

# Design of Photovoltaic System

## In the UK and US

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## Site Selection and Solar Resources

- US: The design proposes a PV system in the parking lot of Santa Barbara Airport, California, US.
- South orientation, which will receive the maximum sunlight and reduce the reflection effect to the airplane.
- Available area 8000 m<sup>2</sup>

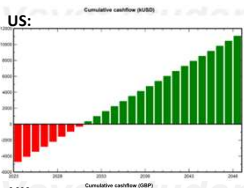


- UK: The design proposes a domestic solar PV application for a single household, located in Essex, UK.
- A west & south orientation, which fits the roof and warehouse
- Available area 42 m<sup>2</sup>

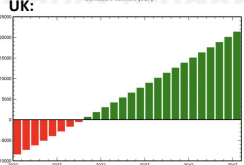


One is large-scale commercial site and another is small-scale residential site. Both two places have abundant solar resources and the irradiation in California is higher.

## Economical Analysis



Description	Cost (\$)
PV Modules	1,720,000
Modules Support	242,200
Inverter	381,270
Feed-in Tariff	0.235 kWh
Installation	442,700
Consumption Tariff	0.48 kWh
Net Present Value	11,079,968.00
Internal Rate of Return	12.78%
Payback Period	7.5 years
Land Rent	1,500,000
Return on Investment	235.50%



Description	Cost (£)
PV Modules	2,682
Modules Support	524
Inverter	1,934
Feed-in Tariff	0.15 £/kWh
Installation	1,980
Consumption Tariff	0.15 £/kWh
Net Present Value	21,338.64
Internal Rate of Return	13.09%
Payback Period	7.4 years
Land Rent	0
Return on Investment	178.60%

The PV system in California, US requires much higher investment on equipment and land rent than the PV System in UK.

However, because of the higher irradiation, more expensive feed-in tariff and consumption tariff, the payback period and return on investment in the two countries are the same.

## Solar Thermal Application



Palmdale Hybrid Power Plant in US



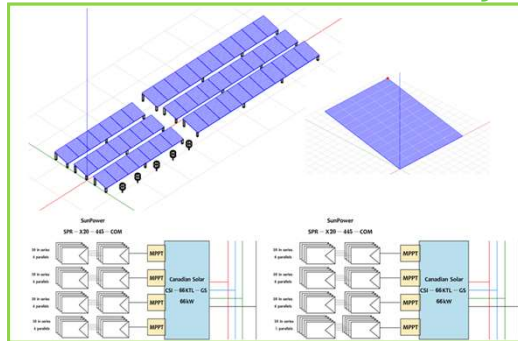
Solar Thermal in the hospital in Birmingham

The Solar Thermal application in the US is usually larger and centralized. While the thermal application in the UK is usually more scattered and smaller.

The thermal projects in California is usually applied to big solar thermal power plant to generate heating and electricity.

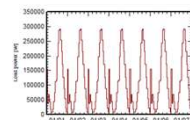
The thermal project in the UK is recommended for locations with high hot water demand as it reduces the costs of water heating

## PV Layout

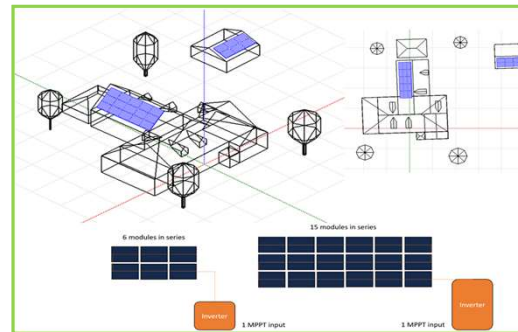


- Module Selection: SunPower SPR-X20-445-COM  
Higher efficiency, high performance in hot climate
- Inverter: Canadian Solar CSI-66KTL-GS  
66 kW input rating, 4MPPT input  
High power, suitable voltage and MPPT control
- Tilt angle: 13°  
Reduce the shading effect and construction cost
- Area of 7500m<sup>2</sup>, with 10 modules in one string and 346 strings parallel totally.
- Two types of panels size.  
12.5 X 74m and 115 X 15m to fit the whole park

### US: The EV load Estimation

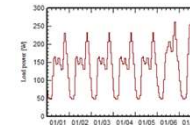


- Estimated by the Monte-Carlo model
- Average Load: 110.9 kW
- Maximum Load: 293 kW
- Annual Needs: 971 MWh



- Module Selection: Trina Solar 425 Wp, 36V mono-crystalline  
Great efficiency, high maximum power and appealing visual aesthetics with invisible busbars
- Inverter: SMA - Sunny Tripower 7000TL-20 and SMA - Sunny Boy 2500TLST-21 7kW and 2.5 kW out putting,
- Tilt angle: 40° west side and 20° south side
- Two types of panels size
- Area of 42 m<sup>2</sup>, 15 modules on the rooftop and 6 modules on the warehouse

### UK: The Household load Data

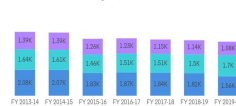


- Based on the specific data sheet
- Average Load: 114.2 W
- Maximum Load: 263.5 W
- Annual Needs: 1000 kWh

## Solar Market and Policy

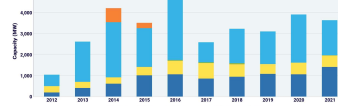
### Solar consumption trend in the UK

Average Solar PV Installation Costs, in GBP/kW, by System Size, United Kingdom, FY 2013-2020



### Solar installation in the California

California Annual Solar Installations



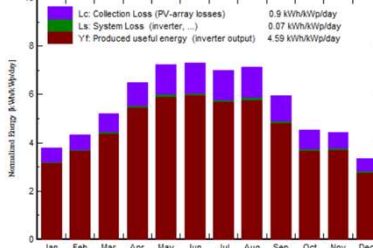
Both UK and California, US show rapid increase in the solar market. Both governments give huge encouragement to the solar energy.

The UK set a net-zero goal by 2050 and the electrical utilities must source 60% from renewable energy in California, US.

## Energy and Losses

### Santa Barbara, US

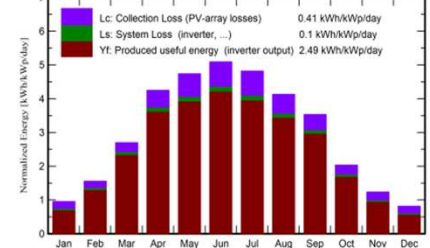
Normalized productions (per installed kWp): Nominal power 1540 kWp



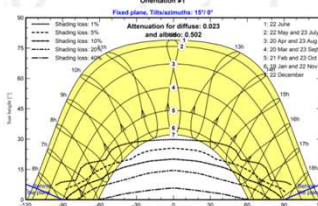
- Useful energy generation: 4.6 kWh/kWp/day
- System losses: 0.07kWh/kWp/day
- PV-array losses: 0.89kWh/kWp/day

### Essex, UK

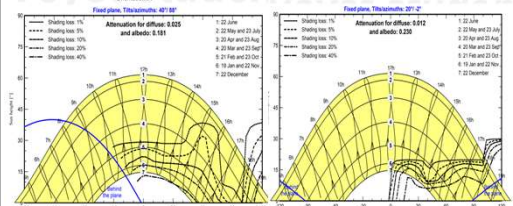
Normalized productions (per installed kWp)



- Useful energy generation: 2.49 kWh/kWp/day
- System losses: 0.1kWh/kWp/day
- PV-array losses: 0.41kWh/kWp/day



Near Shading: 0.66%



Near Shading: 1.92%

The useful energy generation in Santa Barbara is larger than that in Essex because the average solar irradiation in Santa Barbara is much larger than Essex. The shading losses in California is also much lower than Essex.

However the PV-array losses in Santa Barbara is higher than Essex because the long dry summer in California will cause huge soiling losses, which needs additional cleaning to the PV panels.