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The European Union – Turkmenistan Sustainable Energy Days

International Conference

Sustainable Energy in Turkmenistan: prospects and challenges

State Energy Institute of Turkmenistan, Mary, 14 December 2023

Concept for the development of rooftop solar in Tajikistan

Mansurdzhon Kudusov,
Expert in Rooftop Solar Energy, SECCA

Stantec | intec | ACTED | European University Institute | Robert Schuman Centre for Advanced Studies | FSR Energy Florence School of Regulation

The basic principles of assessing the solar potential of roofs

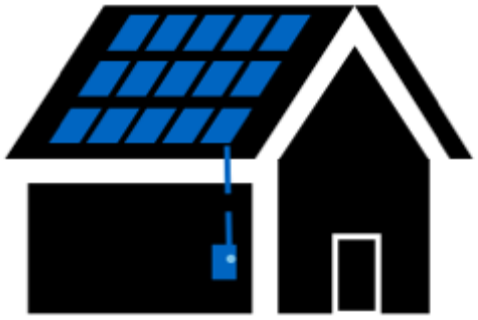
When assessing the feasibility of using photovoltaic panels (solar photovoltaic panels) on building structures, for example, roofs, five basic principles should be taken into account.

- First, it is necessary to estimate the total area available on the roofs of buildings.
- The second principle is that it is necessary to calculate the total area suitable for installing photovoltaic panels on the roof.
- The third principle is that the solar radiation available on the roofs of buildings should be evaluated.
- The fourth and fifth principles relate to technical and economic aspects, that is, the total amount of useful electricity generation by integrated solar panels on the roof and the corresponding investment costs, respectively.

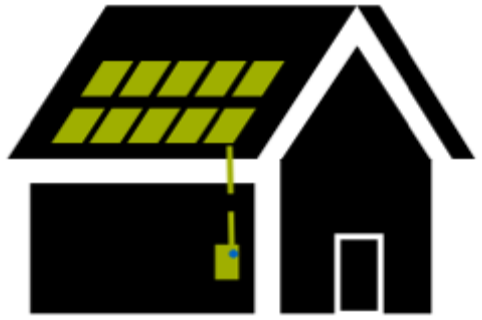
Physical potential

Geographical potential

Technical potential



Economic potential



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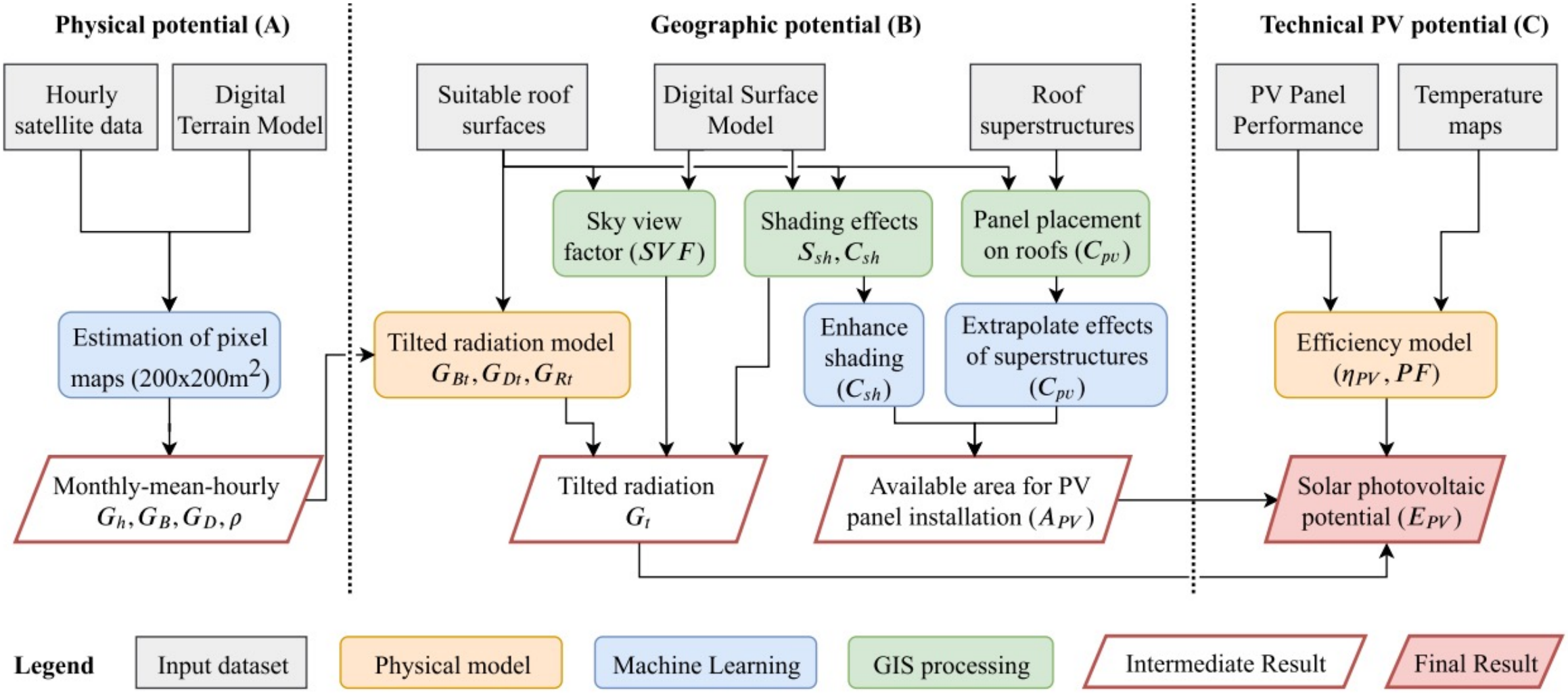
Hierarchical methodology for estimating the potential of solar photovoltaic energy on building roofs



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Dushanbe

Dushanbe is the capital of Tajikistan and the largest city in the country. The area of the city is 203.1825 km2, and the population is 1 million 185.4 thousand people. Dushanbe is rapidly changing, turning from a small city into a shining metropolis. Over the past few years, the appearance of the city has changed a lot, old buildings are being demolished, and new ones are being built in their place. Given the current situation, it is necessary to prepare pilot projects in those neighborhoods where they have already acquired their new look.

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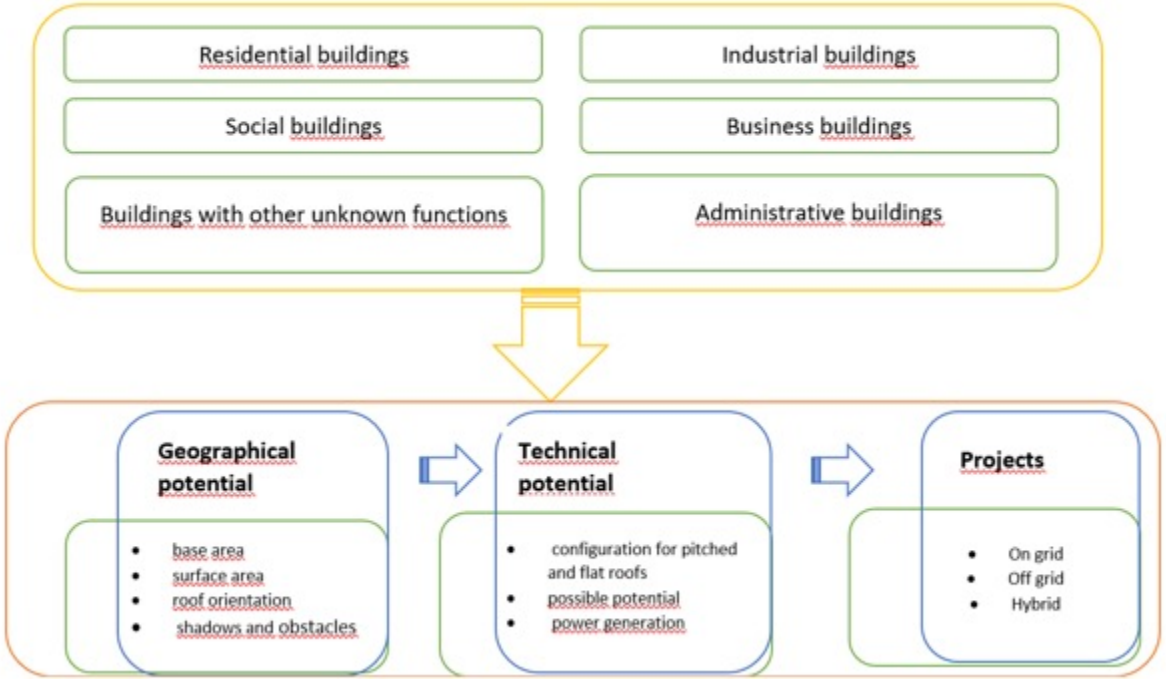

METHODOLOGY FOR ASSESSING THE POTENTIAL OF SOLAR PHOTOVOLTAIC ENERGY ON THE ROOFS OF BUILDINGS IN DUSHANBE

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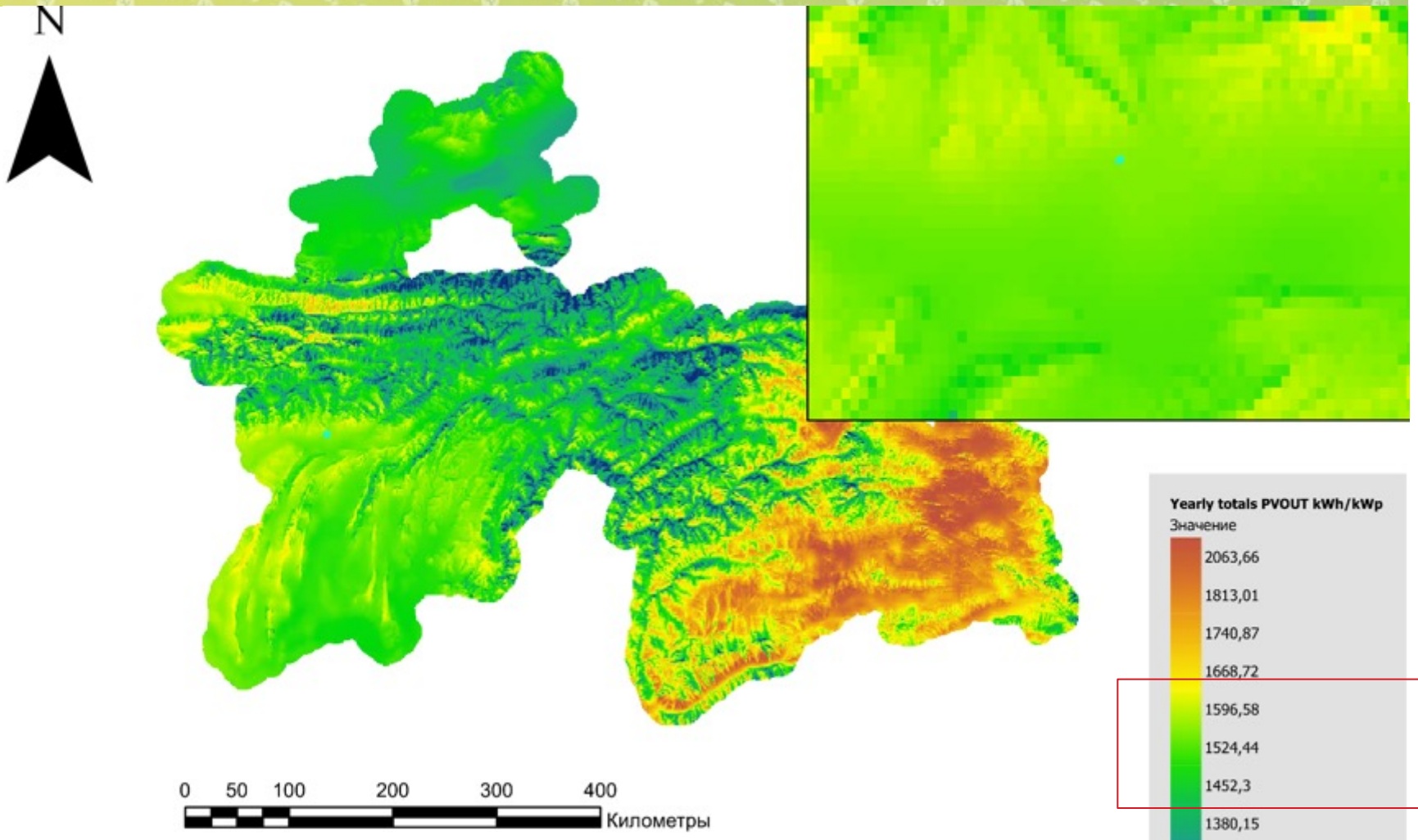
Dushanbe

Physical potential



Yearly Total PVOUT 1400-1600 kWh/kWp

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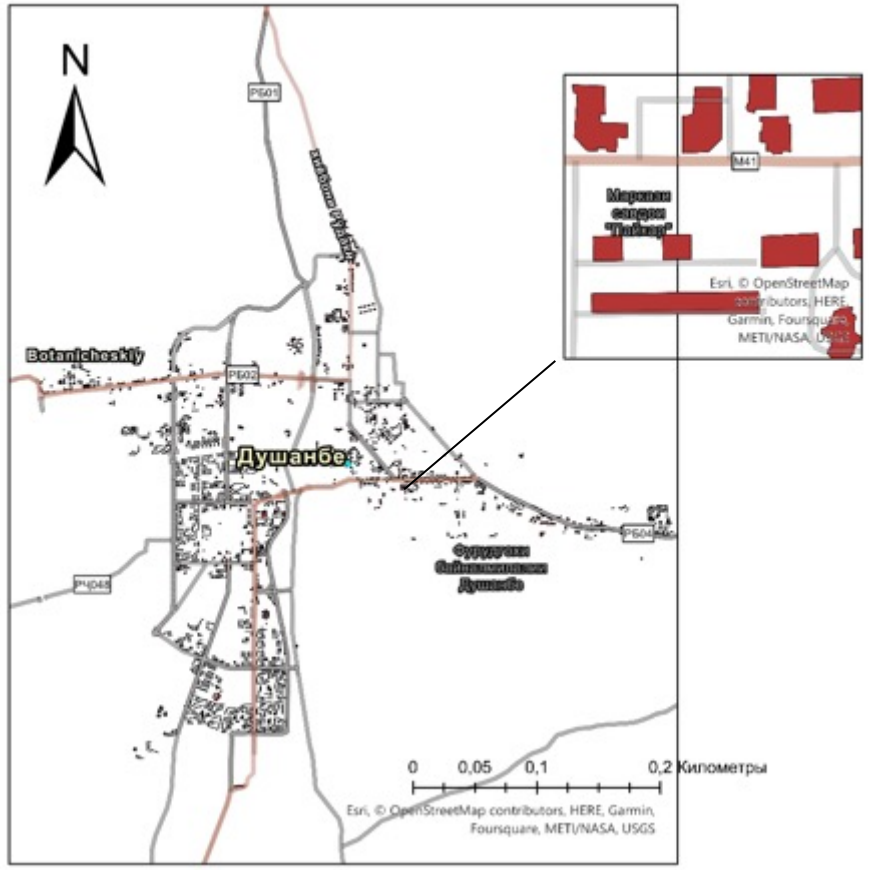
Roof area assessment



Buildings type	#	Area, km2
Residential (old)	1047	1,294089
Residential (new)	1442	1,751792
Social	200	0,588998
Business	14	0,050483

Общая площадь - 3,685 км2 (2703 здания)

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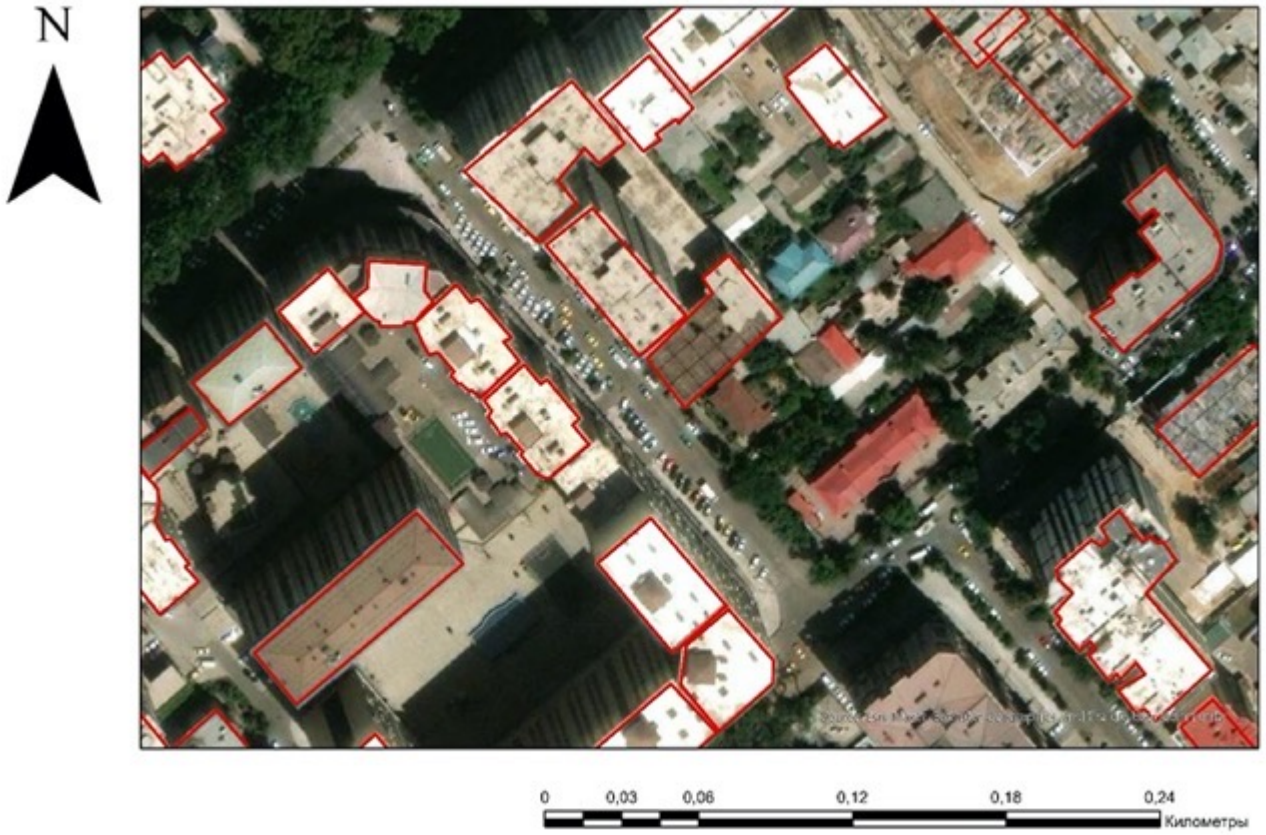
USEFUL AREA FOR PHOTOVOLTAIC SYSTEMS



Each roof has its own usable area for the installation of photovoltaic systems, which averages 80-90% of the total roof area.

In this analysis, this indicator is conditionally assumed to be equal to 80% of the total roof area.

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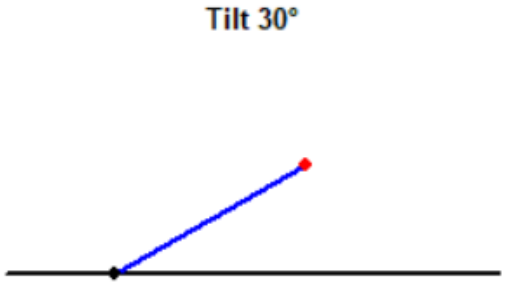
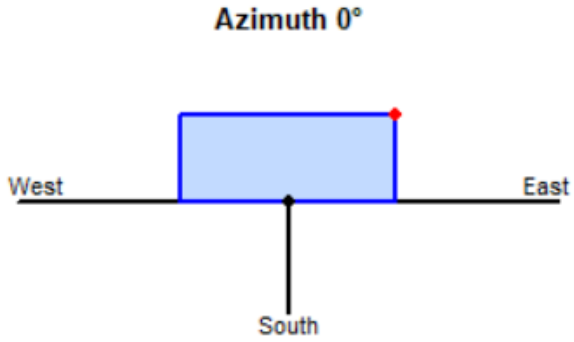
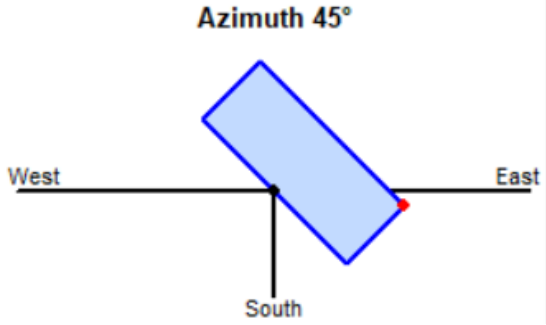
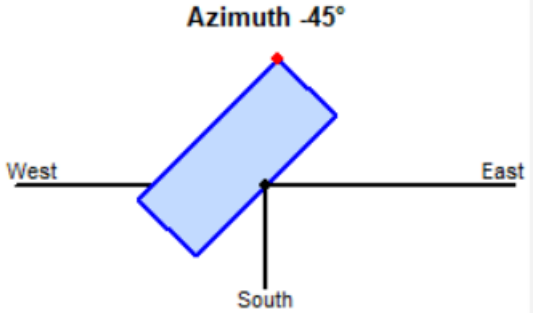
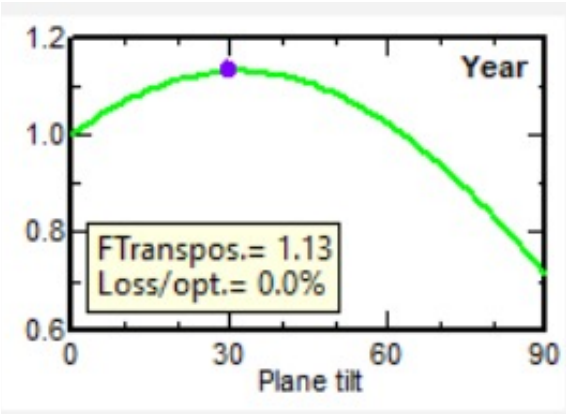
Roof orientation

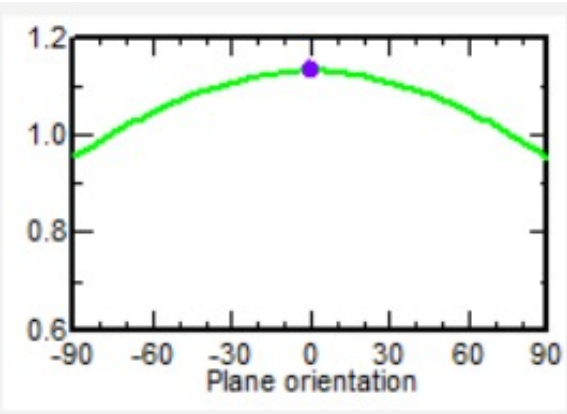


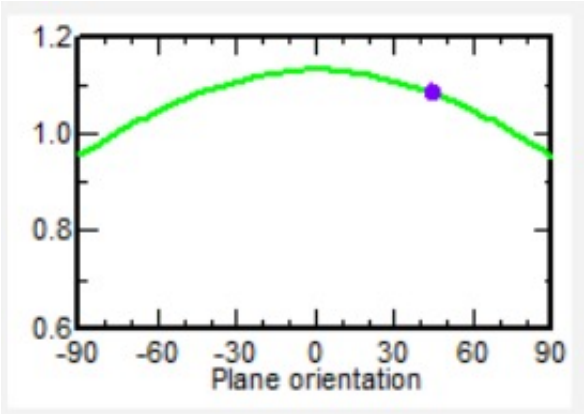


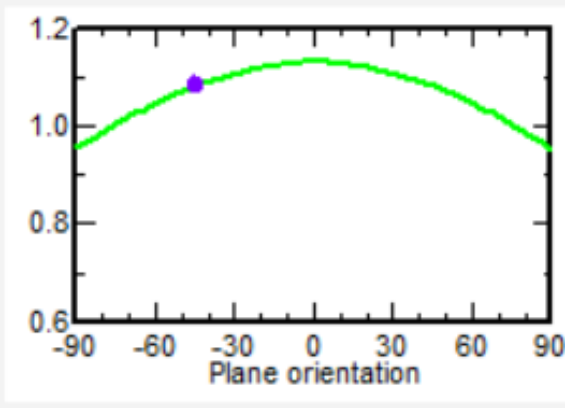












Specific production	**1443 kWh/kWp/yr**	**1351 kWh/kWp/yr**	**1403 kWh/kWp/yr**

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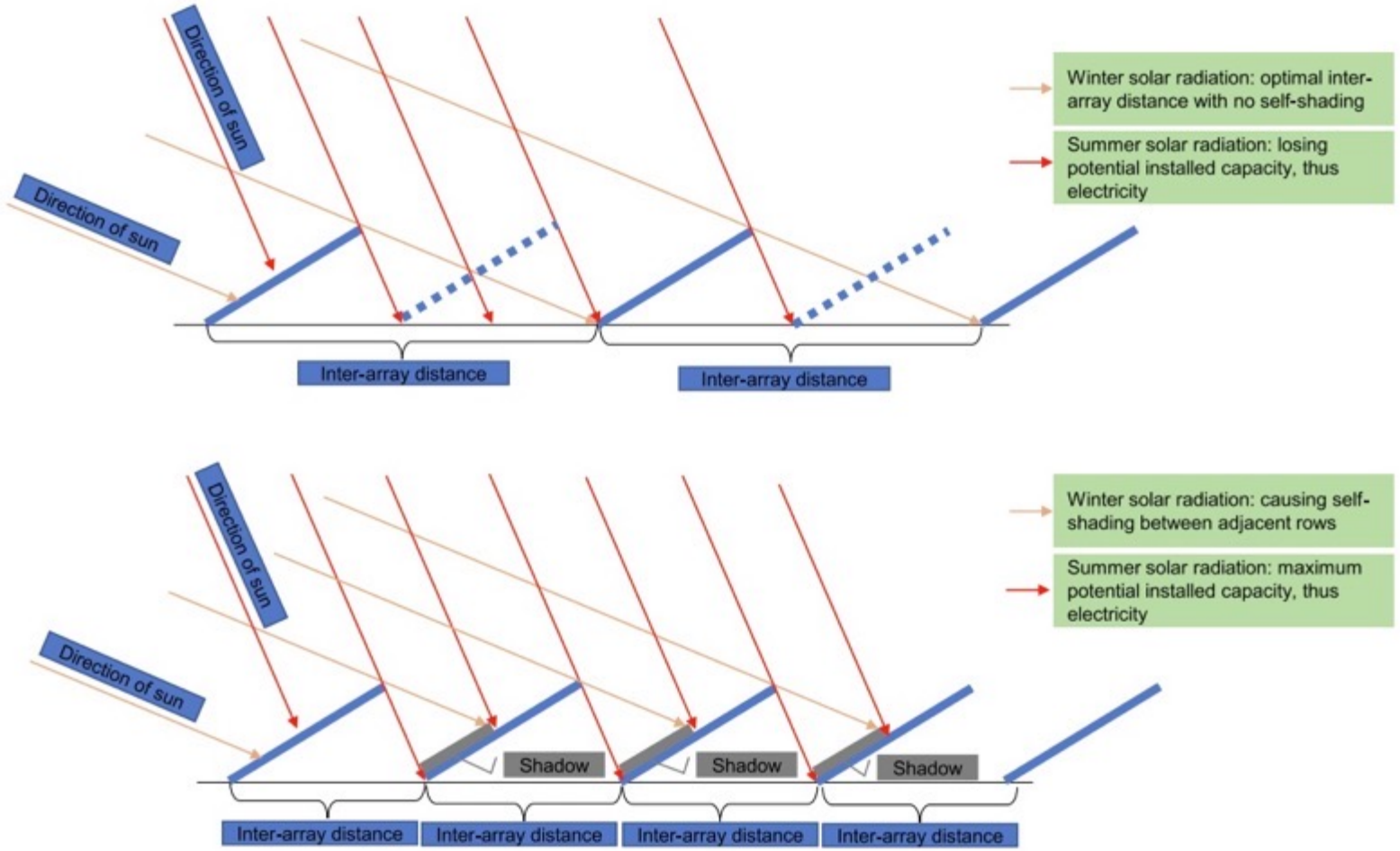
Different row spacing designs and mutual shading effects in winter and summer seasons



1 kW - 10 m2

Flat roof

1 kW - 5 m2

Pitched roof

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Technical potential

Buildings type	Usable area	Potential installed capacity (MWp)	Potential yearly electricity generation (GWh)
Residential (old)	1,04	103,5	149, 1
Residential (new)	1,40	140,1	201,8
Social	0,47	47,1	67,8
Business	0,04	4,04	5,8
	2,95	**294,74**	**275,4**

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Off grid solar power plant

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On grid solar power plant

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Hybryd solar power plant

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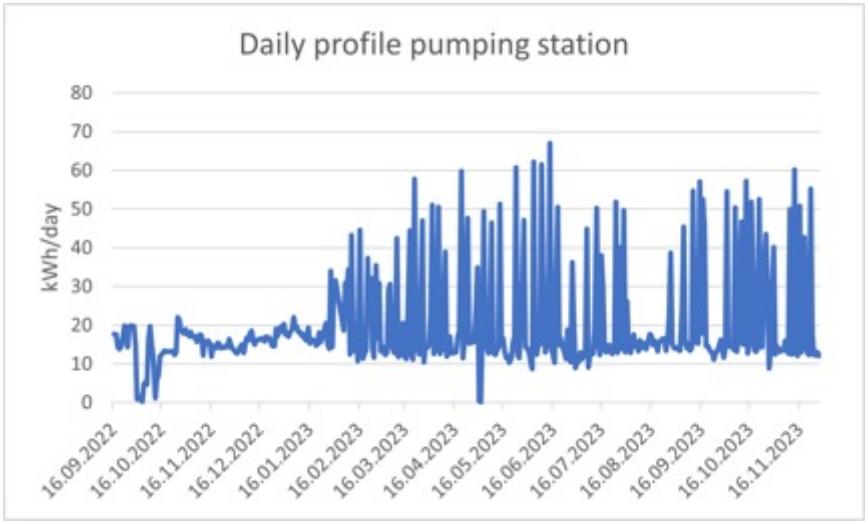
Daily Load - Residential

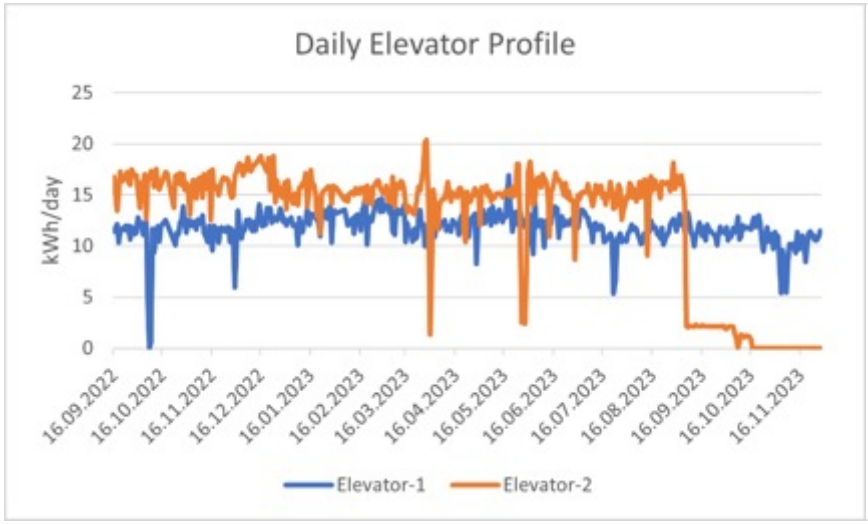
Residential (new)

The total consumption of apartment buildings is mainly used for:

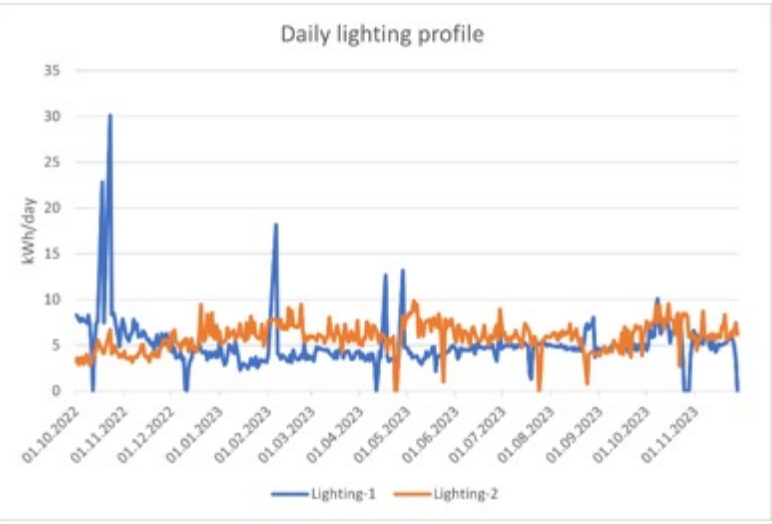
pumping stations



elevators



lighting



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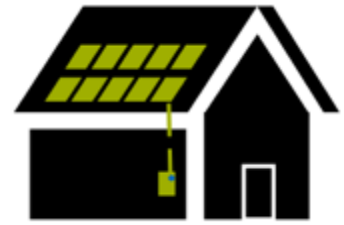
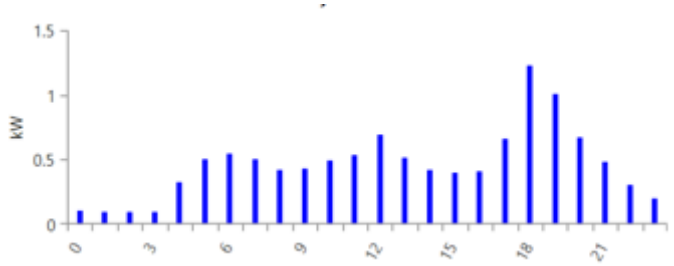
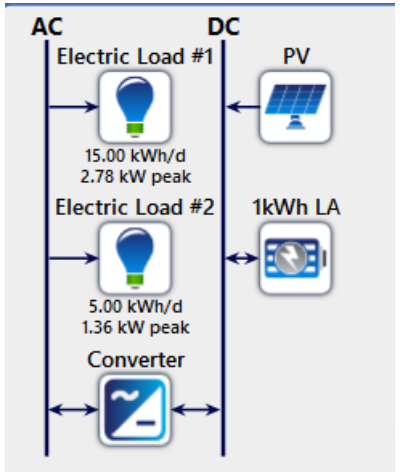
OFF-Grid System for elevators & lighting



Daily Load 20kWh/Day





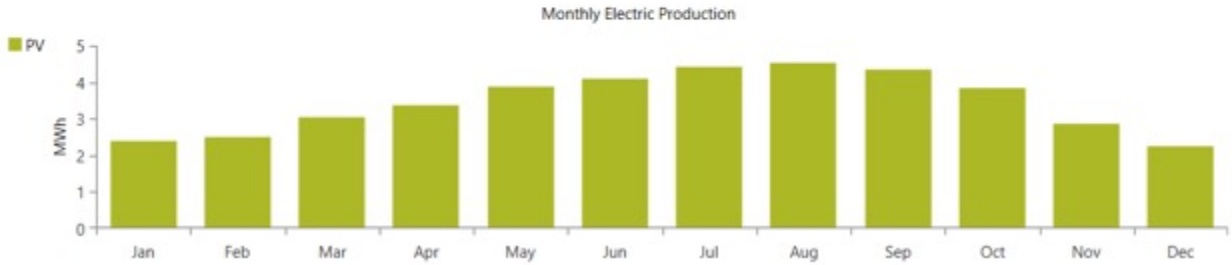
Production	kWh/yr	%
Generic flat plate PV	41,488	100
Total	41,488	100

Consumption	kWh/yr	%
AC Primary Load	7,294	100
DC Primary Load	0	0
Deferrable Load	0	0
Total	7,294	100

Quantity	kWh/yr	%
Excess Electricity	32,707	78.8
Unmet Electric Load	6.06	0.0830
Capacity Shortage	6.70	0.0918

Quantity	Value	Units
Renewable Fraction	100	%
Max. Renew. Penetration	9,698	%

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Generic 1kWh Lead Acid	$26,400.00	$14,906.24	$0.00	$0.00	$0.00	$41,306.24
Generic flat plate PV	$16,270.52	$0.00	$0.00	$0.00	$0.00	$16,270.52
System Converter	$3,000.00	$1,272.82	$0.00	$0.00	($637.61)	$3,635.21
System	$45,670.52	$16,179.06	$0.00	$0.00	($637.61)	$61,211.96



Architecture						Cost			
			PV (kW)	1kWh LA	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)
			27.1	66	10.0	CC	$61,212	$0.725	$1,342	$45,671

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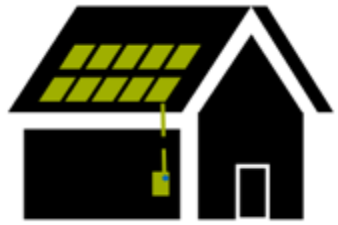
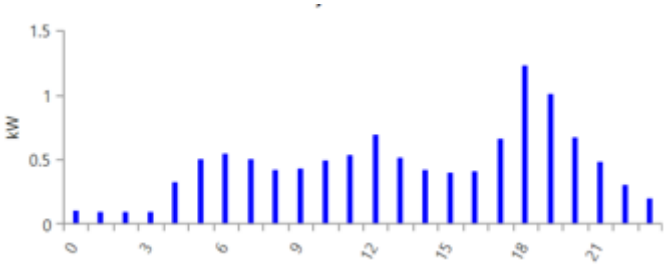
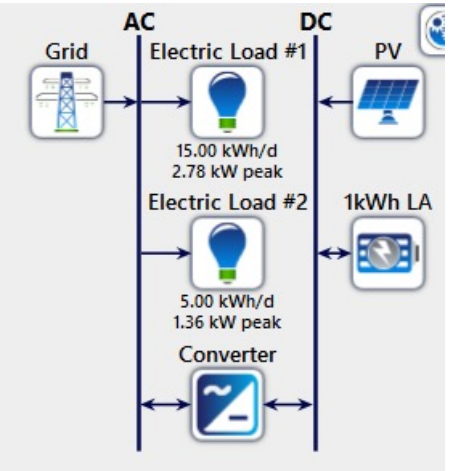
Hybryd System for elevators & lighting



Daily Load 20kWh/Day





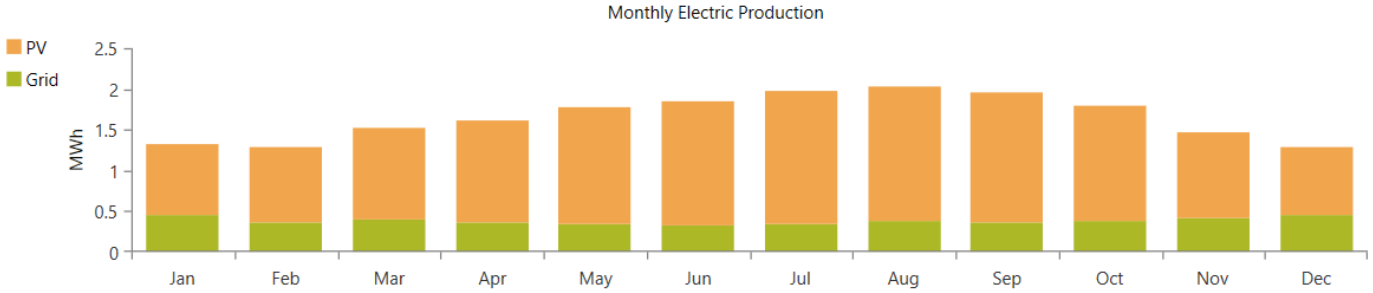
Production	kWh/yr	%
Generic flat plate PV	15,299	76.9
Grid Purchases	4,586	23.1
Total	19,886	100

Consumption	kWh/yr	%
AC Primary Load	7,300	38.2
DC Primary Load	0	0
Deferrable Load	0	0
Grid Sales	11,821	61.8
Total	19,121	100

Quantity	kWh/yr	%
Excess Electricity	0	0
Unmet Electric Load	0	0
Capacity Shortage	0	0

Quantity	Value	Units
Renewable Fraction	76.0	%
Max. Renew. Penetration	105	%

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Generic 1kWh Lead Acid	$8,000.00	$4,517.04	$0.00	$0.00	$0.00	$12,517.04
Generic flat plate PV	$6,000.00	$0.00	$0.00	$0.00	$0.00	$6,000.00
Grid	$0.00	$0.00	($2,513.33)	$0.00	$0.00	($2,513.33)
System Converter	$3,000.00	$1,272.82	$0.00	$0.00	($637.61)	$3,635.21
System	$17,000.00	$5,789.86	($2,513.33)	$0.00	($637.61)	$19,638.92



Architecture							Cost			
				PV (kW)	1kWh LA	Grid (kW)	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)
				10.0	20	999,999	10.0	CC	$19,639	$0.0887	$227.88	$17,000

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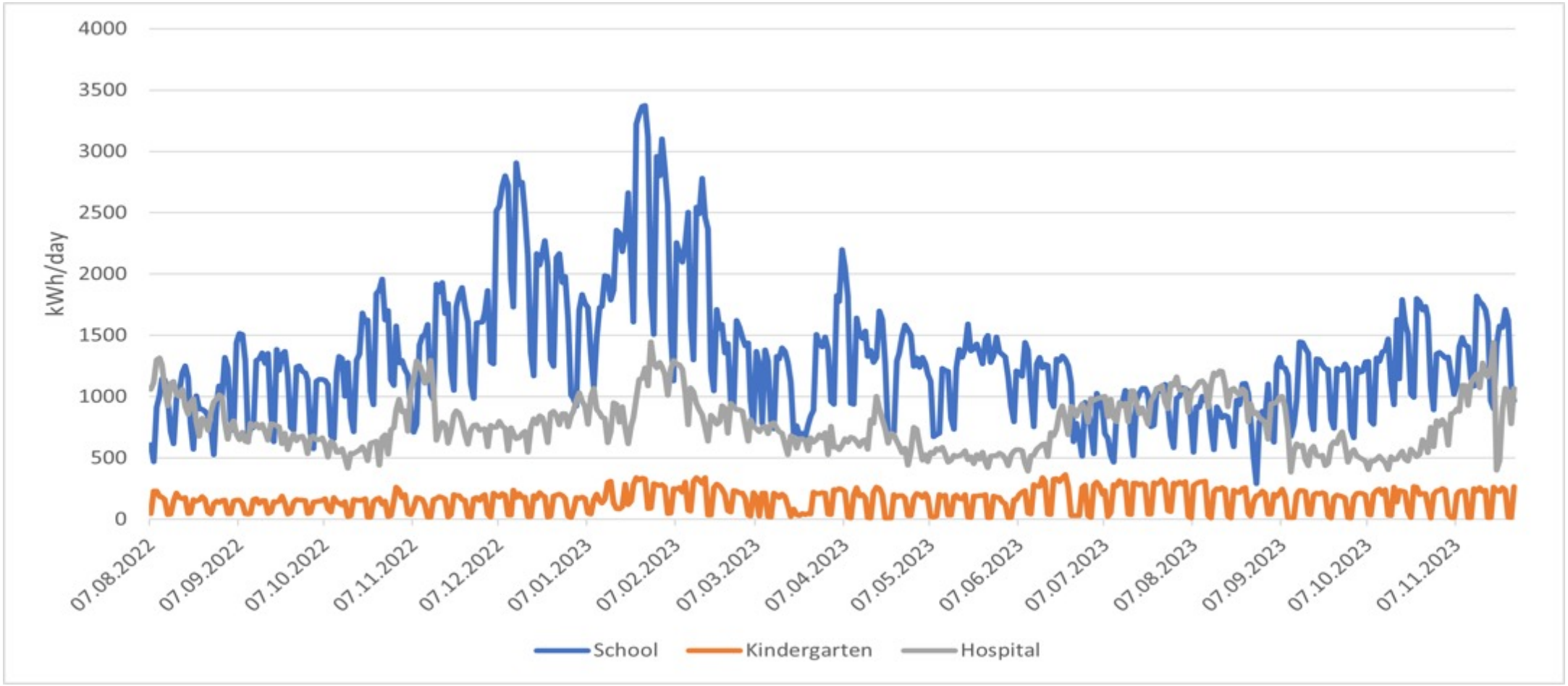
Daily Load - Social



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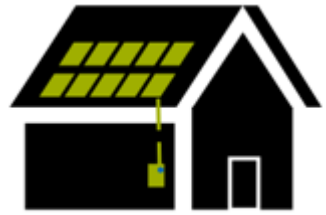
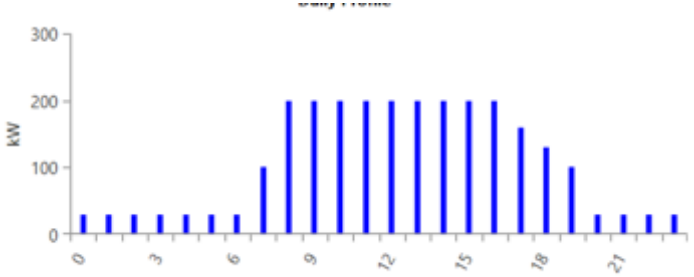
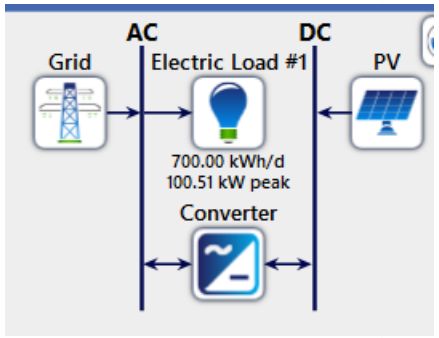
On grid System for social buildings



Daily Load 700kWh/Day





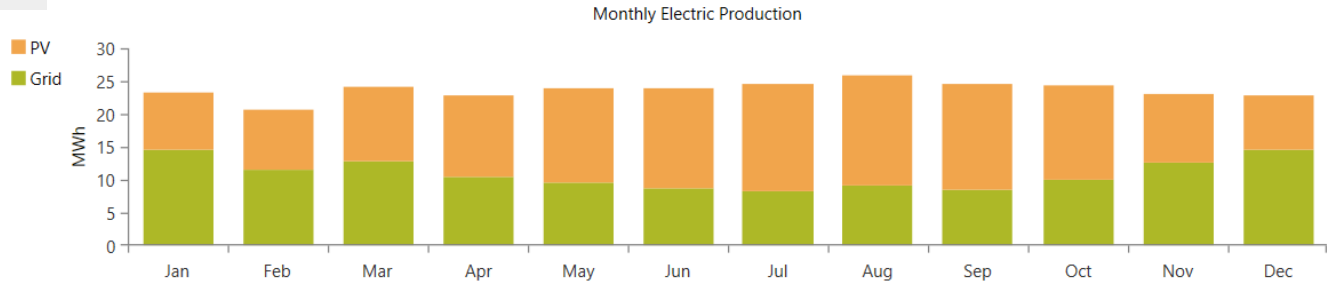
Production	kWh/yr	%
Generic flat plate PV	152,995	53.9
Grid Purchases	130,896	46.1
Total	283,891	100

Consumption	kWh/yr	%
AC Primary Load	255,500	93.0
DC Primary Load	0	0
Deferrable Load	0	0
Grid Sales	19,362	7.04
Total	274,862	100

Quantity	kWh/yr	%
Excess Electricity	1,452	0.511
Unmet Electric Load	0	0
Capacity Shortage	0	0

Quantity	Value	Units
Renewable Fraction	52.4	%
Max. Renew. Penetration	138	%

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Generic flat plate PV	$60,000.00	$0.00	$0.00	$0.00	$0.00	$60,000.00
Grid	$0.00	$0.00	$51,663.78	$0.00	$0.00	$51,663.78
System Converter	$7,550.00	$0.00	$0.00	$0.00	$0.00	$7,550.00
System	$67,550.00	$0.00	$51,663.78	$0.00	$0.00	$119,213.78



Architecture							Cost			
			PV (kW)	Grid (kW)	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)
				999,999		CC	$118,350	$0.0400	$10,220	$0.00
			100	999,999	75.5	CC	$119,214	$0.0375	$4,461	$67,550

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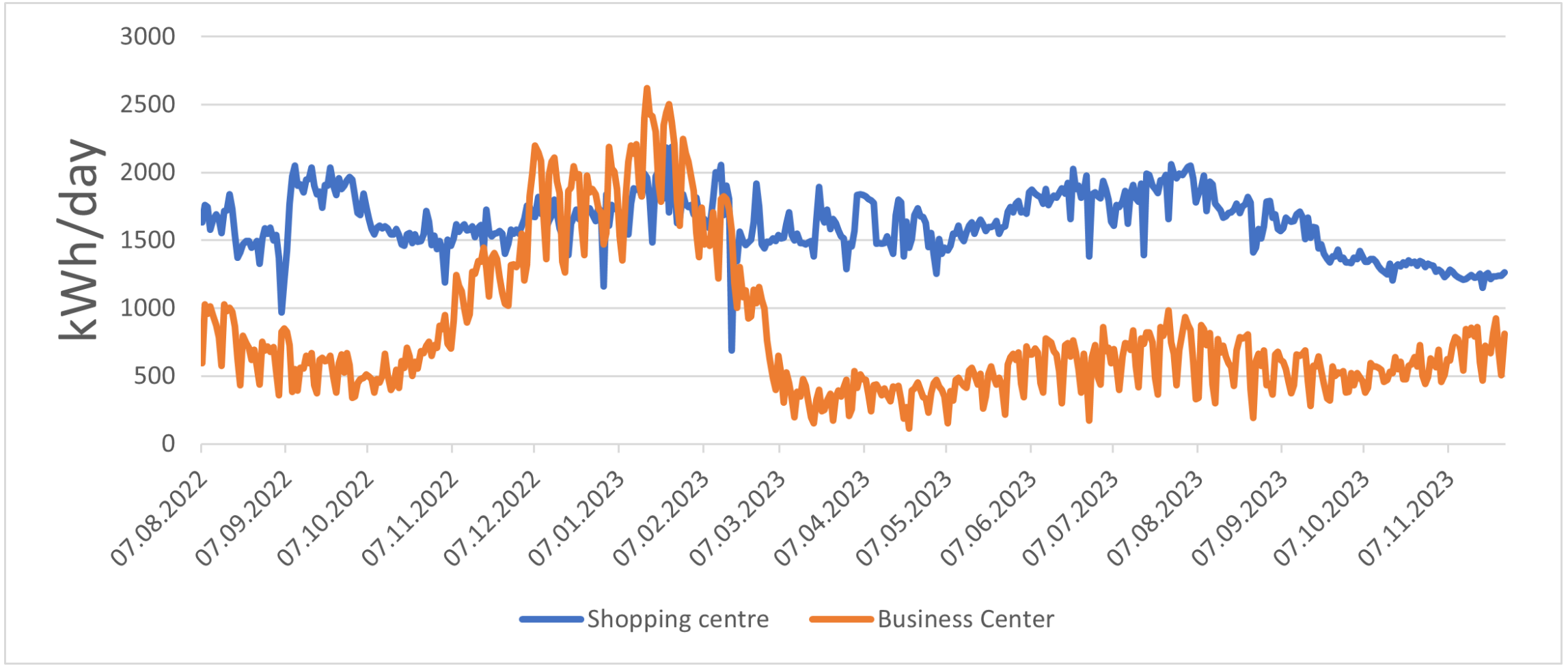
Daily Load - Business



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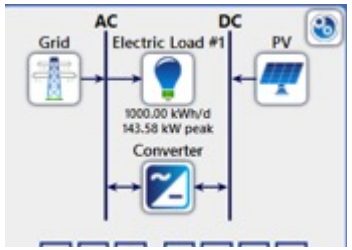
On grid System for Business buildings

Daily Load 1000 kWh/Day

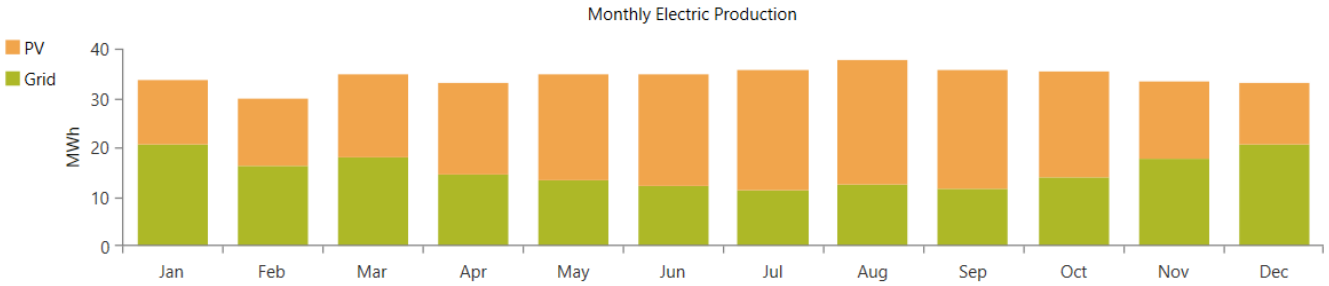


Production	kWh/yr	%
Generic flat plate PV	229,492	55.8
Grid Purchases	182,051	44.2
Total	411,544	100

Consumption	kWh/yr	%
AC Primary Load	365,000	91.2
DC Primary Load	0	0
Deferrable Load	0	0
Grid Sales	35,069	8.77
Total	400,069	100

Quantity	kWh/yr	%
Excess Electricity	0	0
Unmet Electric Load	0	0
Capacity Shortage	0	0

Quantity	Value	Units
Renewable Fraction	54.5	%
Max. Renew. Penetration	105	%



Architecture							Cost			
			PV (kW)	Grid (kW)	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)
			150	999,999	150	CC	$227,147	$0.0490	$10,289	$108,000
				999,999		CC	$295,876	$0.0700	$25,550	$0.00

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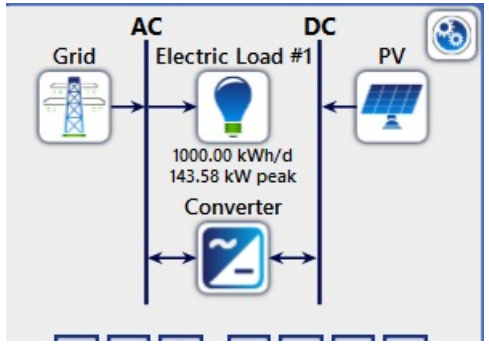
Simple Payback 7,1 yr



Winning System Architecture

- HOMER Cycle Charging
- Grid
- PV - 150 kW
- Converter - 150 kW

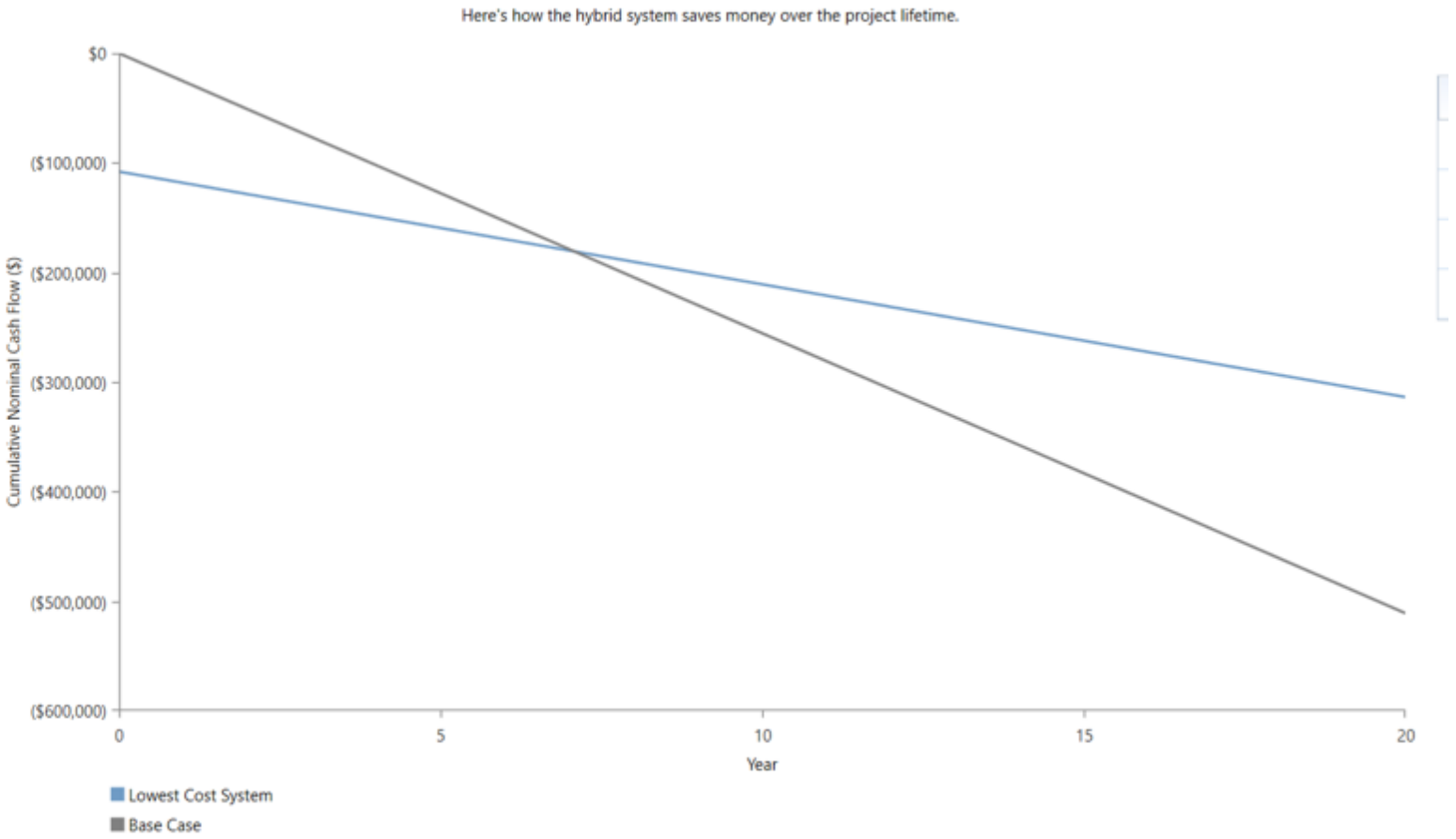
Base Case Architecture

- HOMER Cycle Charging
- Grid

Change Base Case

Economic Metrics

IRR	13%
ROI	9.1%
Simple Payback	7.1 yr



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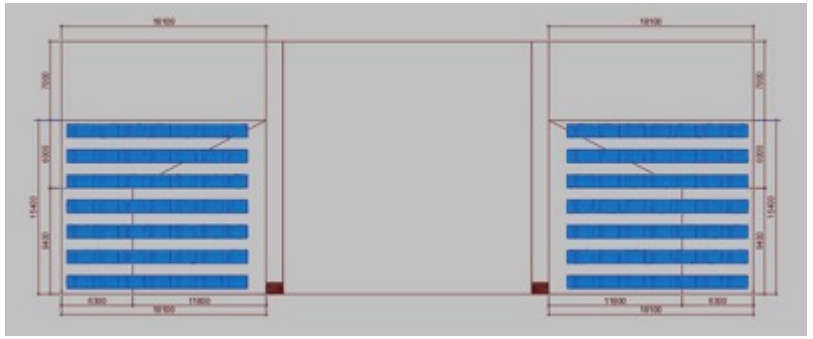
Sustainable Energy Connectivity in Central Asia

Assessment of power generation



МОЩНОСТЬ 54 КВТ

79294 кВтч/год

срок окупаемости 10 лет

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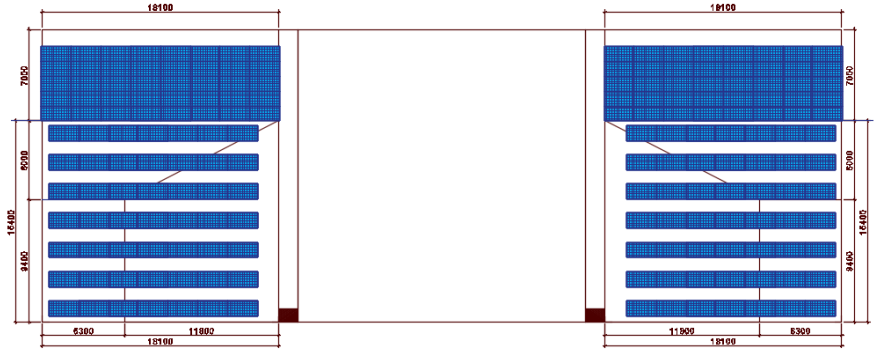
Sustainable Energy Connectivity in Central Asia

Assessment of power generation



МОЩНОСТЬ 90 КВТ

144327 кВтч/год

срок окупаемости 10 лет

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Thank You!

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