Renewable Energy Statistics Training

Exercise 5b: Energy balance solar water heaters

The purpose of this exercise is to take solar thermal electricity generation and heating data and complete the solar thermal column of an energy balance. The exercise uses the Solar Heat Worldwide market report and IRENA's electricity generation data for Morocco and Egypt, but countries can also use their own data on solar heating if this is available.

Attached is a worksheet showing the solar thermal energy column of the IRENA energy balance template for Morocco and Egypt. Use the information about solar water heaters and solar thermal energy production to estimate the consumption, transformation, supply and production of solar thermal energy in each country and complete the two columns.

Conversion factors:

1 GWh = 3.6 TJ

Efficiency of solar thermal energy production = 33% (i.e. heat input = electricity generation x 3)

Solar thermal electricity generation in 2014

Technology	Indicator	Country/area	2014
Concentrated solar power	Electricity capacity (MW)	Morocco	23
		Egypt	20
	Electricity generation (GWh)	Morocco	35
		Egypt	16

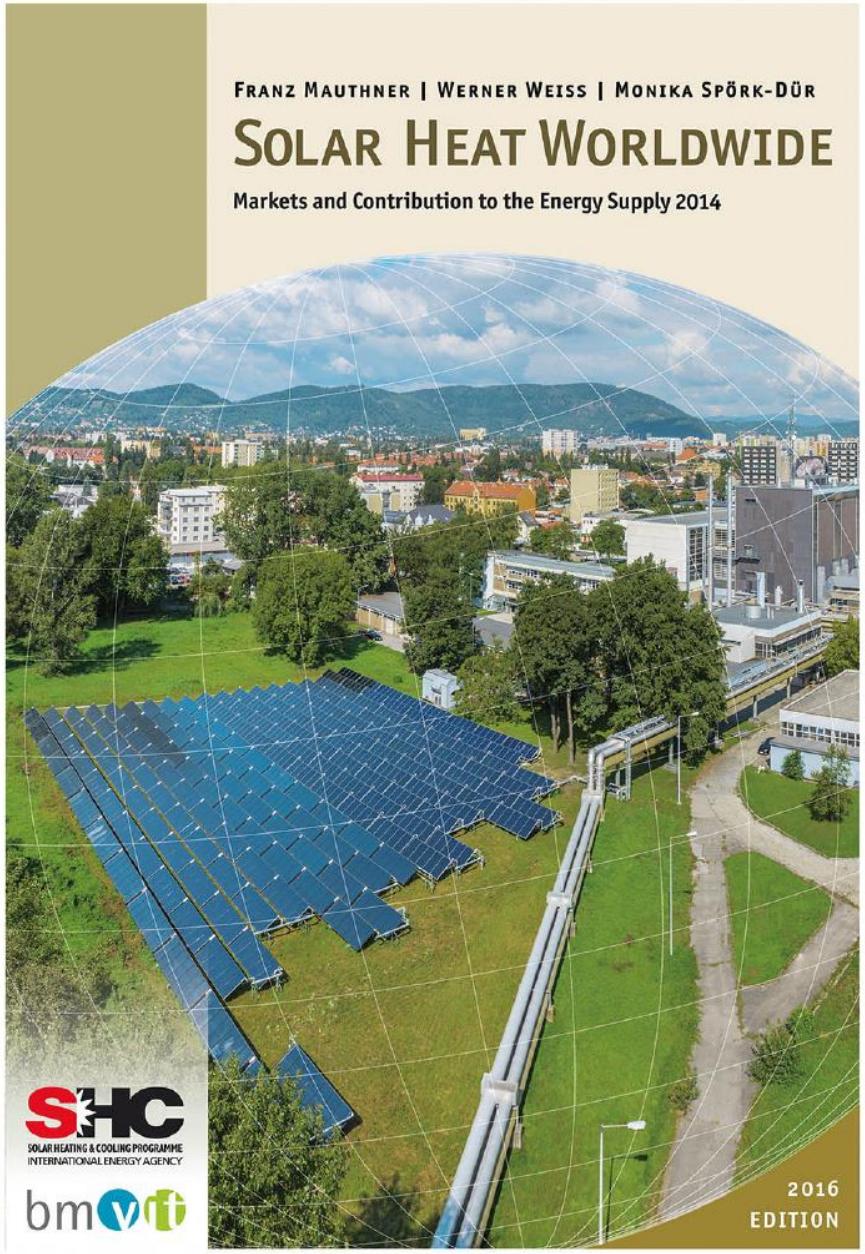
Source: IRENA (2016), Renewable Energy Statistics 2016, The International Renewable Energy Agency, Abu Dhabi.

Solar heat generation in 2014

See data on solar water heaters in attached page. Note that this report includes data for Morocco but not for Egypt. However, a report from the Observatoire Méditerranéen de l'Energie (OME)[1] indicated a total collector surface in Egypt of **800,000 m²**. Use the ratio yield/area from neighbouring Israel to estimate the yield of solar heaters in Egypt.

[1] Available at: https://www.b2match.eu/system/stworkshop2013/files/Market_Assessment_Report_II.pdf

From: IEA SHC (2016), Solar Heat Worldwide, p.8 & 12 - http://www.iea-shc.org/solar-heat-worldwide



Country	Total collector area [m²]	Total capacity [MW$_{th}$]	Calculated number of systems	Collector yield [GWh/a]	Energy savings [t$_{oe}$/a]	CO_2 reduction [t$_{CO2e}$/a]
Albania	162,697	114	29,687	115	12,327	39,790
Australia	8,365,000	5,856	1,062,217	5,199	558,804	1,803,820
Austria	5,161,798	3,613	513,871	2,087	224,309	724,070
Barbados*	131,700	92	32,925	116	12,492	40,323
Belgium	539,033	377	93,806	214	23,031	74,344
Brazil	11,017,333	7,712	3,298,890	7,189	772,664	2,494,159
Bulgaria	130,300	91	22,676	64	6,900	22,273
Canada	904,156	633	15,144	368	39,544	127,648
Chile	231,209	162	31,190	164	17,655	56,991
China	413,600,000	289,520	70,105,200	231,838	24,918,150	80,435,787
Croatia	167,092	117	29,079	84	9,027	29,138
Cyprus	690,447	483	301,787	614	65,961	212,922
Czech Republic	1,044,512	731	72,531	348	37,389	120,691
Denmark	957,341	670	87,705	405	43,508	140,445
Estonia	10,520	7	1,831	4	454	1,465
Finland	55,823	39	9,715	23	2,431	7,848
France (mainland) +	2,520,900	1,765	526,468	1,188	127,687	412,173
Germany	18,256,700	12,780	2,144,037	7,434	798,979	2,579,104
Greece	4,286,300	3,000	1,144,313	2,986	320,900	1,035,865
Hungary	269,100	188	38,697	121	13,053	42,135
India ++	7,451,900	5,216	3,282,003	6,435	691,605	2,232,502
Ireland	300,183	210	69,472	126	13,508	43,605
Israel	4,527,634	3,169	1,449,748	4,182	449,451	1,450,827
Italy	4,006,444	2,805	697,229	2,445	262,738	848,117
Japan	3,730,983	2,612	909,073	2,164	232,602	750,838
Jordan***	1,260,506	882	223,109	1,194	128,286	414,108
Korea, South	1,793,613	1,256	410,916	927	99,657	321,693
Latvia	8,622	6	1,500	4	393	1,269
Lebanon	603,900	423	66,731	500	53,752	173,512
Lesotho #	400	0	200	0	39	126
Lithuania	10,400	7	1,810	4	468	1,510
Luxembourg	51,200	36	8,910	22	2,328	7,515
Macedonia	41,720	29	9,516	26	2,774	8,954
Malta	49,976	35	13,342	40	4,311	13,916
Mauritius***	123,993	87	82,662	106	11,375	36,719
Mexico	2,817,077	1,972	332,818	1,612	173,212	559,127
Morocco***	451,000	316	60,900	383	41,146	132,821
Mozambique	1,143	1	286	1	104	337
Namibia**	22,000	15	2,717	20	2,157	6,963
Netherlands	643,833	451	153,240	257	27,619	89,153
New Zealand*	159,645	112	32,703	99	10,592	34,191
Norway	42,506	30	2,118	16	1,682	5,428
Palestinian Territ.	1,785,625	1,250	613,124	1,666	179,038	577,933
Poland	1,744,000	1,221	219,453	712	76,545	247,087
Portugal	945,181	662	182,666	735	79,049	255,171
Romania	143,050	100	24,895	79	8,491	27,408
Russia	18,464	13	841	8	826	2,667
Slovakia	152,950	107	18,720	71	7,675	24,774
Slovenia	191,500	134	28,961	80	8,563	27,642
South Africa	1,650,050	1,155	693,004	1,178	126,614	408,709
Spain	3,450,433	2,415	413,879	2,409	258,953	835,901
Sweden	497,178	348	37,748	182	19,530	63,044
Switzerland	1,484,640	1,039	179,627	586	63,018	203,423
Taiwan	1,605,989	1,124	317,038	977	104,995	338,923
Thailand***	152,862	107	34,933	128	13,790	44,514
Tunisia	775,935	543	229,641	697	74,922	241,847
Turkey	18,185,901	12,730	4,200,943	16,316	1,753,651	5,660,785
United Kingdom	789,600	553	137,412	307	32,975	106,443
United States	24,279,331	16,996	486,396	10,925	1,174,273	3,790,555
Uruguay	46,241	32	11,560	32	3,387	10,935
Zimbabwe	24,823	17	6,206	21	2,279	7,356
All other countries (5%)	29,185,494	20,430	6,011,466	17,233	1,852,183	5,978,848
TOTAL	583,709,885	408,597	101,221,287	335,463	36,055,821	116,388,189

Note: If no data is given no reliable database for this collector type is available.
* Total capacity in operation refers to the year 2009. ** Total capacity in operation refers to the year 2012.
*** Total capacity in operation is based on estimations for new installations in 2014.
\# New included countries compared to the 2015 edition of this report
\+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered.
++ The figures for India refer to fiscal year April 2014 to March 2015.

Table 5: Calculated annual collector yield and corresponding oil equivalent and CO_2 reduction of glazed and unglazed water collectors in operation by the end of 2014

Answer sheet:

Supply and consumption 2016		Morocco Solar Thermal TJ	Egypt Solar Thermal TJ
Production	(+)		
Imports	(+)		
Exports	(-)		
Stock changes	(+)		
International Bunkers	(-)		
Domestic supply	(=)		
Transfers			
Statistical Differences			
Power plants			
CHP plants			
Commercial heat plants			
Charcoal production			
Biomass pellet and briquette production			
Other transformation			
Energy sector and own use			
Distribution losses			
Total final consumption			
Industry sector			
Transport sector			
of which road transport			
Commercial and public services			
Residential			
of which traditional uses			
Other			

Solar thermal (Answers)

The market report estimates that Morocco produces 383 GWh per year. The ratio yield/area for Israel is 4,182/4,527,634 = 0.000923 GWh/m^2, which multiplied by 800,000m^2 of collector area in Egypt gives 739 GWh.
Converted to TJ (x 3.6) = 1,379 TJ (Morocco) and 2,660 TJ (Egypt)
Split between residential and commercial (hotels) has to be a guess! We assume 50:50

Thermal energy used in concentrated solar power (CSP) generation can be derived by taking electricity production, converting to TJ and converting to primary heat (x3 for a 33% conversion efficiency). So:

Production (GWh) = 35 (Morocco) and 16 (Egypt)
Converted to TJ (x 3.6) = 126 (China) and 57 (Egypt)
Transformation (x3) = 378 (China) and 173 (Egypt)

The above figures can be entered into the worksheet and supply and production (exactly the same) can be calculated and shown above them.

Supply and consumption		**China Solar Thermal**	**Egypt Solar Thermal**
2016		**TJ**	
Production	(+)	1,757	2833
Imports	(+)		
Exports	(-)		
Stock changes	(+)		
International Bunkers	(-)		
Domestic supply	(=)	**1,757**	**2833**
Transfers			
Statistical Differences			
Power plants		378	173
CHP plants			
Commercial heat plants			
Charcoal production			
Biomass pellet and briquette production			
Other transformation			
Energy sector and own use			
Distribution losses			
Total final consumption		**1,379**	**2660**
Industry sector			
Transport sector			
of which road transport			
Commercial and public services		689	1330
Residential		688	1330
of which traditional uses			
Other			