 t		
Used engine oil	1 t	42	1
bio ethanol	1t	26,8	0,638
ester	1t	37,8	0.9
ETBE	1t	35,88	0,854
EMHV	1t	37,4	0,890
Biomass and waste – gas			
Biogas	1000 m3	24	0,57
Électricity			
Nuclear electricity	1 MWh	3,6	0,260606...
Geothermal electricity	1 MWh	3,6	0,86
Other production and exchanges	1 MWh	3,6	0,086
Heat			
Any variation	1 MWh	3,6	0,086

ANNEX 3: Conversion and energy content

deca (da) 10	deci (d) 10^{-1}
hecto (h) 10^{2}	centi (c) 10^{-2}
kilo (k) 10^{3}	milli (m) 10^{-3}
mega (M) 10^{6}	micro (µ) 10^{-6}
giga (G) 10^{9}	nano (n) 10^{-9}
tera (T) 10^{12}	pico (p) 10^{-12}
peta (P) 10^{15}	femto (f) 10^{-15}
exa (E) 10^{18}	atto (a) 10^{-18}

Energy units

Ton oil equivalent (toe): energy produced from combustion of one ton of average oil

1 toe = 10^{10} cal = 10^{4} thermies

kWh: energy consumed by a device of 1 kW (1000 W) during an hour

1 MWh =1000 kWh = 0,086 toe

1toe = 11 630 kWh

GJ: GigaJoule

Btu: British thermal unit.

m^3 of gaz : considered under normal conditions (0℃, sous 1013 hPa, norme ISO)

Therm: used in London stock market for cotation of gaz =: 29,31 kWh = 0,1 MBtu

	GJ	**tep**	**MBtu**	**kWh**	**m^3 of gas ***	**Barrel of oil**
1 GJ	1	0,0238 ***	0,948	278	23,89	0,1751
1 tep	41,855 **	1	39,68	11 628	1 000	7,33
1 MBtu	1,0551	0,0252	1	293,1	25,2	0,185
1 kWh	0,0036	0,086 10^{-3}	3,412 10^{-3}	1	0,086	630,4 10^{-6}
1 m^3 of gas	0,041855	10^{-3}	0,03968	11,628	1	7,33 10^{-3}
1 Barrel of oil	5,7	0,1364	5,4	1 580	136,4	1

ANNEX 4: Thermal solar panel productivity

French source: http://www.outilssolaires.com/Fabricants/prin-compare.htm

Gross productivity

Theoretical productivity is calculated using two coefficients:

- Factor B: defining optical productivity (in France, established by CSTB)
- Factor K: defining heat losses

The higher factor B and the lower factor K, the higher is the productivity of the panel.

Some panels and their productivity

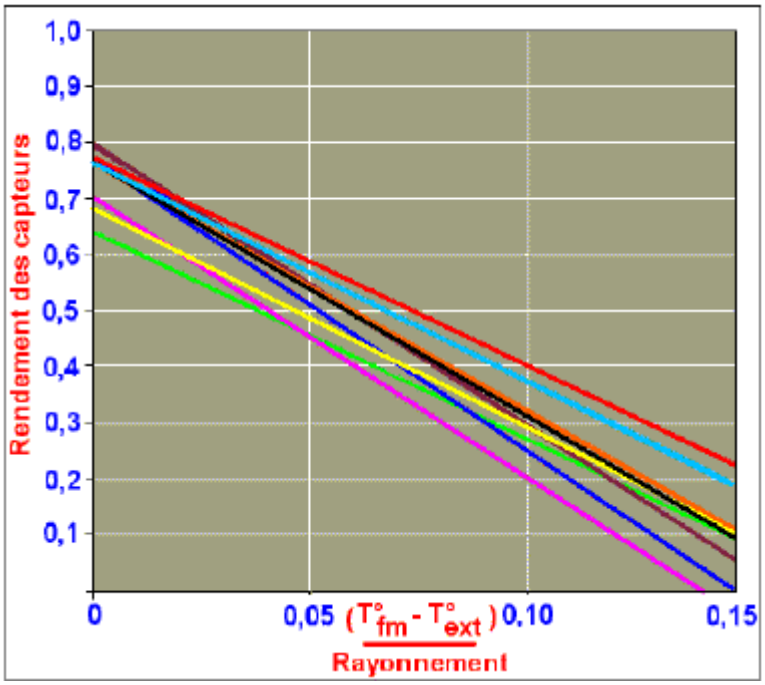
Panel	CSTB reference	Factor B	Factor K (W/m2.℃)
BUDERUS - Logasol SKS	14-00/577	0,79	4,89
CLIPSOL - TGD Y1200	AT 14 + 5/03-839	0,73	4,26
DE DIETRICH - Sol 1	4-00/576	0,68	3,82
GASOKOL - Enersol GKAN et GKAQ	14/02-716	0,77	3,86
GIORDANO - C8 HI	14/02-747	0,72	4,36
PHÖNIX - Infinity 21	14+5/02-756	0,72	4,80
SOLAHART - Solahart Ko	14/01-672	0,79	4,76
SONNENKRAFT - SK500 (Solar Connexion)	14-00/575	0,76	3,78
SUNMASTER - SK20 LM (New Point Products)	14/01 – 650	0,77	4,17
VIESSMANN - Vitosol 100 S1,7	14/00-584	0,76	4,34
WAGNER - EURO C20 AR	14/03-844	0,85	3,34
WEISHAUP - WTS-F	14+5/03-793	0,77	2,75
ZENIT - Thermic	14+5/01-609	0,77	3,62

Productivity is given by the following formula:

$$\Pr oductivity = Factor.B - Factor.K \times \frac{Tfm - Text}{Solar\ RadiationPower}$$

Tm = average temperature of fluid in panel (℃)
Text = external ambient temperature (℃)
Solar radiation power is expressed in W/m²

For a given solar radiation power, productivity varies depending on the difference between fluid temperature and ambient temperature



The Swiss solar technology institute SPF studies solar panels since 1981 and publishes the results http://www.solarenergy.ch/spf.php?lang=fr&fam=1&tab=1

Panel productivity can also be calculated online using SOLO methodology at www.tecsol.fr

Compared productivity

Comparison between panels is made using SOLO methodology at www.tecsol.fr

Studied case:

- Solar water heater in Lyon, France (solar energy about 1425 kWh/m2.an)
- Inside water balloon of 300 liters isolated with 5cm of glass wool
- Forced water circulation and heat transfer with underwater exchanger
- Average consumption of 200 liters at 50°C
- 4 to 5 m² of panels depending on the actual size commercially available
- Orientation: south / Inclination: 45°

Results are shown in the table on the following page.

Notes:

- needs coverage is related to panel surface
- Yearly productivity is related to needs coverage: productivity decreases when coverage increases (see SOLAHART - Mo Oyster with two cases)

	m^2	Needs coverage	Yearly productivity kWh/m^2
BUDERUS - Logasol SKS	4,44	59,8 %	440
CHROMAGEN - CR-110 CA	4,34	54,5 %	410
CLIPSOL - TGD Y1200	4,80	58,2 %	413
DE DIETRICH -DD Sol 1	4,32	55,4 %	418
GASOKOL/SB Thermique - GKAN-GKAQ	4,04	58,1 %	469
GIORDANO - C8 HI	4,00	53,9 %	439
MEGASUN - HELIOAKMI LTD ST 2500	4,61	51,4 %	364
New Point Products - SUNMASTER SK20 LM	4,60	61,6 %	437
PHOENIX Solaire - INFINITY 21	4,26	54,9 %	421
SOLAHART - Mo Oyster	3,68	49,6 %	440
	5,52	62,5 %	369
Solaire Connexion - SONNENKRAFT SK500	4,62	62,2 %	439
VIESSMANN - Vitosol 100 S2.5	5,00	63,3 %	413
WAGNER & Co - EURO C20 AR	4,78	67,6%	461
WEISHAUP - WTS-F	4,56	64,0%	458
ZENIT - Thermic	4,14	59,5 %	469