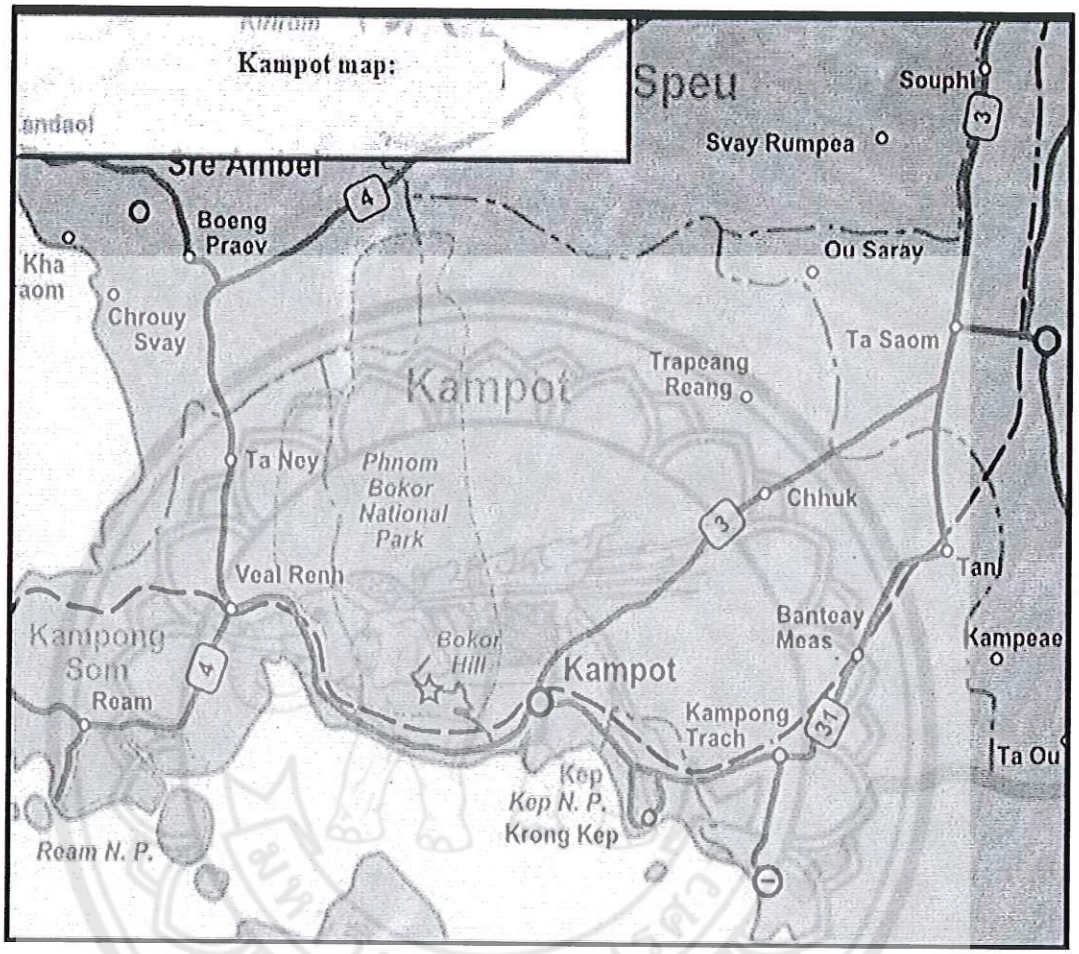
APPENDIX

APPENDIX A: MAP OF KAMPOT PROVINCE



07 KAMPOT

* Commune Code consists of District Code and two digits.

0701 Angkor Chey
070101 Angk Phnum Touch
070102 Angkor Chey
070103 Champei
070104 Dambouk Khpos
070105 Dan Koum
070106 Daeum Doung
070107 Hroum
070108 Phnum Kong
070109 Praphnum
070110 Samlanh
070111 Tani

0702 Banteay Meas
070201 Banteay Meas Khang Kaeut
070202 Banteay Meas Khang Lech
070203 Prey Tonle
070204 Samraong Kraom
070205 Samraong Leu
070206 Sdach Kong Khang Cheung
070207 Sdach Kong Khang Lech
070208 Sdach Kong Khang Tboung
070209 Tnoat Chong Srang
070210 Trapeang Sala Khang Kaeut
070211 Trapeang Sala Khang Lech
070212 Tuk Meas Khang Kaeut
070213 Tuk Meas Khang Lech
070214 Voat Angk Khang Cheung
070215 Voat Angk Khang Tboung

0703 Chhuk
070301 Banlev
070302 Takeen
070303 Boeng Nimol
070304 Chhuk
070305 Doun Yay
070306 Krang Skov
070307 Krang Snay
070308 Lbaeuk
070309 Trapeang Phleang
070310 Mean Chey
070311 Neareay
070312 Satr Pong
070313 Trapeang Bei
070314 Tramaeng

0704 Chum Kiri
070401 Chres
070402 Chumpu Voan
070403 Snay Anhchit
070404 Srae Chaeng
070405 Srae Khang
070406 Srae Samraong
070407 Trapeang Reang

0705 Dang Tong
070501 Damnak Sokram
070502 Dang Tong
070503 Khcheay Khang Cheung
070504 Khcheay Khang Tboung
070505 Mean Rith
070506 Srae Chea Khang Cheung
070507 Srae Chea Khang Tboung
070508 Totung
070509 Angkor Meas
070510 L'ang

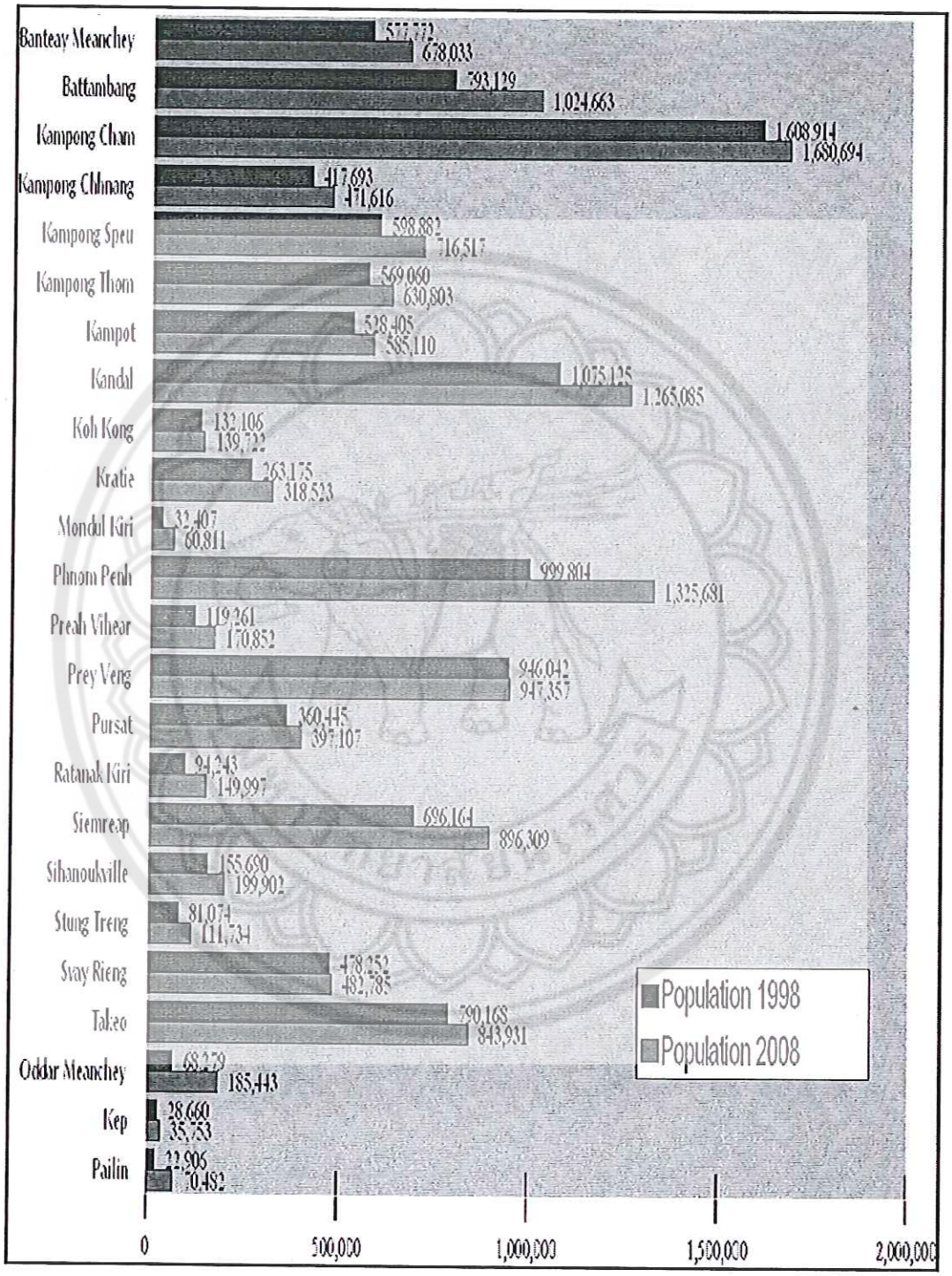
0706 Kampong Trach
070601 Boeng Sala Khang Cheung
070602 Boeng Sala Khang Tboung
070603 Damnak Kantuot Khang Cheung
070604 Damnak Kantuot Khang Tboung
070605 Kampong Trach Khang Kaeut
070606 Kampong Trach Khang Lech
070607 Kanthaor Khang Cheung
070608 Kanthaor Khang Kaeut
070609 Kanthaor Khang Lech
070612 Preaek Kroes
070613 Ruessei Srok Khang Kaeut
070614 Ruessei Srok Khang Lech
070615 Svay Teng Khang Cheung
070616 Svay Teng Khang Tboung

0707 Kampot
070701 Boeng Tuk
070702 Chum Kiri
070703 Kampong Kraeng
070704 Kampong Samraong
070705 Kandal
070707 Kaoh Touch
070708 Koun Satv
070709 Makprang
070711 Preaek Tnoat
070712 Prey Khmum
070713 Prey Thnang
070715 Stueng Kaev
070716 Thmei
070717 Trapeang Pring
070718 Trapeang Sangkae
070719 Trapeang Thum

0708 Kampong Bay
070801 Kampong Kandal
070802 Krang Ampil
070803 Kampong Bay
070804 Andoung Khmaer
070805 Traeny Kaoh

* Codes and boundaries are as of February 9, 2009.

APPENDIX B: POPULATION OF CAMBODIA AND KAMPOT PROVINCE



Provisional Table 1. Number of Households and Population by Province and Sex

Province	Number of Households	Population			Average Household Size (*)
		Both Sexes	Males	Females	Sex Ratio
Cambodia – Total	2,832,691	13,388,910	6,495,512	6,893,398	94.2	4.7
Banteay Meanchey	144,400	678,033	331,289	346,744	95.5	4.6
Battambang	210,327	1,024,663	504,974	519,689	97.2	4.8
Kampong Cham	368,871	1,680,694	817,251	863,443	94.7	4.5
Kampong Chhnang	101,122	471,616	226,357	245,259	92.3	4.6
Kampong Speu	149,132	716,517	347,594	368,923	94.2	4.8
Kampong Thom	134,123	630,803	306,547	324,256	94.5	4.7
Kampot	129,745	585,110	283,604	301,506	94.1	4.5
Kandal	257,857	1,265,085	609,810	655,275	93.1	4.9
Koh Kong	28,853	139,722	70,665	69,057	102.3	4.8
Kratie	65,632	318,523	158,365	160,158	98.9	4.8
Mondul Kiri	12,296	60,811	31,128	29,683	104.9	4.9
Phnom Penh	257,828	1,325,681	622,197	703,484	88.4	5.1
Preah Vihear	33,260	170,852	84,909	85,943	98.8	5.1
Prey Veng	226,764	947,357	451,875	495,482	91.2	4.2
Pursat	83,515	397,107	192,354	204,753	93.9	4.7
Ratanak Kiri	27,396	149,997	75,827	74,170	102.2	5.5
Siemreap	180,097	896,309	437,994	458,315	95.6	5.0
Sihanoukville	40,478	199,902	99,226	100,676	98.6	4.9
Stung Treng	21,179	111,734	55,635	56,099	99.2	5.2
Svay Rieng	115,282	482,785	231,129	251,656	91.8	4.2
Takeo	183,905	843,931	409,799	434,132	94.4	4.6
Oddar Meanchey	38,642	185,443	93,193	92,250	101	4.8
Kep	7,234	35,753	17,603	18,150	97	4.9
Pailin	14,753	70,482	36,187	34,295	105.5	4.7

Based on Normal or Regular Households

Population of Kampot province from 1998-2012

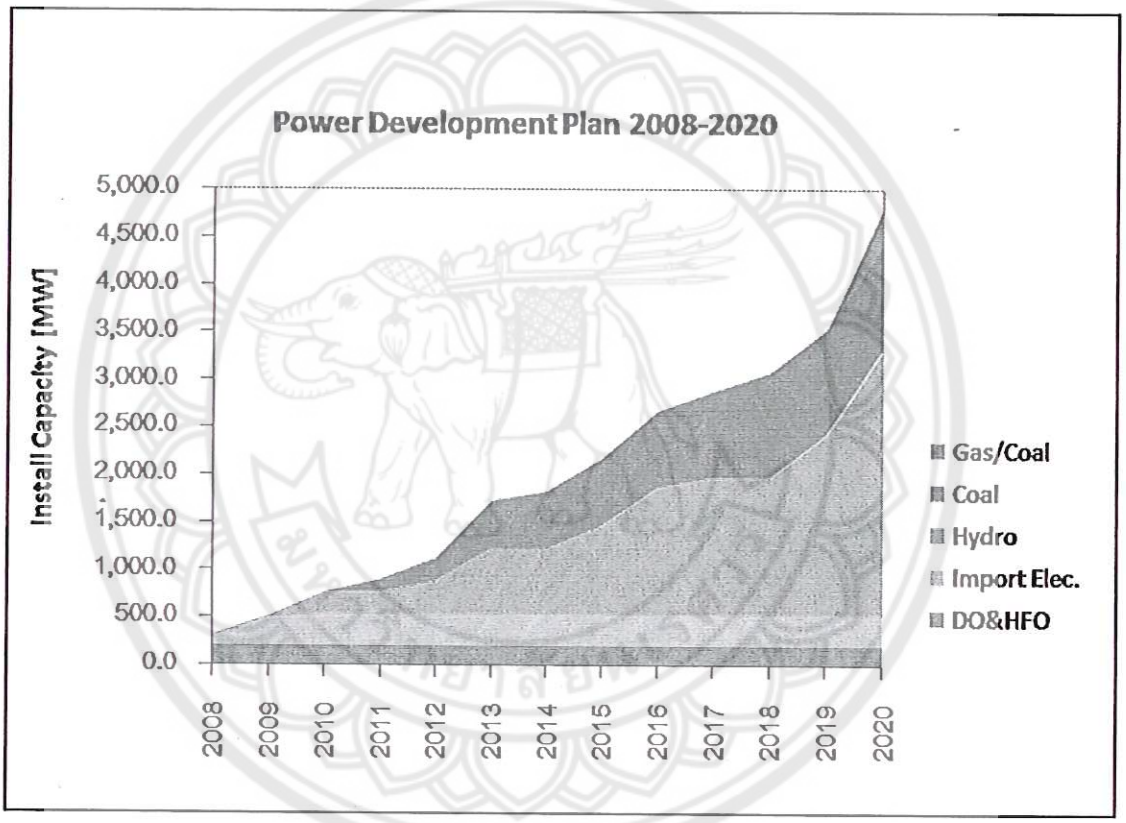
Province	1998	2004	2008	2012
Kampot	528,405	554,825	585,110	620,217

Source: National Institute of Statistics, Ministry of Planning in 2012 and (http://www. nis.gov.kh)

APPENDIX C: ELECTRICITY POWER PRODUCTION AND OTHER COSTS IN KAMPOT PROVINCE FROM 2004-2011 (KW)

Year	2004	2005	2006	2007	2008	2009	2010	2011
Capacity	427	611	3,691	6,173	27,076	51,616	75,860	78,246

Source: Annual report of EAC, 2012



Source: Ministry of Industry, Mines and Energy, 2008

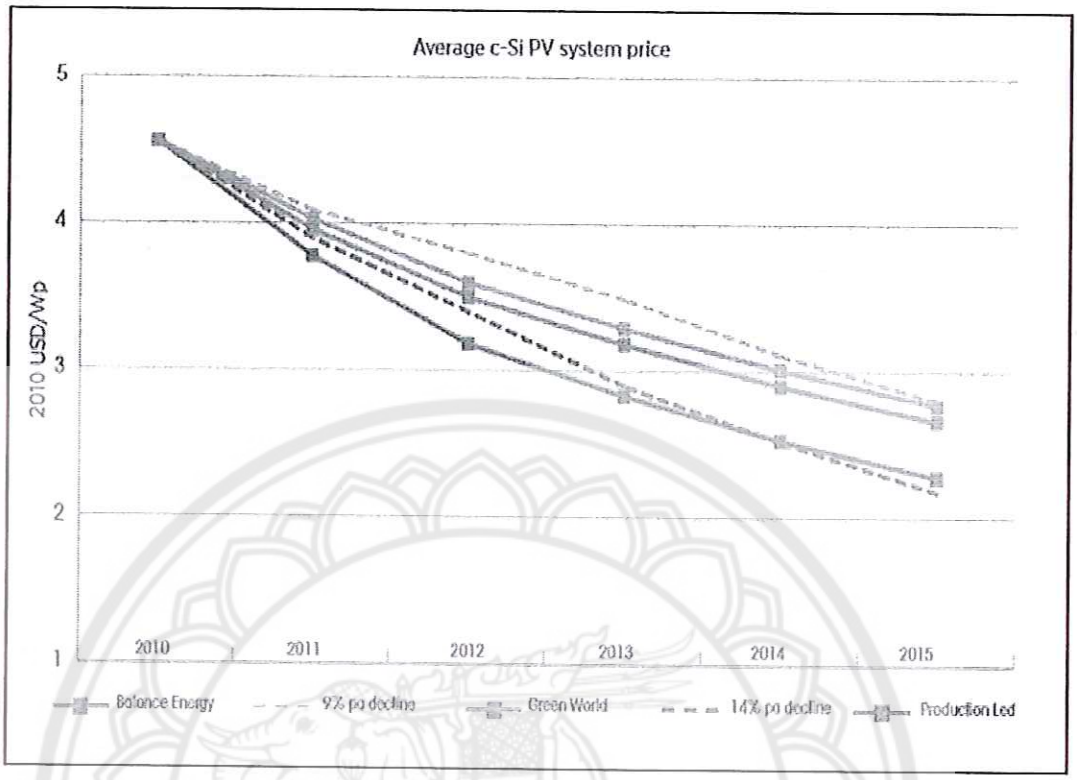


Table 32: Diesel generation costs for different capacities of diesel gensets, and associated competitive PV/hybrid option

Capacity (kW)	Unit cost (USD/kW)	Specific consumption (L/kWh)	Diesel generation cost (Uscts/kWh)	Competitive PV/Hybrid option
20	450	0.40	44	100% storage (42 UScts/kWh)
30	337	0.38	42	
40	296	0.37	40	50% storage (34 UScts/kWh)
50	271	0.36	39	
60	255	0.35	38	
70	237	0.35	37	
80	218	0.34	36	
90	204	0.33	35	
100	192	0.33	35	
150	158	0.31	33	0% storage (27 UScts/kWh)
200	140	0.30	31	
250	130	0.29	30	
300	123	0.28	29	
400	114	0.27	28	

APPENDIX D: SOLAR RADIATION OF FIVE STATIONS IN CAMBODIA, 2010 (kWh/m^2/d)

The solar energy potential of Cambodia can be determined from the geographical distribution of long-term average solar radiation which has been obtained from satellites. To investigate quantitatively this geographical distribution of solar radiation, the percentages of that area which receive different levels of solar radiation were shown the yearly radiation as table below.

Solar Radiation of five stations in Cambodia, 2010 (kWh/m^2/day)

Station	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Phnom Penh	5.39	4.77	4.86	5.10	4.75	5.12	5.18	5.23	5.39	5.13	5.61	5.29
Sihanouk Ville	3.94	4.56	4.86	5.35	5.25	4.67	5.18	5.23	4.08	4.09	4.35	4.12
Kampot	4.95	5.11	4.97	4.88	4.90	5.02	5.77	5.50	5.01	4.98	4.97	5.19
Kampong Thom	5.17	4.47	4.68	5.13	4.85	5.23	5.69	5.66	5.80	5.45	5.64	5.37
Siem Reap	4.95	4.35	4.77	4.95	4.84	4.91	5.66	5.89	5.48	5.35	5.52	5.18

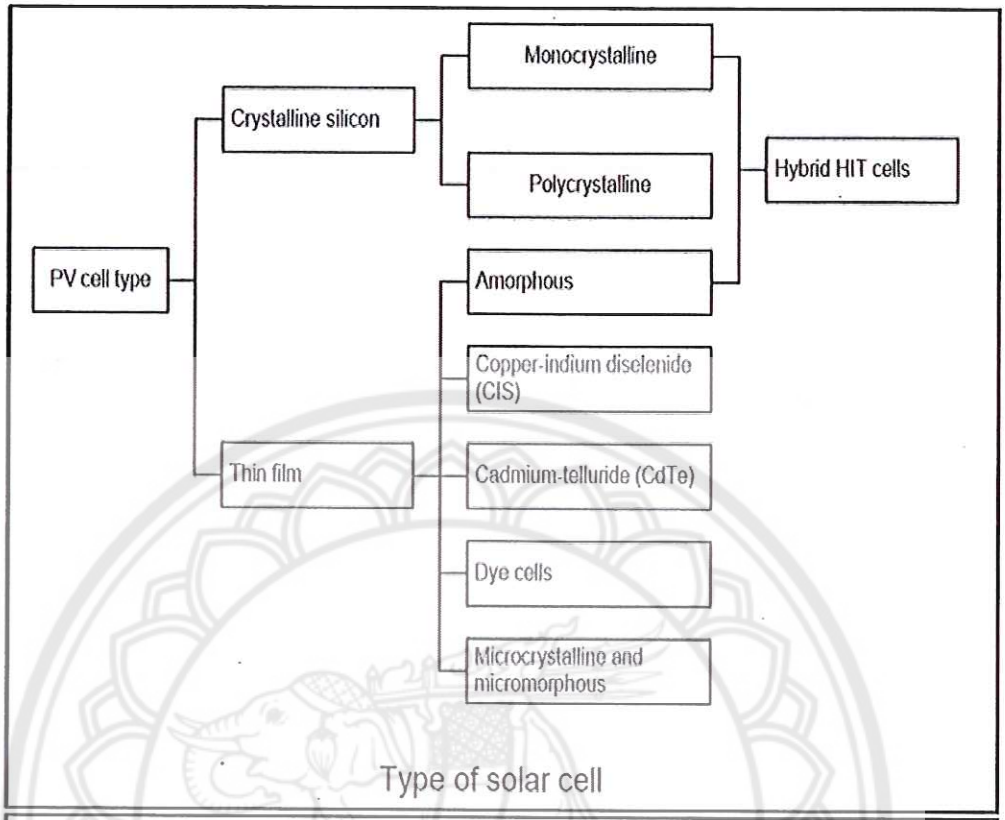
Source: MOWRAM, 2010

APPENDIX E: PHOTOVOLTAIC TECHNOLOGY

1. Types of PV cells

Most commercially available solar cells have a lifespan of at least twenty to twenty-five years. Out of the following types of PV cells, only the first two are commercially available globally:

- Crystalline silicon (c-Si) modules represent 85 to 90% of the global annual market today. These are subdivided into: i) mono crystalline (mono-Si); and ii) polycrystalline (poly-Si). Metallurgical grade silicon is refined to form close to 99% pure silicon. Silicon ingots are obtained from molten poly silicon. Wafers are made by wire-sawing block-cast silicon ingots into very thin (180 to 350 micro-meter) slices. Two sides of the wafer are doped with two different dopants – one side is left electron deficient (the p-layer) and the other side has an excess of electrons (the n-layer). This forms a P–N junction a few hundred nanometers below the surface, which creates an electric field across the junction (PN junction).
- Thin films currently account for 10 to 15% of global PV module sales. These are subdivided into three main families: i) amorphous (a-Si); ii) cadmium telluride (CdTe); and iii) copper indium diselenide (CIS) and copper indium gallium dieselenide (CIGS). Thin film modules are created by coating entire sheets of glass or steel (called substrate) with thin layers of semiconductor materials rather than growing, slicing and treating a crystalline ingot. Emerging technologies include advanced thin films, dye-sensitized cells and organic cells. Concentrator photovoltaic (CPV) technologies use an optical concentrator system that focuses solar radiation onto a small high-efficiency cell. Multi-junction cells are a subclass of photovoltaic cells developed for higher efficiency. These use multiple layers of semiconductor material (from the group III and V elements of the periodic table) to absorb and convert more of the solar spectrum into electricity than is converted by single-junction cells. Hetero-junction with intrinsic thin layer (HIT) solar cells is composed of mono thin crystalline silicon wafer surrounded by ultra-thin amorphous silicon layers.



Type of solar cell

• Comparison of solar cell types

Solar cell	Cell efficiency (laboratory) η_{cell}	Cell efficiency (production) η_{cell}	Module efficiency (series production) η_{module}
Monocrystalline silicon	24.7%	18.0%	14.0%
Polycrystalline silicon	19.8%	16.0%	13.0%
Ribbon silicon	19.7%	14.0%	13.0%
Crystalline thin film silicon	19.2%	9.5%	7.9%
Amorphous silicon[a]	13.0%	10.5%	7.5%
Micromorphous silicon[a]	12.0%	10.7%	9.1%
Hybrid HIT solar cell	20.1%	17.3%	15.2%
CIS, CIGS	18.8%	14.0%	10.0%
Cadmium telluride	16.4%	10.0%	9.0%
III-V semiconductor	35.8%[b]	27.4%	27.0%
Dye-sensitized cell	12.0%	7.0%	5.0%

[a] in stabilized state
[b] measured with concentrated irradiance
[c] small production runs

APPENDIX F: POLICIES PROMOTING ON RENEWABLE ENERGY IN CAMBODIA

The Royal Government of Cambodia has set up the renewable energy policies as following:

1. Endeavor to provide access to reliable, safe electricity services, with insignificant impact on the environment and at an affordable price for rural communities;

2. Provide effective legal, regulatory frameworks and various to an encouragements and train the private sector to participate in providing electricity services by renewable energy to the rural areas;

3. Act as a market enable, through various incentives, for enabling equity in access to reliable and safe electricity services, with insignificant impact on the environment, at an affordable price for the rural communities;

4. Encourage the efficient generation, transmission and distribution of electricity using the renewable energy technologies, through tariffs, which are in conformity with the Electricity Authority of Cambodia (EAC)'s regulation;

5. Promote electricity systems by renewable energy at least cost for rural communities, through research and pilot development, as part of the Royal Government of Cambodia's portfolio on grid and off-grid technologies;

6. Ensure adequate resources, appropriate institutional mechanism and training to empower the poor involving in rural electrification to participate.

Source: Master Plan on Renewable Energy of the Ministry of Industry, Mines and Energy (MIME, 2005).

APPENDIX G: ECONOMIC CALCULATION OF C-Si PV WITH ORIGINAL ELECTRICITY PRICE OF 0.27 US$/KWH AND DIESEL BATTERY CHARGING STATION WITH CAPACITY OF 10 KW_P WITH ORIGINAL ELECTRICITY PRICE OF 0.34 US$/KWH

PV battery charging station in Kampot province can calculate as below:

Charge controller (10 kW_p)		$1,500	Solar radiation =	5.2 $kWh/m^2/day$	(5 hrs/day)	
Investment cost of PV BCS (3US$/$W_p$)		$30,000	Annual Gen. =	14,045.20 kWh	Fixed	2%
Electricity Cost from EAC, 2012 (kWh)		$0.27			Fixed	2%
O & M	0.0005	$16			Fixed	
Envir. Benefits		10.42US$/ton$CO_2$	0.01 US$/kg$CO_2$		DR =	6%
CO_2 Reduction Emission		0.43 kgCO_2/kWh	0.43			

Year	DF (6%)	Direct Benefit: Annual Gen (kWh)	Direct Benefit: Electricity Cost (US$)	Direct Benefit: CO_2 Emission (US$)	Total Benefit (US$)	Total Investment Cost of system (US$)	Present Value @ 6% DR: O & M Cost	Present Value @ 6% DR: Total Cost	Present Value @ 6% DR: Benefit	Present Value @ 6% DR: Cost	NPV
0	1.00	0.00	0.00	0.00	0.00	31,500.00	0.00	31,860.00	0.00	31,860.00	-31,860.00
1	0.94	14,045.20	3,792.20	62.93	3,855.13		15.75	1,335.75	3,636.92	1,260.14	2,376.78
2	0.89	14,044.08	3,867.74	62.93	3,930.66		16.07	1,336.07	3,498.28	1,189.09	2,309.18
3	0.84	14,042.95	3,944.78	62.92	4,007.70		16.39	1,336.39	3,364.94	1,122.06	2,242.89
4	0.79	14,041.83	4,023.35	62.92	4,086.27		16.71	1,336.71	3,236.71	1,058.80	2,177.90
5	0.75	14,040.71	4,103.49	62.91	4,166.40	1,500.00	17.05	2,837.05	3,113.38	2,120.01	993.37
6	0.70	14,039.58	4,185.23	62.91	4,248.13		17.39	1,337.39	2,994.76	942.81	2,051.96
7	0.67	14,038.46	4,268.59	62.90	4,331.49		17.74	1,337.74	2,880.69	889.67	1,991.02
8	0.63	14,037.34	4,353.61	62.90	4,416.51		18.09	1,338.09	2,770.97	839.54	1,931.44
9	0.59	14,036.21	4,440.33	62.89	4,503.22		18.45	1,338.45	2,665.45	792.23	1,873.22
10	0.56	14,035.09	4,528.77	62.89	4,591.66		18.82	1,338.82	2,563.96	747.59	1,816.37
11	0.53	14,033.97	4,618.98	62.88	4,681.86	1,500.00	19.20	2,839.20	2,466.35	1,495.65	970.69
12	0.50	14,032.85	4,710.98	62.88	4,773.86		19.58	1,339.58	2,372.46	665.73	1,706.73
13	0.47	14,031.72	4,804.82	62.87	4,867.69		19.97	1,339.97	2,282.16	628.23	1,653.93
14	0.44	14,030.60	4,900.52	62.87	4,963.39		20.37	1,340.37	2,195.31	592.85	1,602.46
15	0.42	14,029.48	4,998.13	62.86	5,060.99	1,500.00	20.78	2,840.78	2,111.78	1,185.36	926.42
16	0.39	14,028.36	5,097.69	62.86	5,160.54		21.20	1,341.20	2,031.43	527.96	1,503.47
17	0.37	14,027.23	5,199.22	62.85	5,262.07		21.62	1,341.62	1,954.15	498.23	1,455.92
18	0.35	14,026.11	5,302.78	62.85	5,365.63		22.05	1,342.05	1,879.81	470.18	1,409.63
19	0.33	14,024.99	5,408.41	62.84	5,471.25		22.49	1,342.49	1,808.32	443.71	1,364.61
20	0.31	14,023.87	5,516.13	62.84	5,578.97	1,500.00	22.94	2,842.94	1,739.55	886.44	853.11
21	0.29	14,022.74	5,626.01	62.83	5,688.84		23.40	1,343.40	1,673.40	395.17	1,278.23
22	0.28	14,021.62	5,738.07	62.83	5,800.89		23.87	1,343.87	1,609.78	372.93	1,236.85
23	0.26	14,020.50	5,852.36	62.82	5,915.18		24.35	1,344.35	1,548.58	351.95	1,196.63
24	0.25	14,019.38	5,968.93	62.82	6,031.75		24.84	1,344.84	1,489.71	332.15	1,157.57
25	0.23	14,018.26	6,087.82	62.81	6,150.63		25.33	1,345.33	1,433.09	313.46	1,119.63
Total		350,793.12	121,338.94	1,571.76	122,910.70	37,500.00	504.48	71,364.48	59,321.92	51,981.94	7,339.98

Labor	$1,320.00
Transportation	$0.00
Land	$360.00
Total	$1,680.00

4,916.43

20.18

IRR =	1.91%	
Benefit/Cost =	1.14	
LCOE =	0.15	US$/kWh
Simple Payback Period =	10.57	Years

O & M 0.05% of investment cost (Ketjoy N., 2005)

Note: Replaced charge controller every 5 years.

Charge controller cost = 1,500 US$.

Diesel battery charging station in Kampot province can be calculated as:

					Annual Gen	13,200.00 kWh	(4 hrs/day)			
Investment cost of diesel system		$3,000				Fixed	2%			
Original Electricity Cost from EAC, 2012 (kWh)		$0.34				Fixed	2%			
O & M	7%	$630.00				Fixed				
Diesel engine operation [(4h/day), 330/year] =		13,200.00 kWh				DR =	6%			

		Direct Benefit			Total Investment	Present Value @ 6% DR				
Year	DF (6%)	Annual Gen (kWh)	Electricity Cost (US$)	Total Benefit (US$)	Cost of system (US$)	O & M Cost	Total Cost	Benefit	Cost	NPV
0	1.00	0.00	0.00	0.00	3,000.00	0.00	4,100.00	0.00	4,100.00	-4,100.00
1	0.94	13,200.00	4,488.00	4,488.00		630.00	4,617.90	4,233.96	4,356.51	-122.55
2	0.89	13,200.00	4,577.76	4,577.76		642.60	4,630.50	4,074.19	4,121.13	-46.94
3	0.84	13,200.00	4,669.32	4,669.32		655.45	4,643.35	3,920.45	3,898.65	21.80
4	0.79	13,200.00	4,762.70	4,762.70		668.56	4,656.46	3,772.51	3,688.35	84.15
5	0.75	13,200.00	4,857.96	4,857.96		681.93	4,669.83	3,630.15	3,489.57	140.58
6	0.70	13,200.00	4,955.11	4,955.11		695.57	4,683.47	3,493.16	3,301.66	191.50
7	0.67	13,200.00	5,054.22	5,054.22		709.48	4,697.38	3,361.34	3,124.03	237.32
8	0.63	13,200.00	5,155.30	5,155.30		723.67	4,711.57	3,234.50	2,956.10	278.40
9	0.59	13,200.00	5,258.41	5,258.41		738.15	4,726.05	3,112.44	2,797.34	315.10
10	0.56	13,200.00	5,363.58	5,363.58	3,000.00	752.91	7,740.81	2,994.99	4,322.43	-1,327.43
11	0.53	13,200.00	5,470.85	5,470.85		767.97	4,755.87	2,881.97	2,505.33	376.64
12	0.50	13,200.00	5,580.26	5,580.26		783.33	4,771.23	2,773.22	2,371.15	402.07
13	0.47	13,200.00	5,691.87	5,691.87		798.99	4,786.89	2,668.57	2,244.28	424.29
14	0.44	13,200.00	5,805.71	5,805.71		814.97	4,802.87	2,567.87	2,124.31	443.55
15	0.42	13,200.00	5,921.82	5,921.82		831.27	4,819.17	2,470.97	2,010.87	460.10
16	0.39	13,200.00	6,040.26	6,040.26		847.90	4,835.80	2,377.72	1,903.59	474.13
17	0.37	13,200.00	6,161.06	6,161.06		864.85	4,852.75	2,288.00	1,802.14	485.86
18	0.35	13,200.00	6,284.28	6,284.28		882.15	4,870.05	2,201.66	1,706.19	495.47
19	0.33	13,200.00	6,409.97	6,409.97		899.80	4,887.70	2,118.58	1,615.45	503.13
20	0.31	13,200.00	6,538.17	6,538.17	3,000.00	917.79	7,905.69	2,038.63	2,465.03	-426.40
21	0.29	13,200.00	6,668.93	6,668.93		936.15	4,924.05	1,961.70	1,448.43	513.27
22	0.28	13,200.00	6,802.31	6,802.31		954.87	4,942.77	1,887.68	1,371.64	516.03
23	0.26	13,200.00	6,938.36	6,938.36		973.97	4,961.87	1,816.44	1,299.00	517.44
24	0.25	13,200.00	7,077.12	7,077.12		993.45	4,981.35	1,747.90	1,230.29	517.61
25	0.23	13,200.00	7,218.67	7,218.67		1,013.32	5,001.22	1,681.94	1,165.28	516.66
Total		330,000.00	143,751.99	143,751.99	9,000.00	20,179.09	129,976.59	69,310.55	67,418.77	1,891.78

Fuel dies	$2,187.90
Labor	$1,800.00
Transportation	$950.00
Land	$150.00
Total	$5,087.90

5,750.08

807.16

IRR =	3.15%	
Benefit/Cost =	1.03	
LCOE =	0.20	US$/kWh
Simple Payback Period =	11.72	Years

O & M 7% of investment costs

Note: Replaced generator every 10 years.

Small-scale project = 0.45 L/kWh.