

Off-Grid Rooftop PV Power Plant Design for a Duplex Apartment on PV*SOL

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Introduction

- The aim of this project work is to simulate an off-grid rooftop PV power plant for a duplex apartment in the following coordinates:

Longitude	Latitude
37.50404415	35.86275261

Table 1: Coordinates of Duplex Apartment

This design will be done in two different ways:

- Manual calculation with block diagram that illustrates methodology of design which we have learned in the scope of EEE407.
- on PV*SOL 5.5(R2)

Location

- Coordinates show this address: Gedikli-Kozan/Adana/Turkey

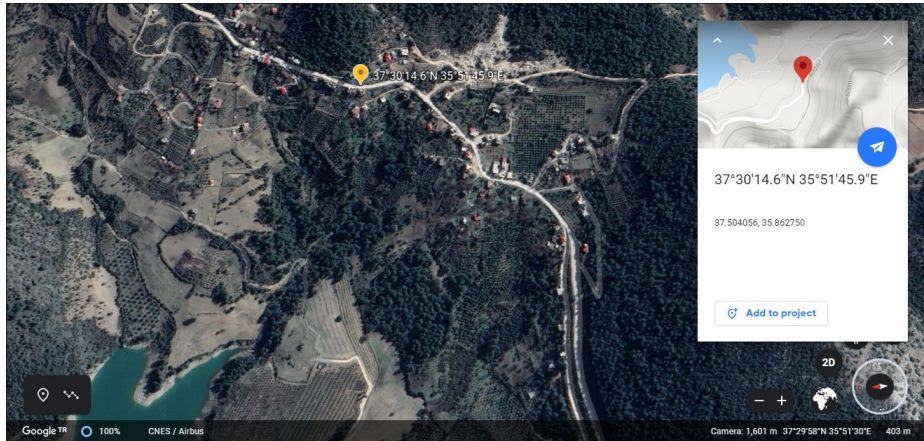


Figure 1: Location on Google Earth

The Duplex Apartment

- One person lives in this duplex apartment.
- Surface area belonging to the duplex apartment is 60 square meters.

Number of rooms:

- a hall
- a bedroom
- a guestroom
- a kitchen
- a cellar
- a bathroom and an en-suite bathroom

The Duplex Apartment

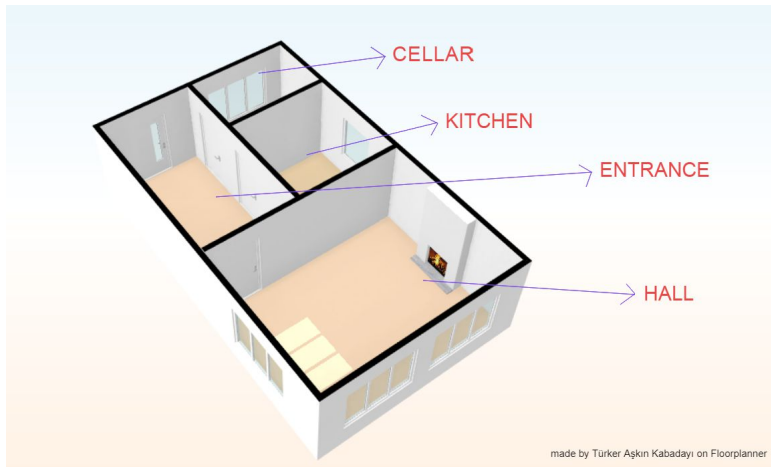


Figure 2: First Floor of the Duplex Apartment

The Duplex Apartment

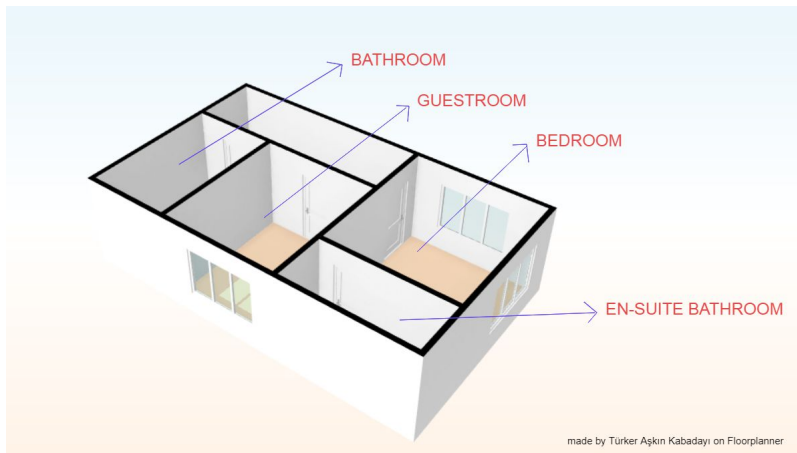


Figure 3: Second Floor of the Duplex Apartment

Climate Data

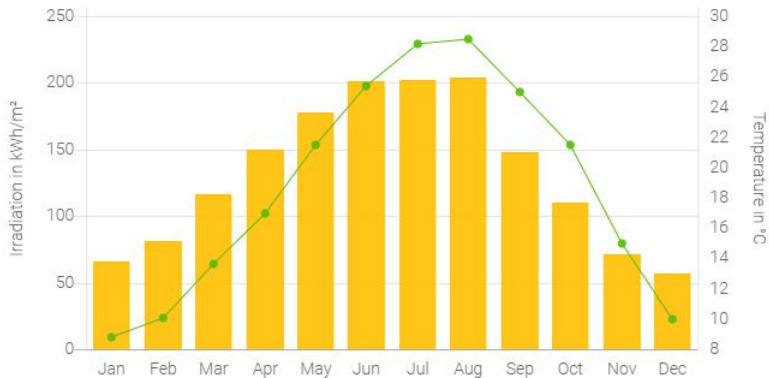


Figure 4: Climate Data during a Year

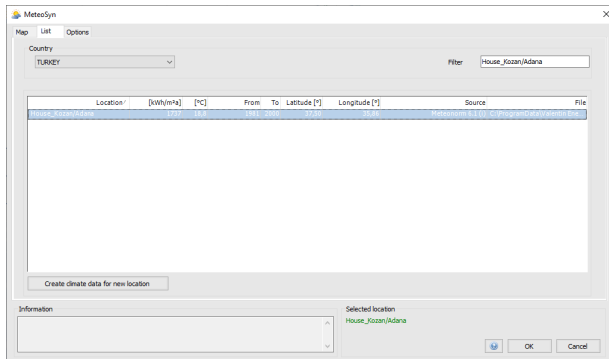


Figure 5: Average Climate Data per Year

Irradiation in kWh/m ²	1737
Avg. Temperature [°C]	18.8

Table 2: Average Climate Data per Year

*Climate datas PV * SOL 5.5 (R2) software and
<http://pvsol-online.valentin-software.com/> belongs to the site.*

SOLAR RESOURCE MAP

PHOTOVOLTAIC POWER POTENTIAL TURKEY

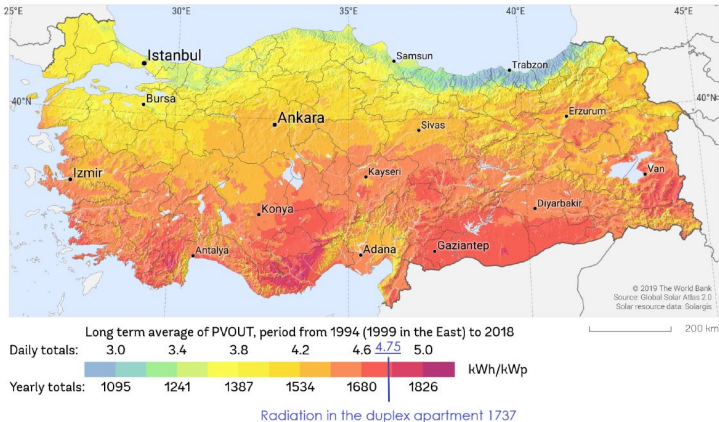


Figure 6: Insolation Map of Turkey

Manual Calculation

In this section manual calculations with block diagram showing the design methodology will be applied.

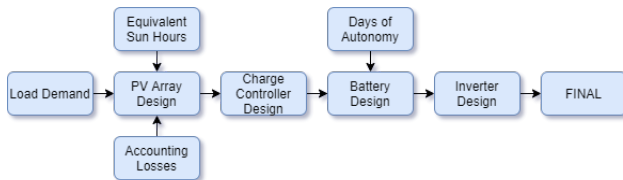


Figure 7: Block Diagram of Design Methodology

Manual Calculation

Equipment

- Inverter Efficiency=0.98
- Battery System=0.90
- PV Module Characteristics:

$P (W_p)$	$V_{mpp} (V)$	$I_{mpp} (A)$	$V_{oc} (V)$	$I_{sc} (A)$
300	36.7	8.17	43.6	8.71

- MPPT Charge Controller Specifications:

$V_{max} (V)$	$I_{max} (A)$	$V_{operational} (V)$
150	40	12/24

- Battery Features:

DoD (%)	$V_{battery} (V)$	$C_{battery} (Ah)$
70	12	180

Manual Calculation

Load Demand

Load demand is the first element of the system and is very important. Because if it is analyzed incorrectly, missing or more panels can be used in the system.

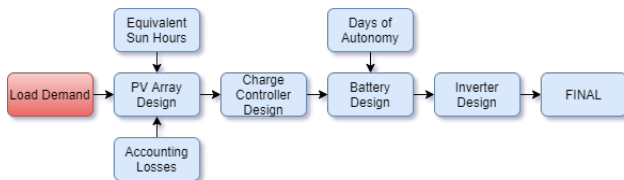


Figure 8: Step of Design Methodology

Manual Calculation

Load Demand

Electrical Needs of the House					
Item	Type	Quantity	Power per Item (W)	Time of Use per Day	Consumption (kWh/Day)
Washing Machine	AC	1	500	1	0.5
Deep Freezer	AC	1	19	24	0.456
Laptop Computer	AC	1	50	2	0.1
Dishwasher	AC	1	1200	1	1.2
Domestic Water Pump	AC	1	200	1	0.2
Refrigerator	AC	1	100	24	2.4
Air Conditioner 12.000 Btu A+++	AC	1	1000	3	3
Philips Hue Smart Bulb	AC	10	8	7	0.56
Electric Oven	AC	1	1550	1	1.55
49 Inch LED TV	AC	1	85	2	0.17
Apple TV	AC	1	3	1	0.003
Xbox One	AC	1	50	1	0.05
Phone Charger	AC	1	4	1	0.004
Power consumption datas belong to daftlogic.com			TOTAL		10.193
////////////////////////////////////			AC POWER (kW)		4841
Designed by Türker Aşkın Kabadayı on Microsoft Excel			DC POWER (kW)		0

Figure 9: Electrical needs of the duplex apartment

Manual Calculation

Load Demand

Formula-Consumption per Item

$$\text{Consumption per Item} = \text{Quantity} \times \text{Power per Item} \times \text{Time of Use}$$

Example-Consumption of Refrigerator

$$1 \times 100 \text{ W} \times 24 \text{ h/day} = 2.4 \text{ kWh/day}$$

$$\text{Total Consumption} = 10.193 \text{ kWh/day}$$

Manual Calculation

Equivalent Sun Hours and Accounting Losses

Equivalent Sun Hours=4.75 hours
Accounting Losses are ignored

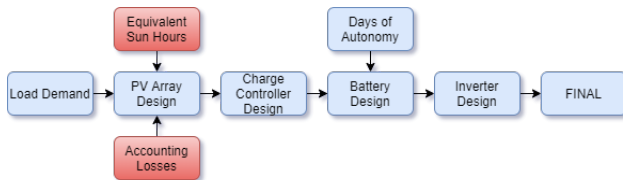


Figure 10: Step of Design Methodology

Manual Calculation

PV Panels Design

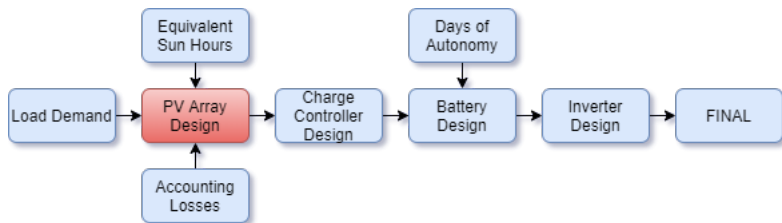


Figure 11: Step of Design Methodology

Manual Calculation

PV Panels Design

Selection: Polycrystalline Solar Cell

Polycrystalline solar panel can be called a full market product. It is balanced in terms of both efficiency and unit cost and it is the cheapest solar panel. Many solar power plants are built with polycrystalline solar panels. Almost 68 percent of the market uses polycrystalline solar cells. Also, it is not affected by the temperature changes in the air. The efficiency rates of these solar cells are around 15 percent.

The main reason for choosing a polycrystalline solar cell is that Adana's climate (dust and hot weather) and its low-cost.

This data belongs to the website of Ayges Technology Company.

Manual Calculation

PV Panels Design

Manufacturer: Chinaland Solar Energy Co., Ltd.

Model: CHN300-72P

Rated Max. Power (P_{max})	300 W
Max. Power Voltage (V_{mp})	36.7 V
Max. Power Current (I_{mp})	8.17 A
Open Circuit Voltage (V_{oc})	43.6 V
Short Circuit Current (I_{sc})	8.71 A

Table 3: Parameters of PV Panel

Manual Calculation

PV Panels Design

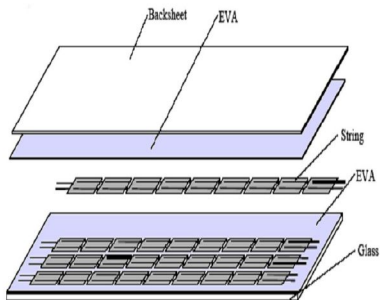


Figure 12: CHN300-72P

Manual Calculation

PV Panels Design

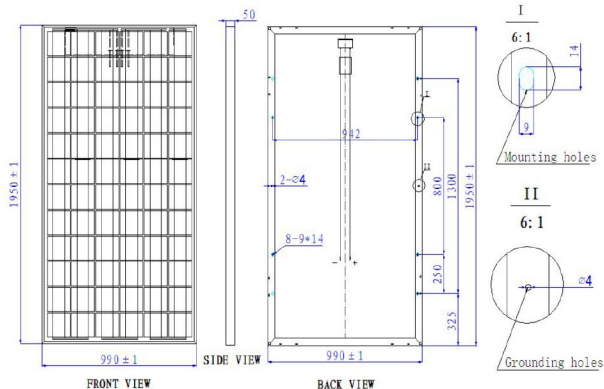


Figure 13: Dimensional Characteristics

Manual Calculation

PV Panels Design

$$E_{total} = (10.193 \text{ kWh/day}) / (0.98 \times 0.90) = 11.556 \text{ kWh/day}$$

$$\text{Minimum } W_p = (11.556 \text{ kWh/day}) / (4.75 \text{ h/day}) = 2.433 \text{ kW}$$

$$\text{Numbers of Panels} = 2.433 \text{ kW} / 300 \text{ W} = 8.11 = 9 \text{ Panels}$$

Manual Calculation

PV Panels Design

Parallel

Maximum Current $I_{max} = 8.71 \text{ A} \times 3 = 26.13 \text{ A}$ (smaller than 40 A)

Series

Maximum Voltage $V_{max} = 43.6 \text{ V} \times 3 = 130.8 \text{ V}$ (smaller than 150 V)

Panels will be install in 3 parallel sticks consisting of 3 series panels.

Configuration = 3×3

Manual Calculation

Charge Controller Design

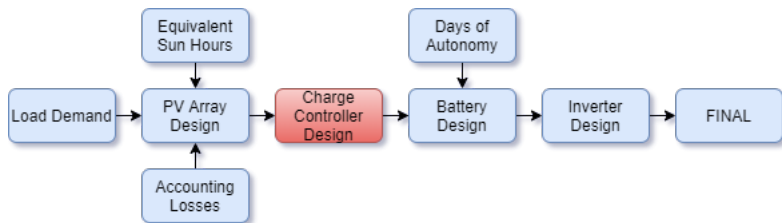


Figure 14: Step of Design Methodology

Manual Calculation

Charge Controller Design

Manufacturer: Epever

Model: 4215BN

$V_{max}(V)$	150V
$I_{max}(A)$	40A
$V_{operational}(V)$	12/24V

Table 4: MPPT Charge Controller Specifications

Manual Calculation

Charge Controller Design



Figure 15: 4215BN

Manual Calculation

Days of Autonomy

Days of Autonomy=2

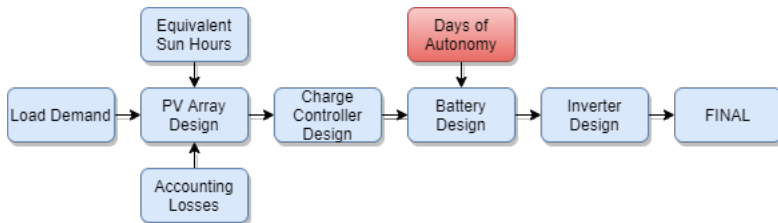


Figure 16: Step of Design Methodology

Manual Calculation

Battery Design

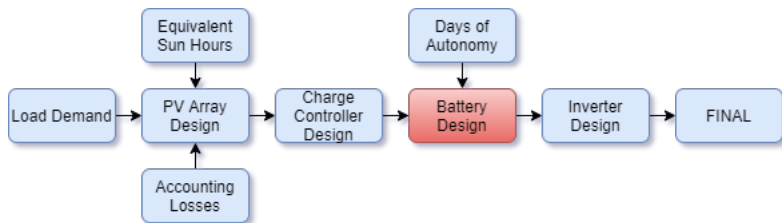


Figure 17: Step of Design Methodology

Manual Calculation

Battery Design

Manufacturer: DETA

Model: 12VSolar190

DoD(%)	70
$V_{battery}$	12V
$C_{battery}$	180Ah

Manual Calculation

Battery Design



Figure 18: 12VSolar190

Manual Calculation

Battery Design

$$\text{Minimum } C_{\text{battery}} = (11.556 \text{ kWh/day} / (0.7 \times 24)) \times 2 = 1375.71 \text{ Ah}$$

$$\text{Num. of batt. in series} = 24 \text{ V} / 12 \text{ V} = 2 \text{ batteries}$$

$$\text{Num. of batt. in parallel} = 1375.71 \text{ Ah} / 180 \text{ Ah} = 7.64 = 8 \text{ batteries}$$

$$2 \times 8 = 16 \text{ Batteries}$$

Manual Calculation

Inverter Design

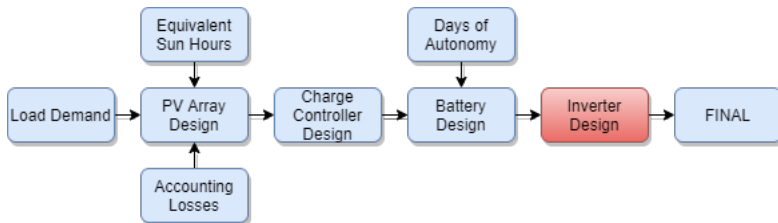


Figure 19: Step of Design Methodology

Manual Calculation

Inverter Design

Manufacturer: Essen Solar

Model: FSP302PV-230F-24

Efficiency	98%
Opr. Voltage	24V

Manual Calculation

Inverter Design



Figure 20: FSP302PV-230F-24

$$AC\ Power = 4.841\ kW$$

$$\begin{aligned} \text{Minimum Nominal Power Rating} \\ &= (4.841\ kW / 0.98) \\ &= 4.939\ kW \end{aligned}$$

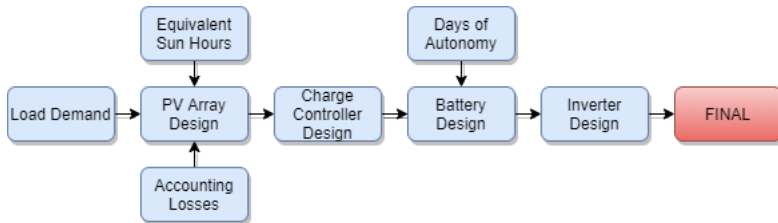


Figure 21: Step of Design Methodology

Design on PV*SOL

Why PV*SOL?

Climate Data

The MeteoSyn Climate database contains about 450 climate data provided by Deutsche Wetterdienst for Germany for 1981-2010 and more than 8,000 climate data available for 1986-2005 in the world and meteonorm 7.1 base. Climate data can be easily selected on the map.

Components Database

The broad base module and inverter database can contain 13 000 modules and 3 100 inverter records and the database automatically updates itself. Records to the database are updated by manufacturers. It can create favorite lists to achieve faster results.

These datas <http://pvsol-online.valentin-software.com/> belong to the site.

Design on PV*SOL

Why PV*SOL?

Battery Storage

Select the battery to be used in your own battery storage system, and determine and design the inverter and charge controller.

With safe and approved simulation results, you can evaluate your self-consumption and independence rate.

Photo Plan

With the roof exploration / measurement software integrated into Photo Plan, the dimensions of the roof can be calculated easily and quickly. By visualizing a photovoltaic system to be installed on the roof with reference points and the required roof dimensions can be provided from the software. With the roof exploration / measurement software integrated into Photo Plan, the dimensions of the roof can be calculated easily and quickly. By visualizing a photovoltaic system to be installed on the roof with reference points and the required roof dimensions can be provided from the software.

These datas <http://pvsol-online.valentin-software.com/> belong to the site.

Design on PV*SOL

Why PV*SOL?

Simulation Results

The result summary presents detailed simulation results, tables and cash flows. With the energy balance sheet, all income and losses of a photovoltaic system can be evaluated. All results and system details can be presented as desired.

Software Maintenance

Software maintenance involves updating both the software and databases. One year maintenance fee is included in the software fee from the date of purchase.

These datas <http://pvsol-online.valentin-software.com/> belong to the site.

Design on PV*SOL

Climate Data

The meteorological data of the location marked on the map are loaded.

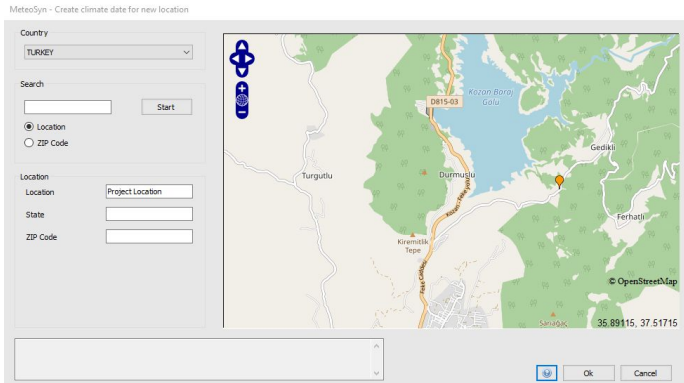


Figure 22: Climate Data Selection on PV*SOL

Individual appliance models:

- User-Independent Appliance
- User-Dependent Appliance
- Short-time Use Appliance
- Light

Design on PV*SOL

Consumption

Individual Appliances

Name: Deep Freezer

Model: User-Independent Appliance (eg Fridge,...)

Output [W]: 19

Stand-by Input [W]: 0.0

Annual Energy Requirement [kWh]: 166.4400

Operating Times

☒ Appliance Runs Constantly

☐ Runs Every: 2 Hours

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Operating Time: 365 Days

Load

Save

Graph

OK

Cancel

Figure 23: Example/User-Independent Appliance

Design on PV*SOL

Consumption

Individual Appliances

Name: Washing Machine

Model: User-Dependent Appliance (eg TV,...)

Output [W]: 500

Stand-by Input [W]: 0,0

Operating Times

☒ All Days the Same

Appliance switches on during the selected operating times as follows

☐ No other Restrictions

☒ Nighttime only

☐ Daytime only

Operating Time: 365 Days

Buttons: Load, Save, Graph, OK, Cancel

Figure 24: Example/User-Dependent Appliance

Design on PV*SOL

Consumption

Individual Appliances

Name: Hair Dryer

Model: Short-Time Use Appliance (eg Coffee Machine,...)

Output [W]: 2200,00

Stand-by Input [W]: 0,0

Operating Times

Period of Use [mins.]: 3 per use

Hourly Use

☒ All Days the Same

Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Operating Time: 365 Days

Buttons: Load, Save, Graph, OK, Cancel

Figure 25: Example/Short-Time Use Appliance

The list does not consist this load.

Design on PV*SOL

Consumption

Individual Appliances

Name: Philips Hue Smart Bulb

Model: Light

Output [W]: 8

Stand-by Input [W]: 0.0

Operating Times

☒ All Days the Same

Appliance switches on during the selected operating times as follows

☒ No other Restrictions

☐ Full Darkness

☐ Dusk/Dawn

☐ Dull Weather

Operating Time: 365 Days

Buttons: Load, Save, Graph, OK, Cancel

Figure 26: Example/Light

Design on PV*SOL

Consumption

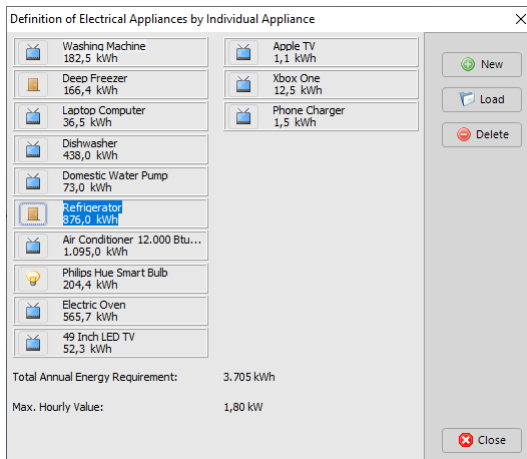


Figure 27: Consumption/Appliances List

Design on PV*SOL

PV Array Design

The screenshot shows the 'Technical Data: Array' window in PV*SOL. The window is divided into several sections for configuring the PV array. On the right side, there are buttons for 'Losses', 'Check', 'System Diagram', and 'Simulation'. At the bottom, there are buttons for 'OK' and 'Cancel', and a status bar with tabs for 'System', 'PV Array', 'Stand-Alone Inverter', 'Battery', and 'Charge Controller'.

Reference: Array Name

PV Module: Solar Europa Ltd. CHN300-72P

Create preview of roof layout with Photo Plan

Installation Type:

- ☐ Free-Standing
- ☒ With Ventilation
- ☐ Without Ventilation

Generator Output:

- ☒ Define Module Number No. of Modules: 18
- ☐ Determine Output from Roof Area

Roof Parameters

Resulting PV Array Output: 5,40 kWp

Orientation:

- ☐ Set Inclination
- ☐ Single Axis Tracking
- ☒ Dual Axis Tracking

Orientation (Azimuth): 0,0 °

Inclination (Tilt Angle): 70,0 °

Irradiation: 1.364 kWh/m²a

Configuration:

No. of Modules in Series: 1 Configuration

No. of Parallel Strings: 18

MPP Voltage (STC) [V]: 36,7

Graph

Figure 28: PV Array

Design on PV*SOL

Battery Design

Technical Data: Battery

Battery

Delta 12 V Solar 190
C:\ProgramData\...\Delta_12_V_180_Ah.acc

No.:

No in Series:

Charge Condition at Simulation Start:

or ☒ Preliminary Simulation to Establish Start Condition

Battery Voltage: V

Total Battery Capacity: kWh

Appliances Max. Daily Consumption: kWh

MPP Voltages (STC) [V]
Array 1:

Losses

Check

System Diagram

Simulation

OK

Cancel

System PV Array Stand-Alone Inverter **Battery** Charge Controller

Figure 29: Battery

Design on PV*SOL

Charge Controller Design

Technical Data: Charge Controller

Lower Battery Discharge Threshold: % (*)
(* ref. to Nom. Battery Capacity)

Info on Sizing of Charge Controller

Short Circuit Current at 1000 W/m² Irradiation and 50°C Module Temp.: A

Max. Appliances Current calculated from average Hourly Values: A

Losses

Check

System Diagram

Simulation

OK

Cancel

System PV Array Stand-Alone Inverter Battery **Charge Controller**

Figure 30: Charge Controller

Design on PV*SOL

The screenshot shows the 'Stand-Alone Inverter' configuration window. The title bar indicates the file path: 'C:\...\ASP Top Class TC 20 24 2 kW 24 V.wra'. The window contains several input fields for configuring the inverter's parameters. On the right side, there are buttons for 'Losses', 'Check', 'System Diagram', and 'Simulation'. At the bottom, there are 'OK' and 'Cancel' buttons. The bottom status bar shows tabs for 'System', 'PV Array', 'Stand-Alone Inverter' (which is currently selected), 'Battery', and 'Charge Controller'.

Parameter	Value	Unit
AC Power Rating:	2,00	kW
Max. Power - Appliances:	1,80	kW
Installed PV Output:	5,40	kW
Nom. DC Voltage:	24,0	V
Battery Voltage:	24,0	V

Figure 31: Stand-Alone Inverter

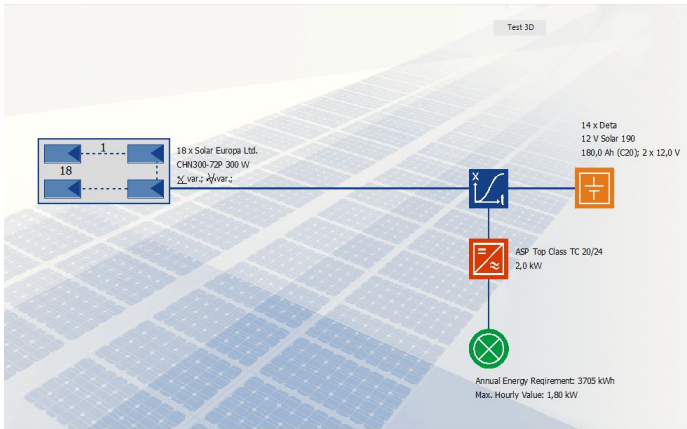


Figure 32: System

Design on PV*SOL

Report

Please enter under Options-> Settings



Project Name: Gartenlaube
Variant Reference: System Variant

27.05.2020

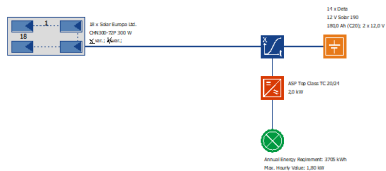


Figure 33: Report/Page 1

Design on PV*SOL

Report

Location:	House_Kozan/Adana
Climate Data Record:	House_Kozan/Adana (1981-2000)
PV Output:	5,40 kWp
Gross/Active PV Surface Area:	34,75 / 34,60 m²
<hr/>	
PV Array Irradiation:	47.178 kWh
Energy Produced by PV Array:	4.906,8 kWh
Consumption Requirement:	3.704,9 kWh
Consumption Covered by Solar Energy:	2.961,5 kWh
Consumption Not Covered by System:	743,5 kWh
<hr/>	
Solar Fraction:	79,9 %
Performance Ratio:	40,2 %
Specific Annual Yield:	548,4 kWh/kWp
CO2 Emissions Avoided:	1.819 kg/a
System Efficiency:	6,3 %
PV Array Efficiency:	10,4 %
<hr/>	
<small>The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system.</small>	
<hr/>	
PV*SOL Expert 5.5 (R2)	1

Figure 34: Report/Page 2

Problem:

Looking at the second part of the report, *consumption not covered by system=743.5 kWh* will be seen.

This cannot be tolerated because the system is off-grid.

Solution

Back up generator can be used to reset this value.

Design on PV*SOL

Technical Data: Back-up Generator

Power Rating (AC): 3,000 kW

Min. Power Output: 0,500 kW

Fuel Consumption: 0,35 l/kWh

Max. Power - Appliances: 1,80 kW

Total Battery Capacity: 30,24 kWh

Battery Charger

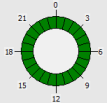
AC/DC Conversion Efficiency: 85,0 %

Switch On Threshold: 30 % (*)

Switch Off Threshold: 90 % (*)

(*) ref. to Nom. Battery Capacity

Timings for Battery Charging up to Switch-off Threshold:



Losses

Check

System Diagram

Simulation

OK

Cancel

System PV Array Stand-Alone Inverter Battery Charge Controller Back-up Generator

Figure 35: Back-up Generator

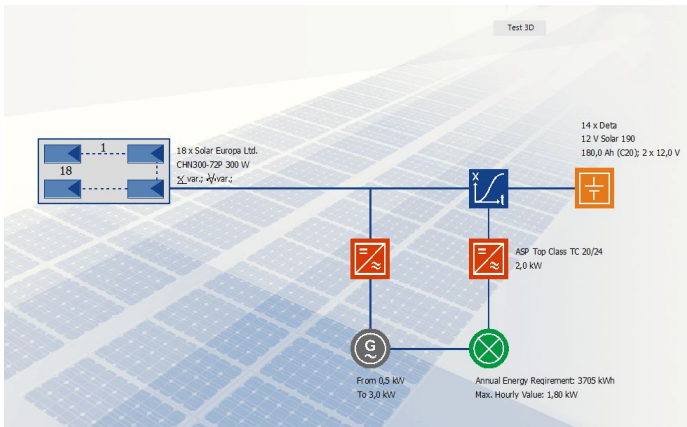


Figure 36: System

Design on PV*SOL

Report

Please enter under Options-> Settings



Project Name: Gartenlaube
Variant Reference: System Variant

27.05.2020

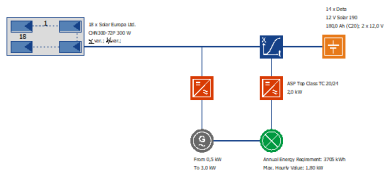


Figure 37: Report/Page 1

Design on PV*SOL

Report

Location:	House_Kozan/Adana
Climate Data Record:	House_Kozan/Adana (1981-2000)
PV Output:	5,40 kWp
Gross/Active PV Surface Area:	34,75 / 34,60 m ²
<hr/>	
PV Array Irradiation:	47.178 kWh
Energy Produced by PV Array:	4.981,7 kWh
Energy Produced by Back-up Generator:	1.141,9 kWh
Consumption Requirement:	3.704,9 kWh
Consumption Covered by Solar Energy:	2.949,5 kWh
Consumption Covered by Back-up Generator:	755,46 kWh
Consumption Not Covered by System:	0,0 kWh
<hr/>	
Solar Fraction:	79,6 %
Performance Ratio:	40,1 %
Specific Annual Yield:	546,2 kWh/kWp
CO2 Emissions Avoided:	2.675 kg/a
System Efficiency:	6,3 %
PV Array Efficiency:	10,6 %
<hr/>	
<small>The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system.</small>	
<hr/>	
PV*SOL Expert 5.5 (R2)	
1	

Figure 38: Report/Page 2

Design on PV*SOL

3d Visualization

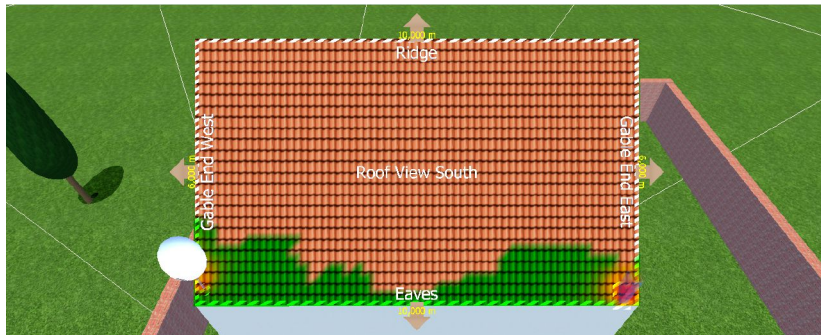


Figure 39: Shade Frequency Distribution

Design on PV*SOL

3d Visualization

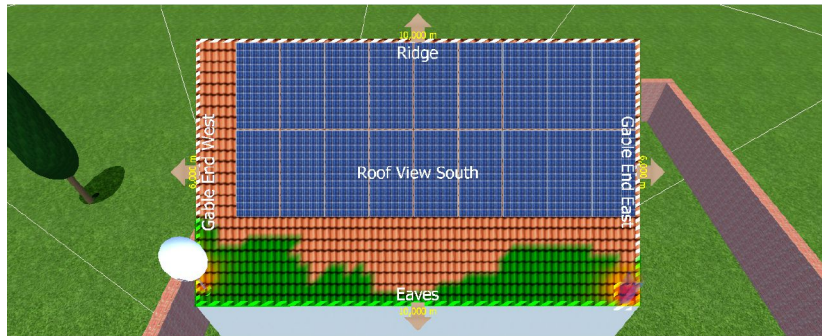


Figure 40: Shade Frequency Distribution with PV Panels

Design on PV*SOL

3d Visualization

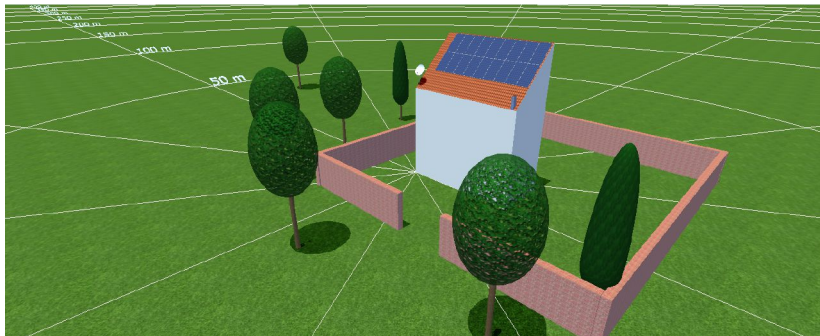
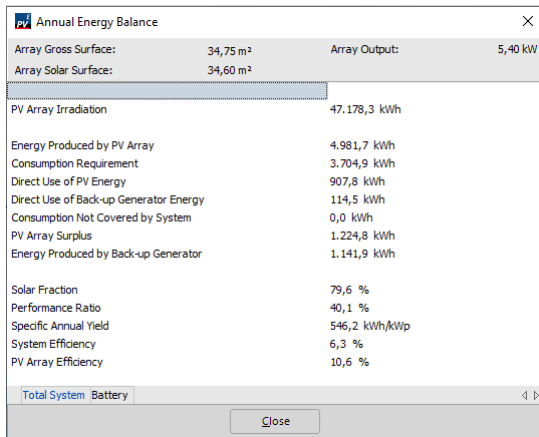


Figure 41: South East View

Design on PV*SOL

System Analysis



Annual Energy Balance	
Array Gross Surface:	34,75 m²
Array Solar Surface:	34,60 m²
Array Output:	5,40 kW
PV Array Irradiation 47.178,3 kWh	
Energy Produced by PV Array	4.981,7 kWh
Consumption Requirement	3.704,9 kWh
Direct Use of PV Energy	907,8 kWh
Direct Use of Back-up Generator Energy	114,5 kWh
Consumption Not Covered by System	0,0 kWh
PV Array Surplus	1.224,8 kWh
Energy Produced by Back-up Generator	1.141,9 kWh
Solar Fraction	79,6 %
Performance Ratio	40,1 %
Specific Annual Yield	546,2 kWh/kWp
System Efficiency	6,3 %
PV Array Efficiency	10,6 %

Total System Battery

Close

Figure 42: Annual Energy Balance/Total System

Design on PV*SOL

System Analysis

pv Annual Energy Balance				×
Array Gross Surface:	34,75 m ²	Array Output:	5,40 kW	
Array Solar Surface:	34,60 m ²			
Battery Discharge		3.107,0 kWh		
Battery Solar Discharge		2.389,4 kWh		
Battery Charge		3.722,4 kWh		
Battery Solar Charge		2.849,1 kWh		
Battery Losses		615,4 kWh		
Battery Balance Gain/Loss		-0,1 kWh		
Battery Efficiency		83,5 %		
Charge Condition at Simulation Start:		69 %		
Charge Condition at Simulation End:		69 %		
Back-up Generator Fuel Consumption		399,7 l		
Total System Battery				◀ ▶
Close				

Figure 43: Annual Energy Balance/Battery

Design on PV*SOL

System Analysis

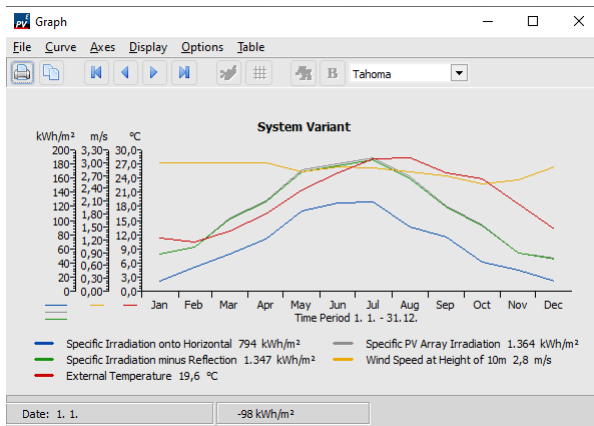


Figure 44: Climate Data Analysis

Design on PV*SOL

System Analysis

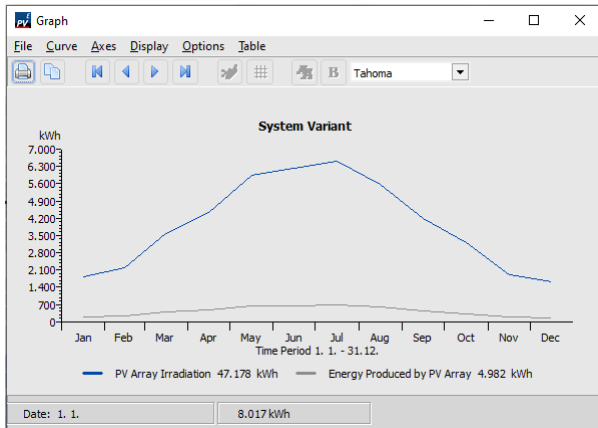


Figure 45: PV Array Irradiation-Energy Produced by PV Array Analysis

Design on PV*SOL

System Analysis

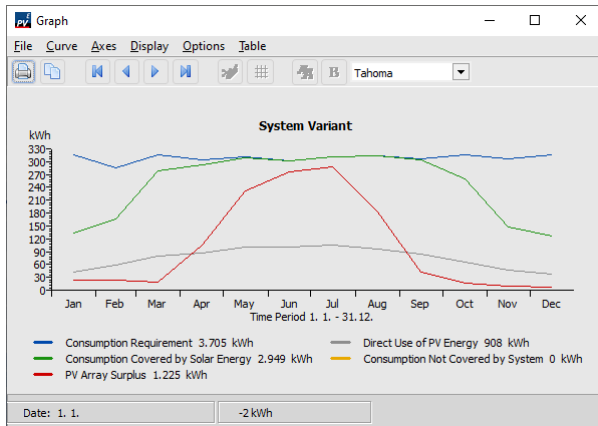


Figure 46: Consumption Analysis

Design on PV*SOL

System Analysis

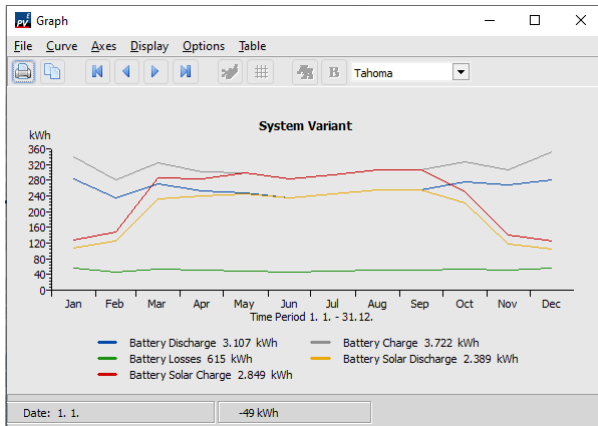


Figure 47: Battery Analysis

Design on PV*SOL

System Analysis

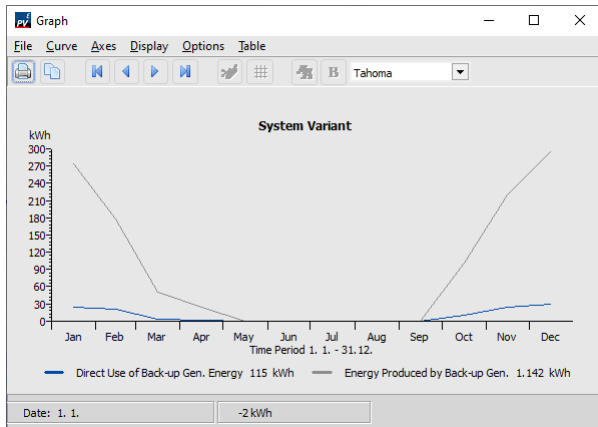


Figure 48: Back-up Generator Analysis

Design on PV*SOL

System Analysis

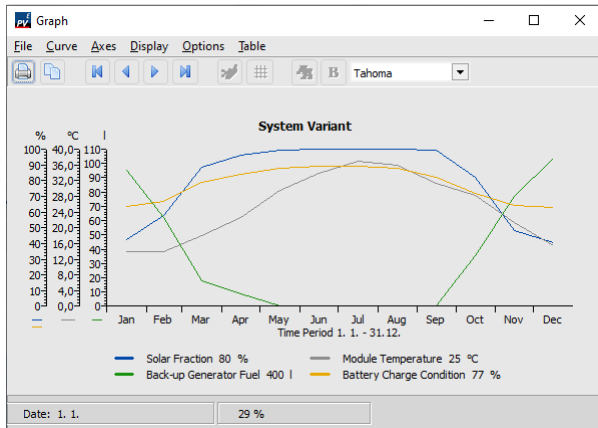


Figure 49: Total System Analysis

List of Turkish Banks Loan Support

- Türkiye İis Bankası
- Garanti BBVA
- Halkbank
- Türkiye Finans

Turkish Banks Loan Support

IS Bankasi

Installed power less than 5 MW&Electricity production based on solar, wind and other renewable energy sources

Features

- Unlicensed electricity production projects are exempted from the obligation to obtain a license from EMRA and to establish a company.
- For the surplus part produced, purchase guarantee is given by the relevant electricity network operator from the tariff determined for a period of 10 years. This enables investors to generate as much electricity as they need, and to generate income by selling surplus production to the network operator.
- Documents pertaining to all legal approvals / permits required for unlicensed energy projects, especially the agreements signed with the network operator prior to credit disbursement, and the policy showing that the facility is insured should be submitted to Bank.
- Disbursements made in foreign currencies are limited to USD and EUR.

[1]

Turkish Banks Loan Support

Garanti BBVA

Installed power less than 1 MW&Electricity production from solar energy.

Features

- Real or legal enterprises that have at least one consumption facility, that is, electricity subscription and who want to produce unlicensed electricity from solar energy 1MW and below can establish PV plant without license.
- Additional conditions, including the submission of the Connection Agreement signed with the electricity grid operator, must be met at the time of credit issuance.
- Credit can be used with a grace period up to 2 years and a payment plan suitable for cash flow.
- The loan can be used in TL or foreign currency.
- The excess electricity you produce is guaranteed to be purchased over the tariff determined for 10 years with the legal regulation.

[2]

Turkish Banks Loan Support

Halkbank

Installed power less than 1 MW&Electricity production from solar energy and wind energ.

Features

- Those who want to produce unlicensed electricity should be electricity subscribers real and legal persons.
- Necessary licenses and permits have been obtained to obtain credit and the project must be approved.
- Investment loan 2 years grace period 7 years term.
- Business loan 2 years grace period 7 years term.
- The loan can be used in TL or foreign currency.

[3]

Turkish Banks Loan Support

Türkiye Finans

Installed power less than 1 MW&Electricity production based on solar, wind and other renewable energy sources

Features

- Those who want to produce unlicensed electricity should be electricity subscribers real and legal persons.
- Low cost and advantageous profit rates with 10% discount on signage prices in TL and foreign currency loans for Corporate and Commercial customers
- As a result of the project-based evaluation, up to 1 year of non-refundable, up to 5 years in total, the opportunity to make appropriate term.
- Fixed cost advantage that protects your business against economic volatility.
- The loan can be used in TL or foreign currency.

[4]

Feasibility Study

Components of Feasibility

- Project Scope
- Market Feasibility(N/A)
- Technical Feasibility
- Financial Feasibility
- Results

N/A(This section has been left blank since no energy was produced to be sold.)

Feasibility Study

Project Scope

An off-grid rooftop PV power plant for a duplex apartment in the following coordinates and features:

- 37.50404415 35.86275261
- Surface area belonging to the duplex apartment is 60 square meters (Rectangle: 6 m x 10 m)

Feasibility Study

Technical Feasibility

The panel system, which gives efficient outputs as a result of simulation, will be installed on the roof.

Materials Needed:

- PV Panels
- Batteries
- Charge Controller
- Inverter
- Cables
- Measurement Equipments
- a Simulate Software(PV*SOL)
- Climate Data

Feasibility Study

Financial Feasibility

ELECTRIC BILL			
CONSUMPTION DATA			
Daytime Index (kWh)	Puant Index (kWh)	Night Index (kWh)	Total (kWh)
51.6	158.4	95.7	305.70
BILL DETAILS			
Consumption (kWh)			305.7
Unit Price			₺ 0.574
Energy Consumption Price			₺ 175.48
Taxes&Funds			
Energy Fund+TRT+etc.			₺ 14.04
KDV %18 (Tax Assessment ECP+EF+TRT+etc)			₺ 34.11

<u>Bill Amount</u>			<u>₺ 223.63</u>
////////////////////////////////////			
Unit price, taxes&funds etc. values belong to a sample invoice of Enerjisa Company.			
////////////////////////////////////			
Designed by Türker Aşkın Kabadayı on Microsoft Excel for EEE407 Project.			

Figure 50: Electric Bill

Feasibility Study

Financial Feasibility

COST REPORT																	
Appliance	Manufacturer	Model	Quantity	Unit Price	Price												
PV Panel	Chinaland Solar Energy	CHN300-72P	9	\$ 143.40	\$ 1,290.60												
MPPT Charge Cont.	Epever	4215BN	1	\$ 178.64	\$ 178.64												
Battery	DETA	12V Solar 190	16	\$ 179.99	\$ 2,879.84												
Off-Grid Inverter	Essen Solar	FSP302PV-230F-24	1	\$ 309.00	\$ 309.00												
Another (cables, installation equipment etc.)					\$ 30.00												
Total Price					\$ 4,688.08												
Total Price					₺ 32,744.36												
<div><h3>Cost Pie Chart</h3><table><tr><th>Category</th><th>Price (\$)</th></tr><tr><td>Batteries</td><td>3,039.84</td></tr><tr><td>PV Panels</td><td>1,290.60</td></tr><tr><td>Charge Cn.</td><td>178.64</td></tr><tr><td>Inverter</td><td>309.00</td></tr><tr><td>Others</td><td>30.00</td></tr></table></div>						Category	Price (\$)	Batteries	3,039.84	PV Panels	1,290.60	Charge Cn.	178.64	Inverter	309.00	Others	30.00
Category	Price (\$)																
Batteries	3,039.84																
PV Panels	1,290.60																
Charge Cn.	178.64																
Inverter	309.00																
Others	30.00																
Exchange Rate (1 USD = 6.9846 TL)																	
Designed by Türker Aşkın Kabadayı on Microsoft Excel for EEE407 Project.																	

Figure 51: Cost Report

Feasibility Study

Financial Feasibility

With a simple calculation, how many years the system will payback for itself is found as follows:

$$32,744.10 \text{ tl} / (223.63 \text{ tl} \times 12) = 12.2$$

12 years

Feasibility Study

Financial Feasibility on PV*SOL

Please enter under Options-> Settings

PV*SOL Expert 5.5 (R2)

Gartenlaube



Variant Reference: System Variant

Date: 28.05.2020

-Economic Efficiency Calculation-

System

PV Output:	5,400 kWp
Gross PV Surface Area:	34,75 m ²
Back-up Generator:	3,00 kW

Electricity Balance

Appliances - Requirement:	3.705 kWh
PV Array Generated Energy:	4.982 kWh
Back-up Generator Energy:	1.142 kWh

Fuel Costs

Specific Fuel Costs:	1,50 ?/Liter
----------------------	--------------

Figure 52: Economic Efficiency Calculation

Feasibility Study

Financial Feasibility on PV*SOL

Economic Efficiency Parameters

Lifespan of Modules:	25 Years
Lifespan of Electronics:	25 Years
Lifespan of Battery:	5 Years
Lifespan of Back-up Generator:	25 Years
Price Increase Rate for Battery:	0 %
Interest on Capital:	4,7 %
Price Increase Rate for Service Costs:	2,0 %
Price Increase Rate for Fuel Costs:	3,0 %

Costs (Cash Value)

PV System Investment:	-41.035 ?
PV Modules:	-16.800 ?
Electronics:	-5.600 ?
Battery:	-18.635 ?
Back-up Generator Investment:	-1.200 ?
PV System Subsidy:	0 ?
PV System Running Costs:	0 ?
Back-up Generator Running Costs:	0 ?

Figure 53: Economic Efficiency Calculation

Feasibility Study

Financial Feasibility on PV*SOL

Total Electricity Production Costs:	0,61 ₺/kWh
PV Electricity Production Costs:	0,57 ₺/kWh
Back-up Gen. Electricity Production Costs:	0,79 ₺/kWh
Total Annual Costs:	3.723 ₺/a
PV System Annual Costs:	2.825 ₺/a
Back-up Generator Annual Costs:	898 ₺/a

Economic Efficiency Calculation according to the net present value methods.
Other methods can lead to other results.

Figure 54: Economic Efficiency Calculation

Feasibility Study

Results

When the system is install on the right foundations, it will definitely be successful and its financial return will be high.

So why solar energy?

- Saves Money on Invoices
- Increases the Value of Your Home
- Provides Long Term Warranty To Its User
- Waste Free And Environmentally Friendly
- Saves Energy from Dependence on Foreign

References

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-  <https://www.garantibbva.com.tr/tr/kobi/krediler/gunes-enerjisi-kredisi.page>
-  <https://www.halkbankkobi.com.tr/NewsDetail/Lisanssiz-Elektrik-Uretimi-Destek-Kredisi/1987>
-  <https://www.turkiyefinans.com.tr/tr-tr/kobi/sector-ve-urun-paketleri/sayfalar/lisanssiz-yenilenebilir-enerji-paketi.aspx>

Thank you
for your attention