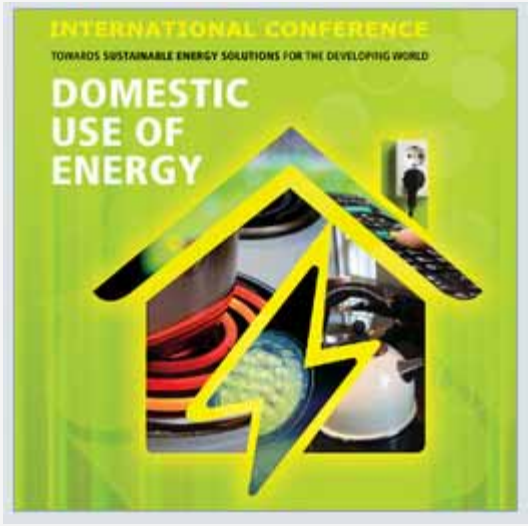
Optimisation of Residential Solar PV System Rating for Minimum Payback Time Using Half-Hourly Profiling



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University of Stellenbosch

Question

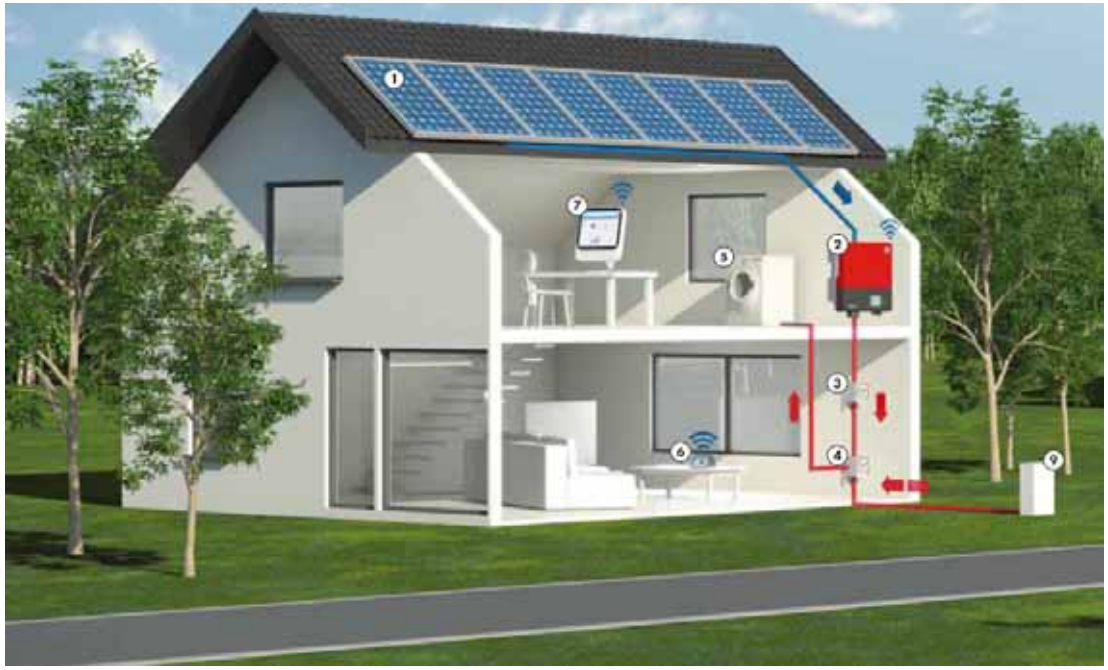
Payback time

Load profile & Solar profile

Load schedule optimisation

PV system

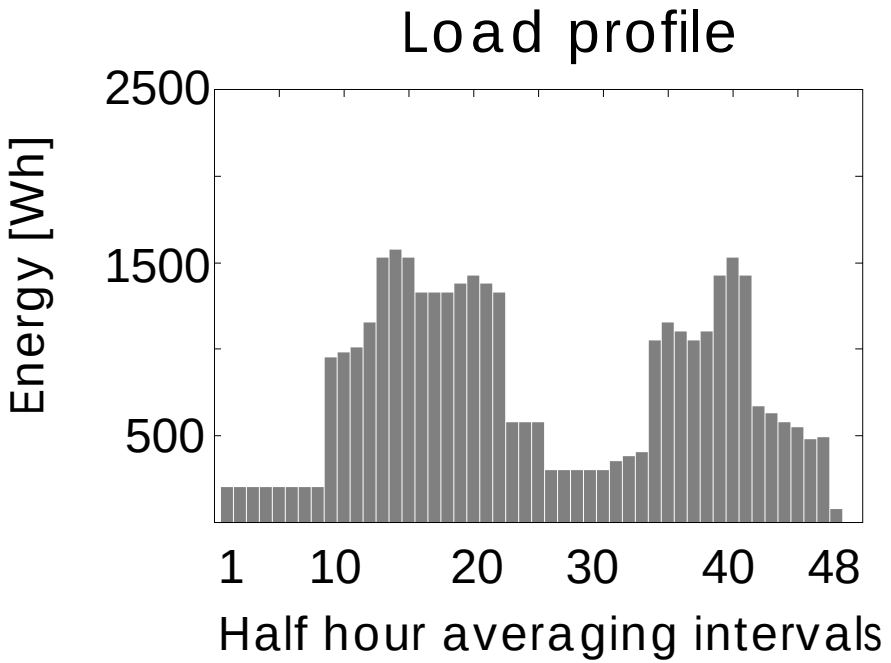
Standard turn-key installation



Source: SMA Product catalog – Sunny familiy 2012

Profiles

Represented by half-hour averaged values



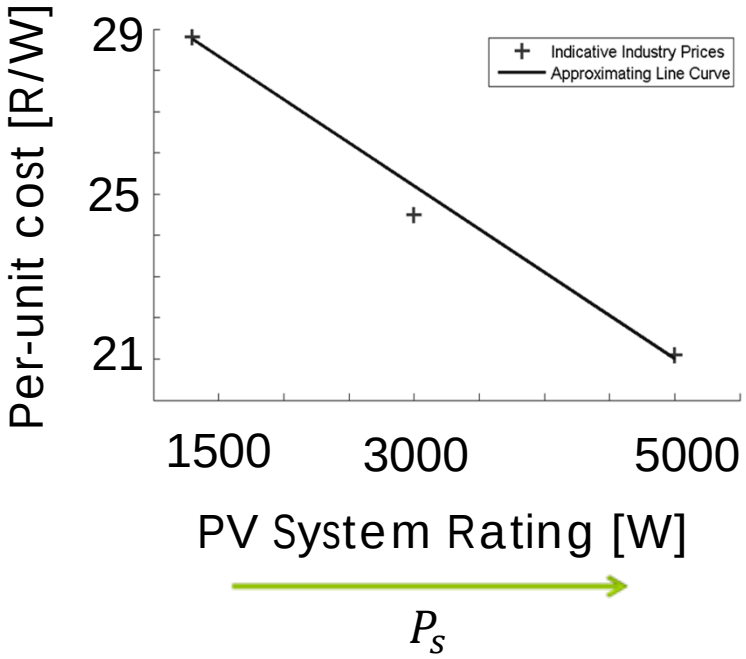
$$\overline{\boldsymbol{x}} = x_1, x_2 \ \ldots x_{48}$$

Payback time

$$\text{Payback time} = \frac{Capital\ Cost}{Savings\ (achieved\ through\ capital\ cost)}$$

Capital Cost

Per-Unit cost



Total cost

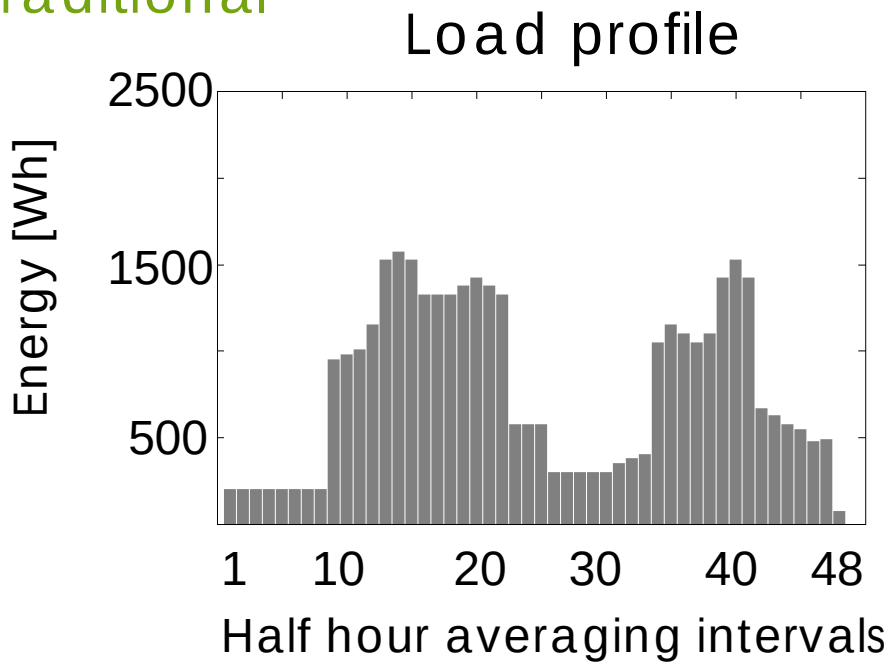
$$Capital\ Cost\ = (m\ P_s + c)P_s$$

Payback time

$$\text{Payback time} = \frac{Capital\ Cost}{Savings\ (achieved\ through\ capital\ cost)}$$

Savings

Traditional



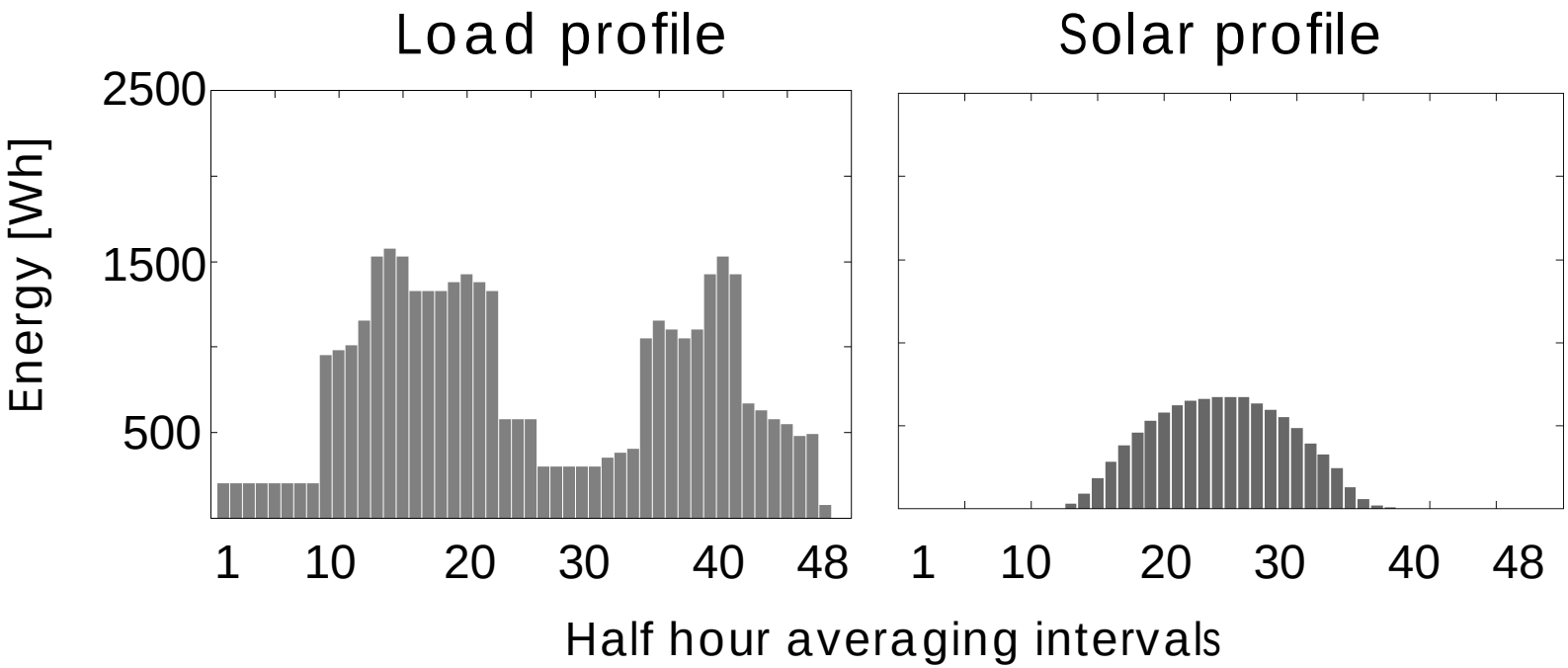
Load profile: $\bar{\boldsymbol{x}} = x_1, x_2 \ldots x_{48}$

Electricity tariff: t

Total expense: $t.\sum \bar{\boldsymbol{x}}$

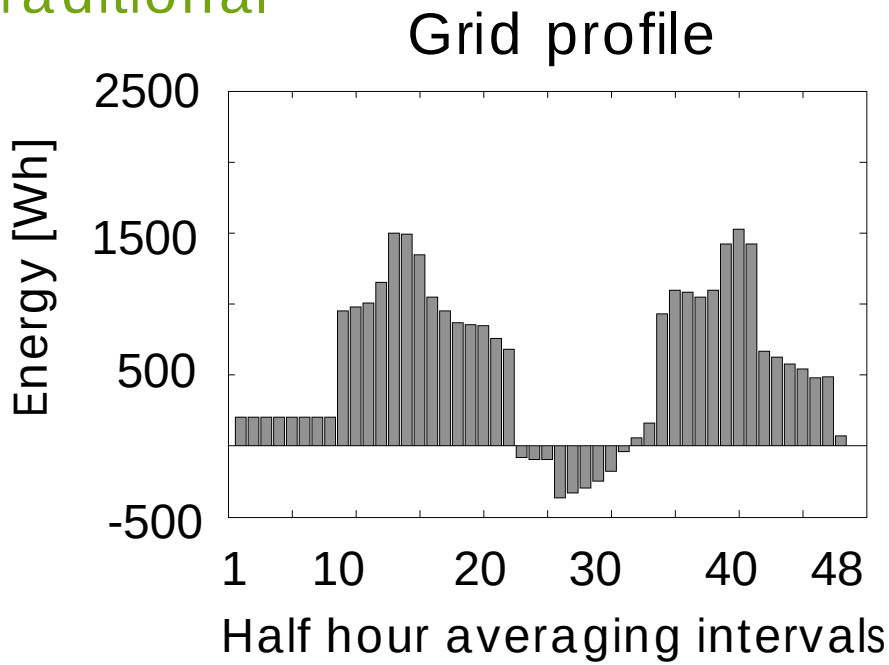
Savings

Traditional



Savings

Traditional



Total expense: $t.\sum \bar{x}, \quad x_i > 0$

Payback time

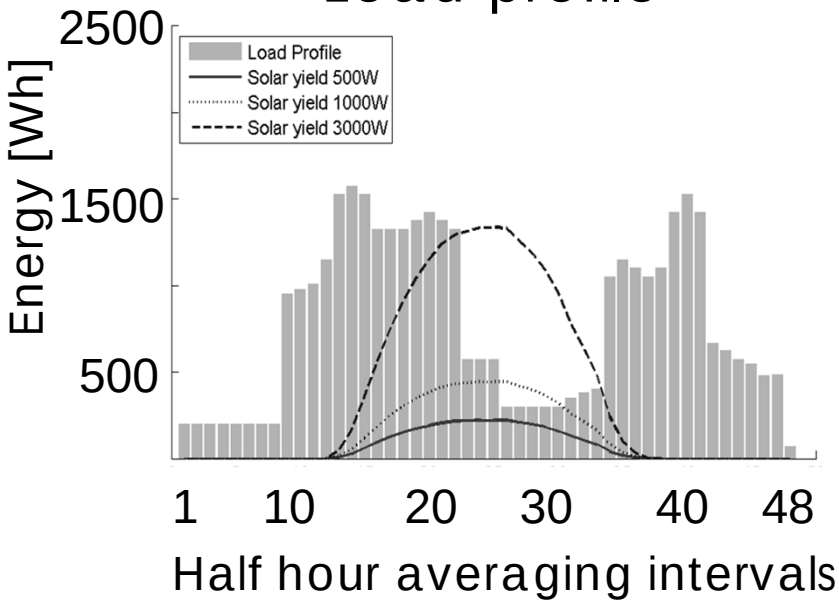
$$\text{Payback time} = \frac{Capital\ Cost}{Savings}$$

$$\text{Payback time} = \frac{(m\ P_s + c)P_s}{t.\sum \bar{x} - \ t.\sum \bar{x}'}$$

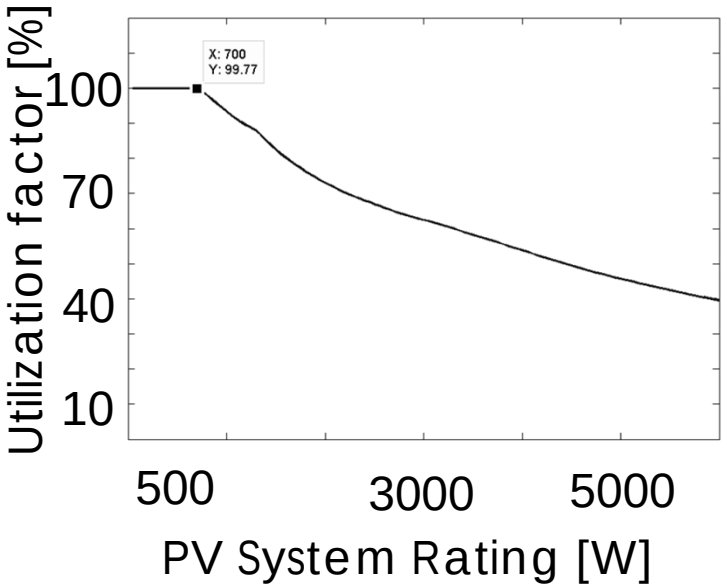
Savings

Using the concept of utilization factor

Load profile



Utilization factor $z(P_s)$



$$Savings = Savings\ if\ 100\%\ of\ solar\ energy\ was\ used * z\ (P_s)$$

$$C_s' = K.P_s.a.t.z(P_s)$$

Payback time

$$\text{Payback time} = \frac{Capital\ Cost}{Savings\ (achieved\ through\ capital\ cost)}$$

Payback time

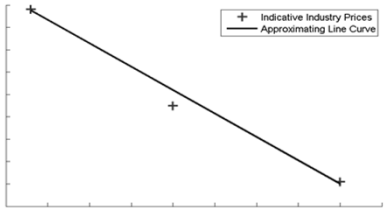
Now back into the payback equation

$$T_{pb} = \frac{(m\,P_s + c)P_s}{K.P_s.a.t.z\,(P_s)}$$

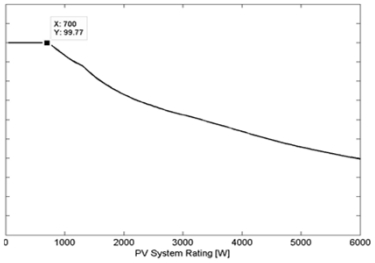
$$T_{pb} = \frac{m\,P_s + c}{K.a.t.z(P_s)}$$

constant

Per-Unit Cost

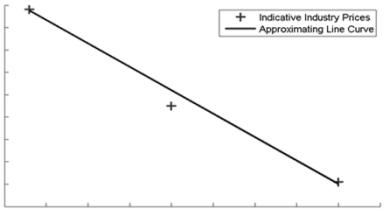


Utilization Factor



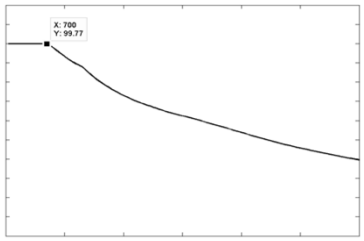
Payback time

Per-Unit Cost



Utilization Factor

$c \times$



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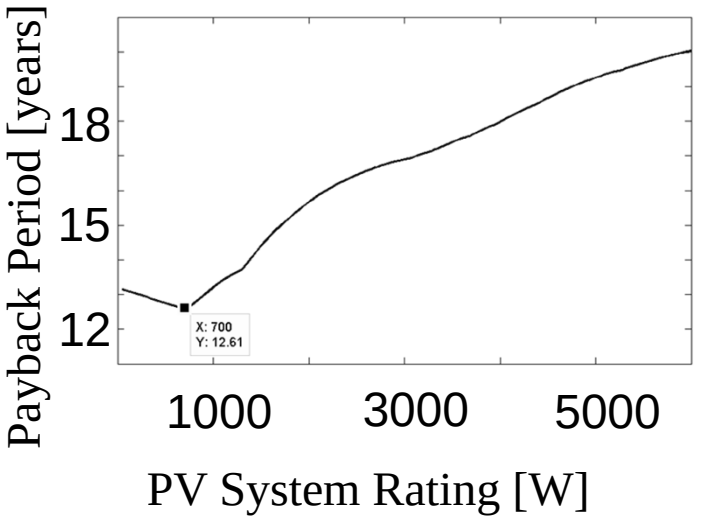
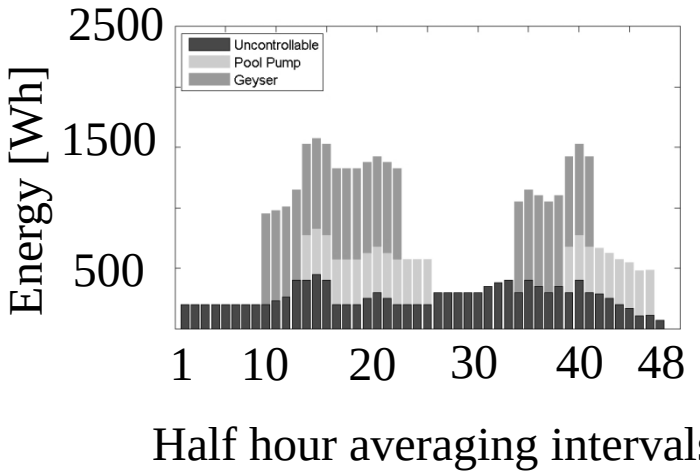
Payback time

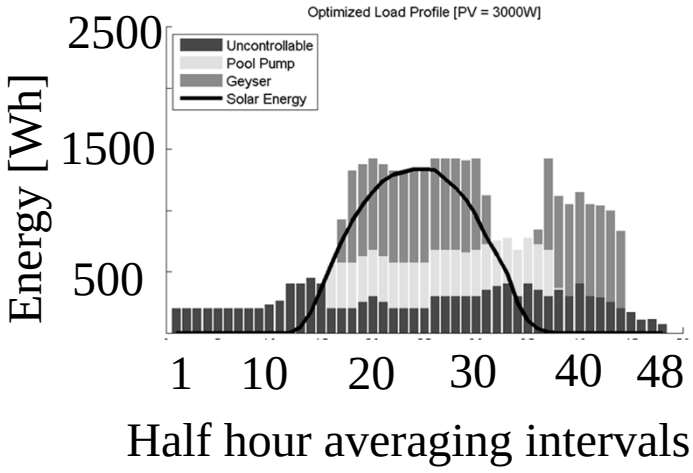


Load optimisation

Unoptimized Load Schedules

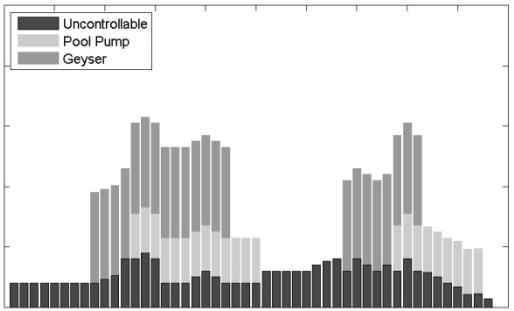


Optimized Load Schedules

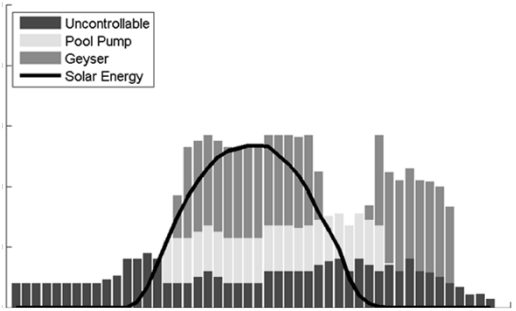


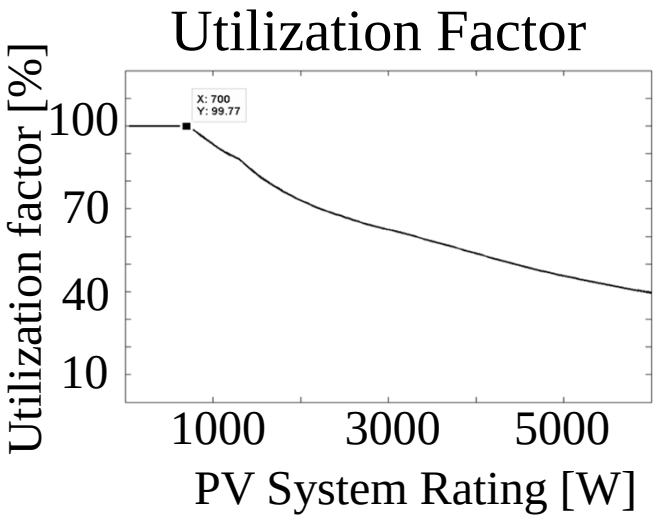
Load optimisation

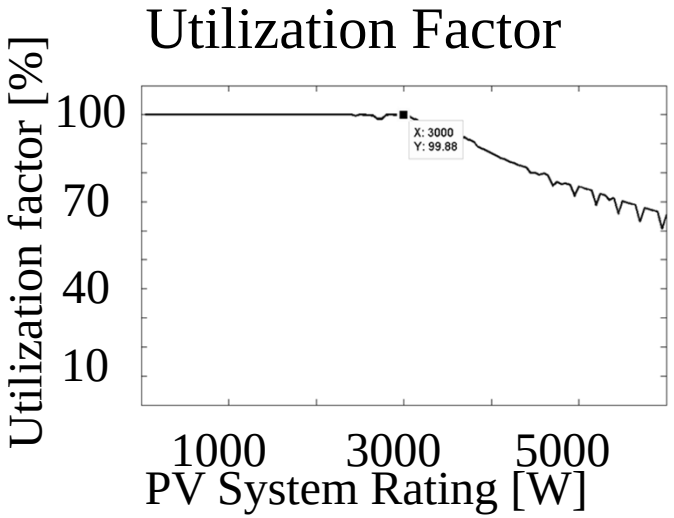
Unoptimized Load Schedules



Optimized Load Schedules

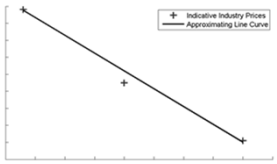




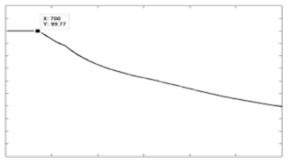


Load optimisation

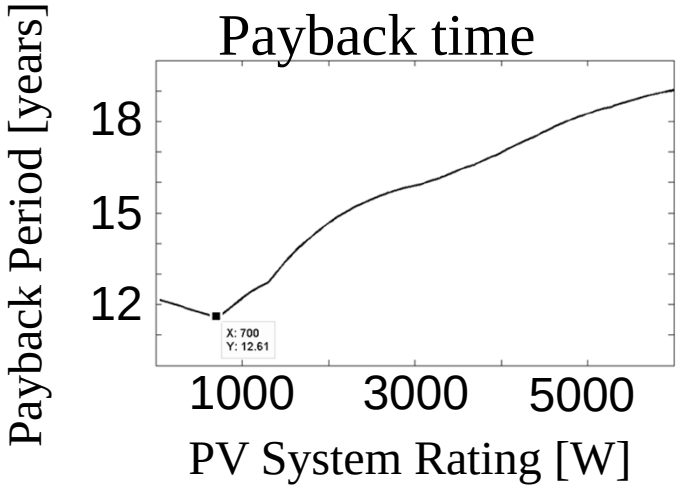
Unoptimized Load Schedules



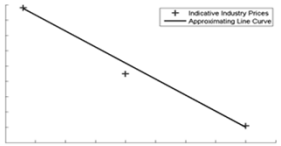
$c \times$



Payback time



Optimized Load Schedules



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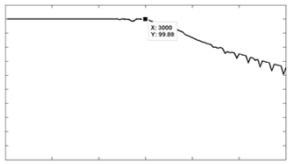
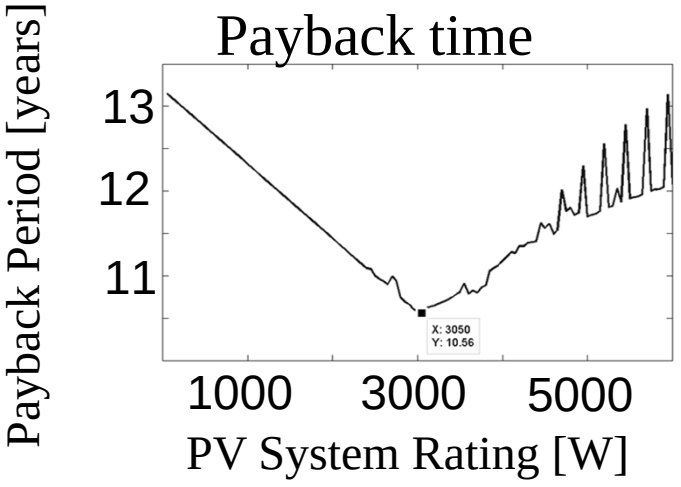
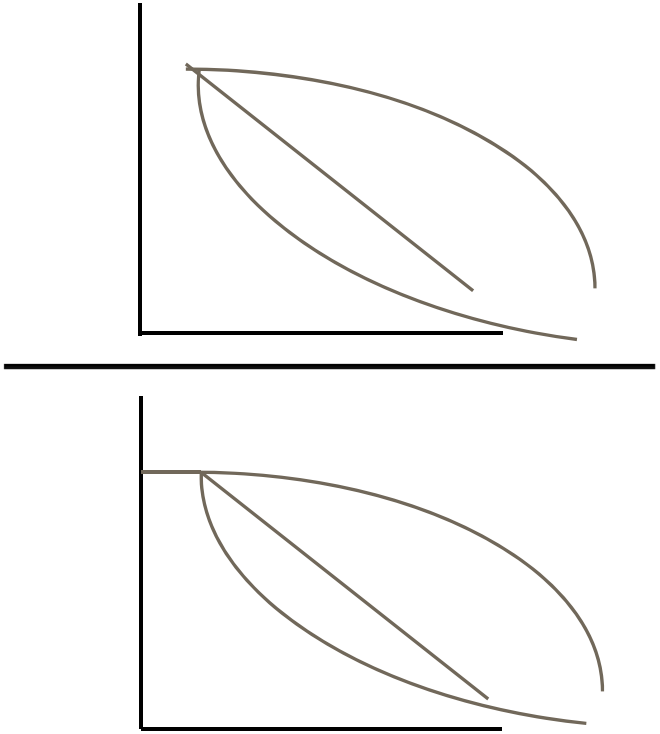


Payback time



Future work



Extending the model to annual profiles

Including complex cases: Time-of-use tariffs, Feed-in tariffs.

Discussions

Effect of using half hour averaging

Acquisition of annual load profile data