Photovoltaics for product designers

PV voor productontwerpers

Kenniskracht

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PV powered products





- bags - chargers - lights - office - garden - navigation - travel/sports - personal electronics - clothing - toys -



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Points for improvement

- Not clear how it works
- Many connectors needed
- Self-discharge battery
- No charging
- Aesthetics
- Low overall quality
- PV as add-on rather than integral part of product

Design challenge

- Balance technological possibilities with user demands
- Combine specific characteristics of PV system with the actual functional product




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Design challenge

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- Combine specific characteristics of PV system with the actual functional product

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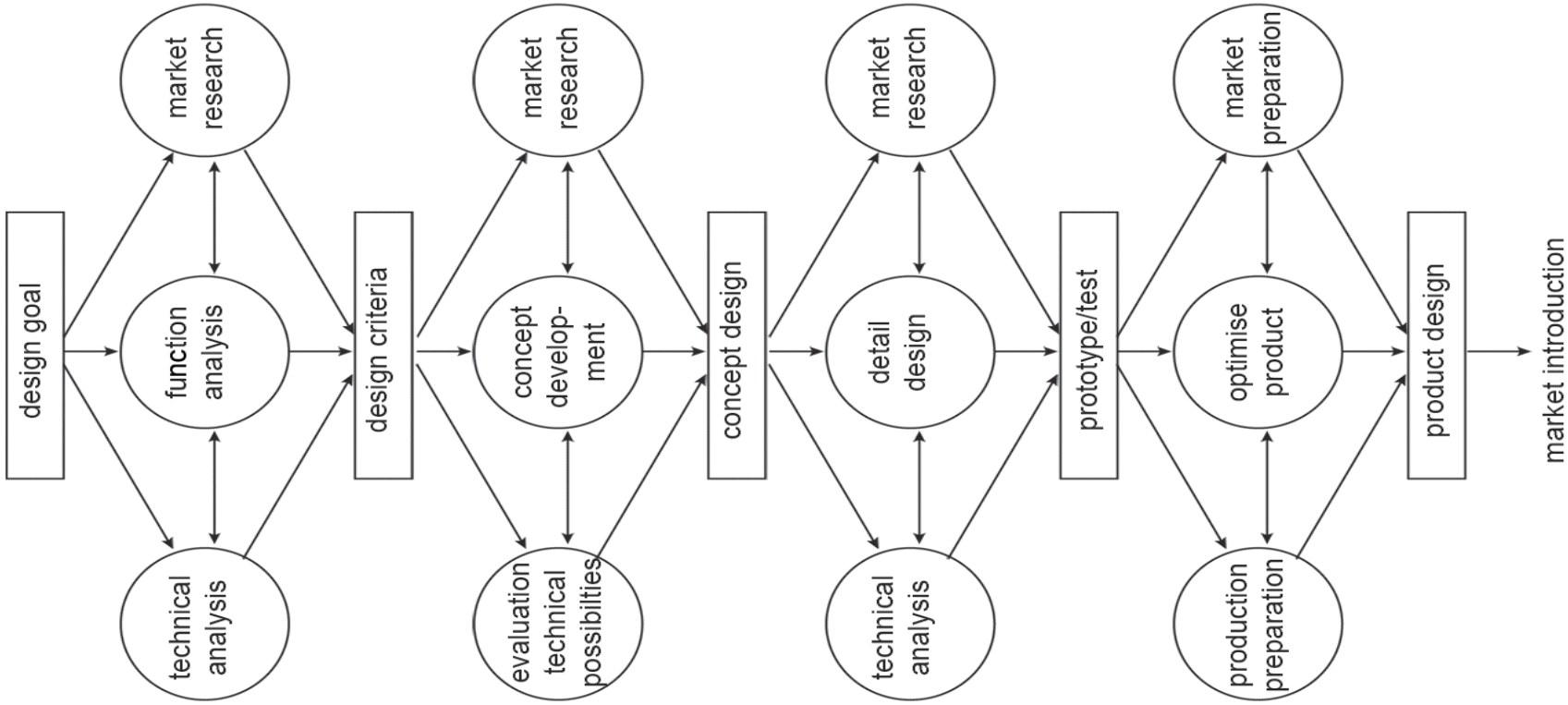
Design Approach for renewable energy powered products

- Integral model for product development process
- Product benchmarking (D4S)
- Energy Matching Model and Figure of Matching algorithm

Integral model for product development process



[J. Buijs, R. Valkenburg, 1997]

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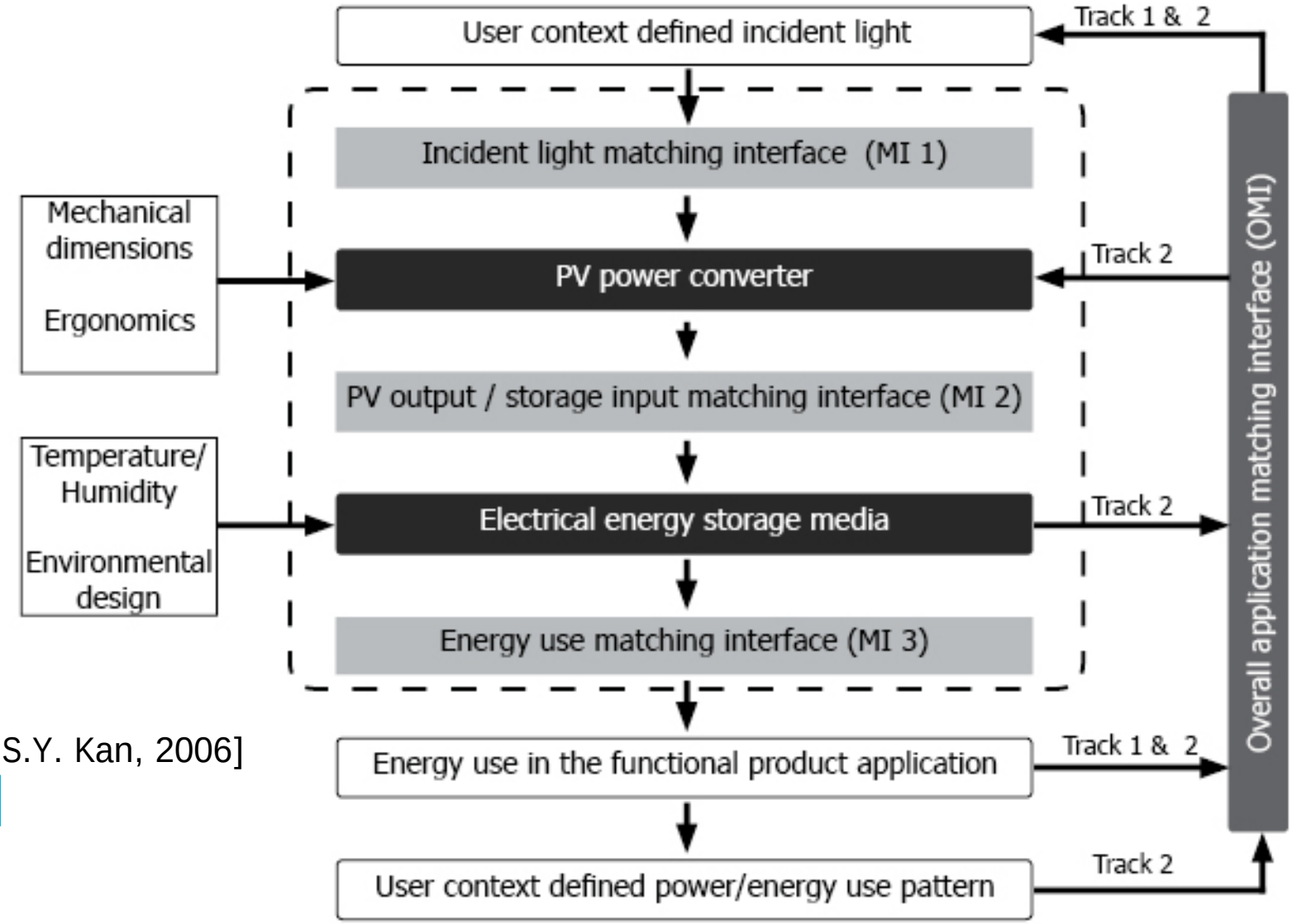
D4S Product benchmarking

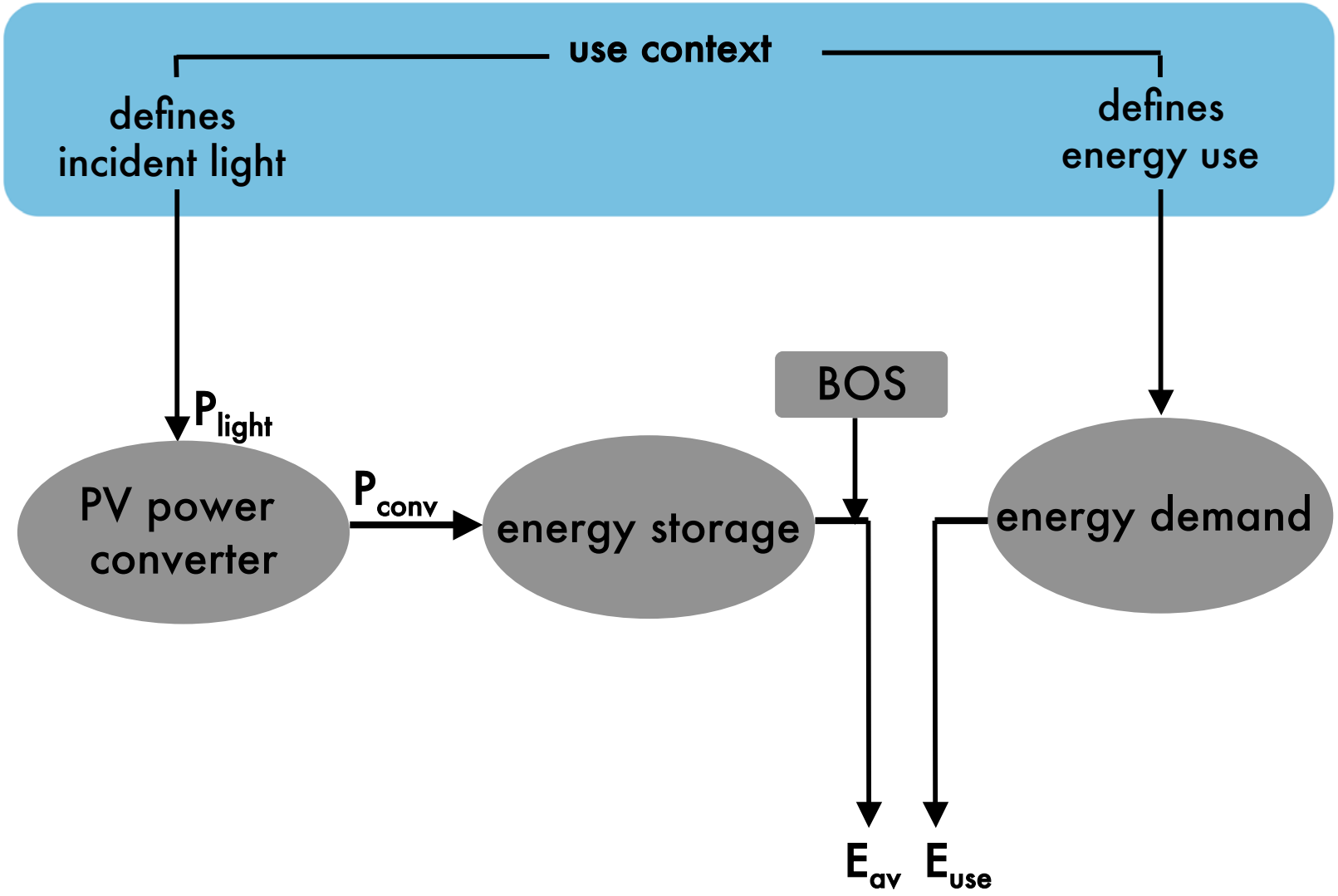
- Compare the performance of a company's products against competitors' products
- Generate improvement options
- Specific guidelines and stepwise planning

Energy Matching Model and Figure of Matching algorithm



[S.Y. Kan, 2006]

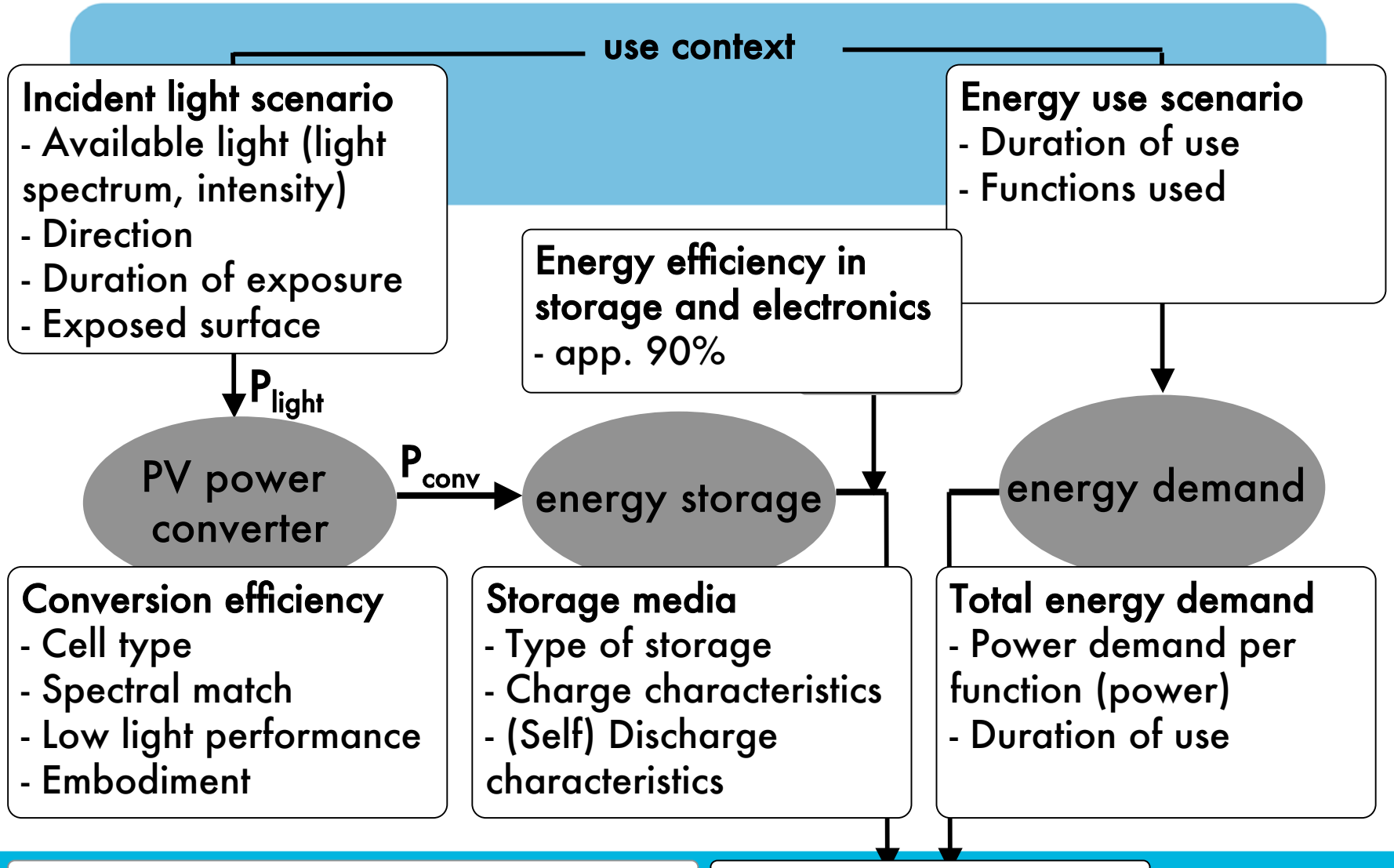
PV system at a glance (2)



Energy balance (saldo)

$E_{available} = E_{use}$

PV system at a glance (2)



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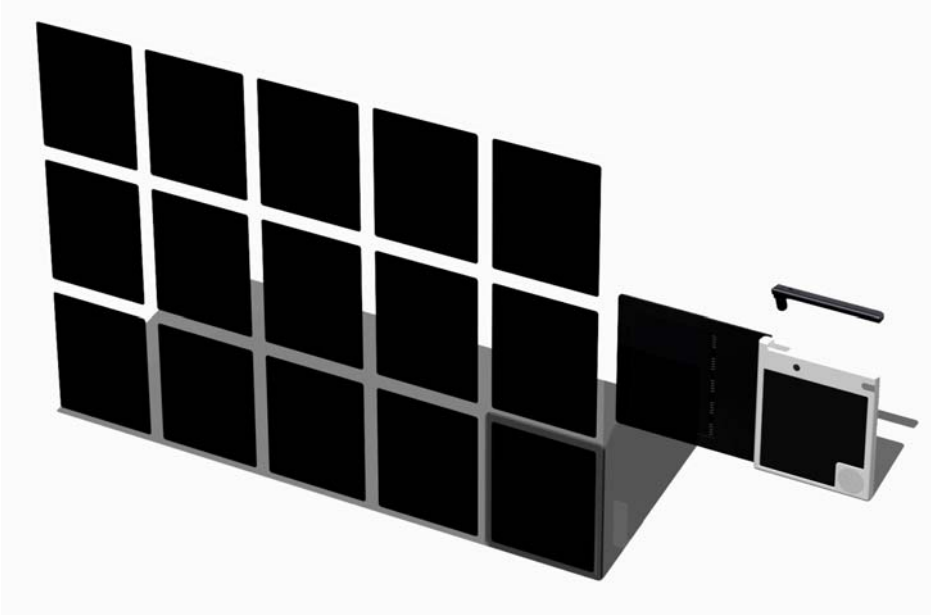
Examples

Solar Mobile Companion



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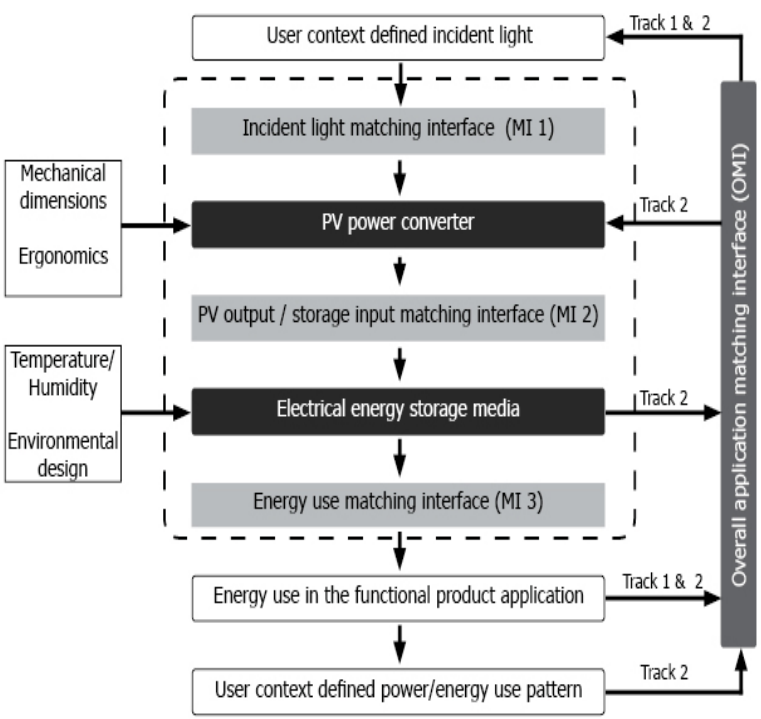

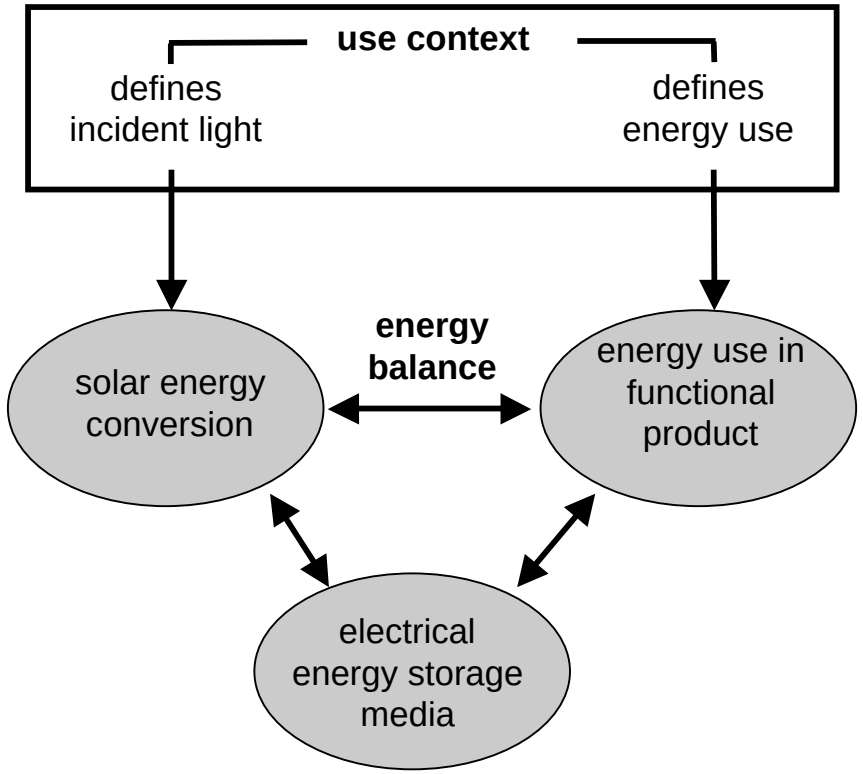

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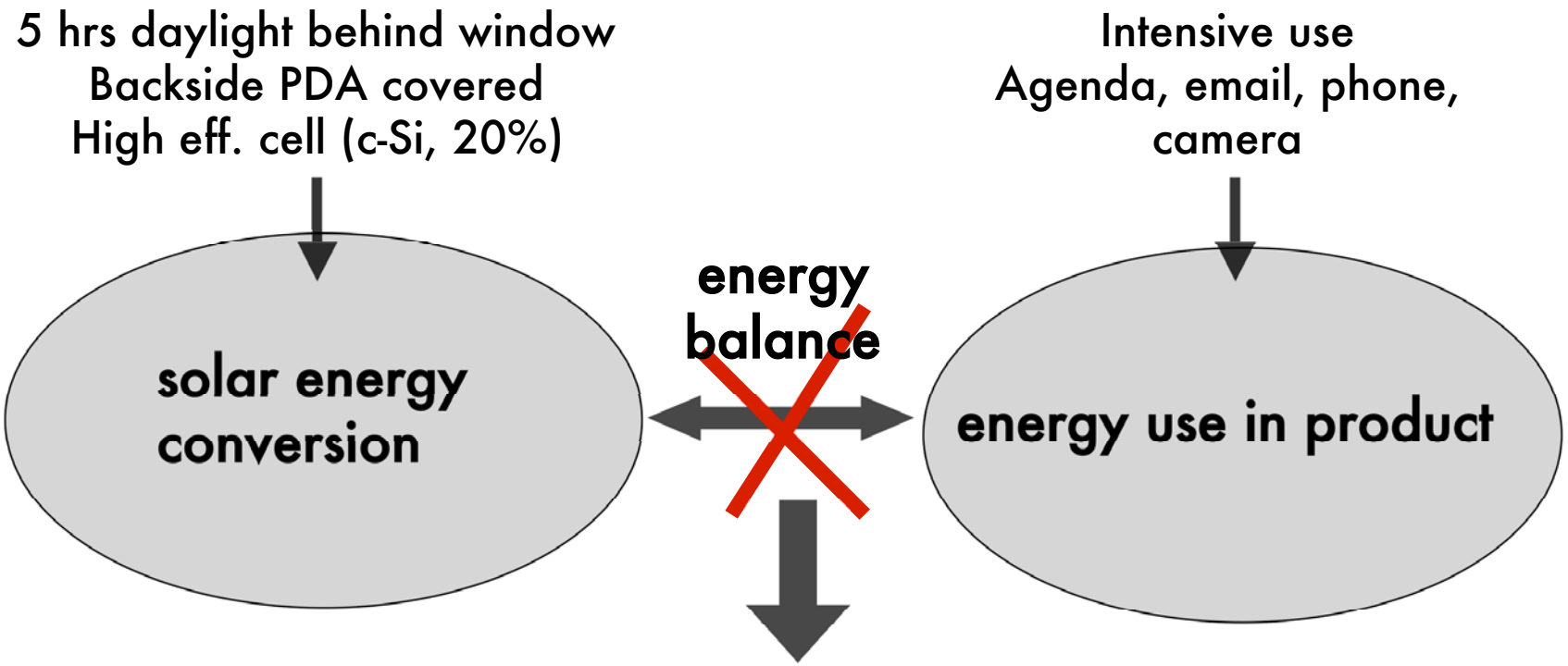
Solar Mobile Companion
First estimate energy balance



0,25 m^2 surface needed

Challenge!

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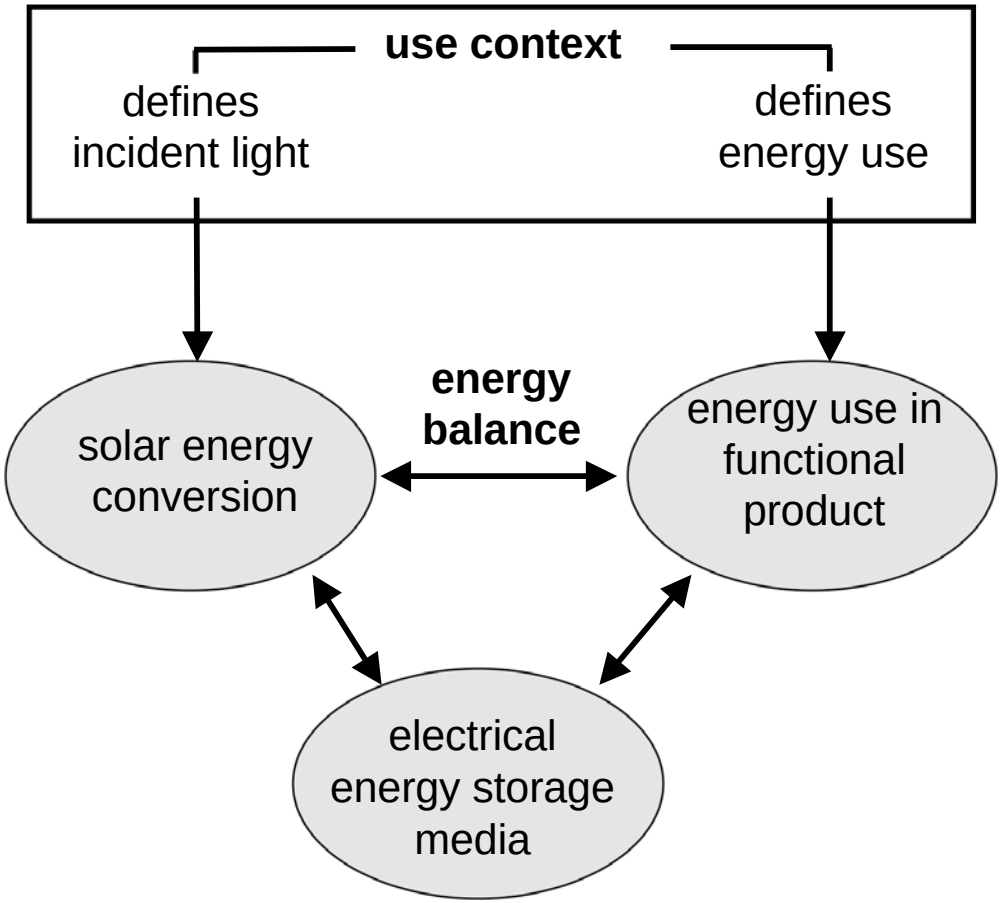
Solar Mobile Companion
Optimized energy matching



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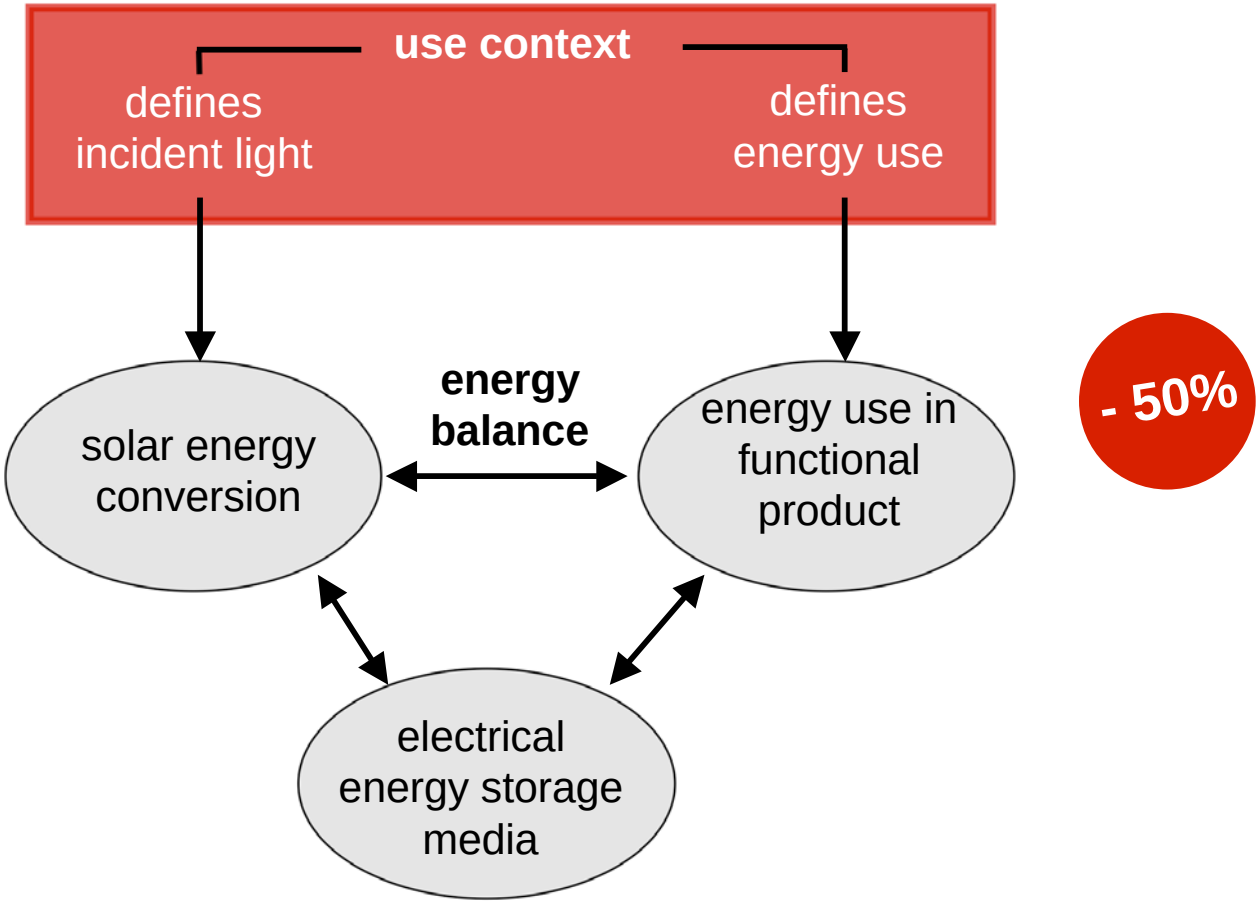
Optimized energy matching



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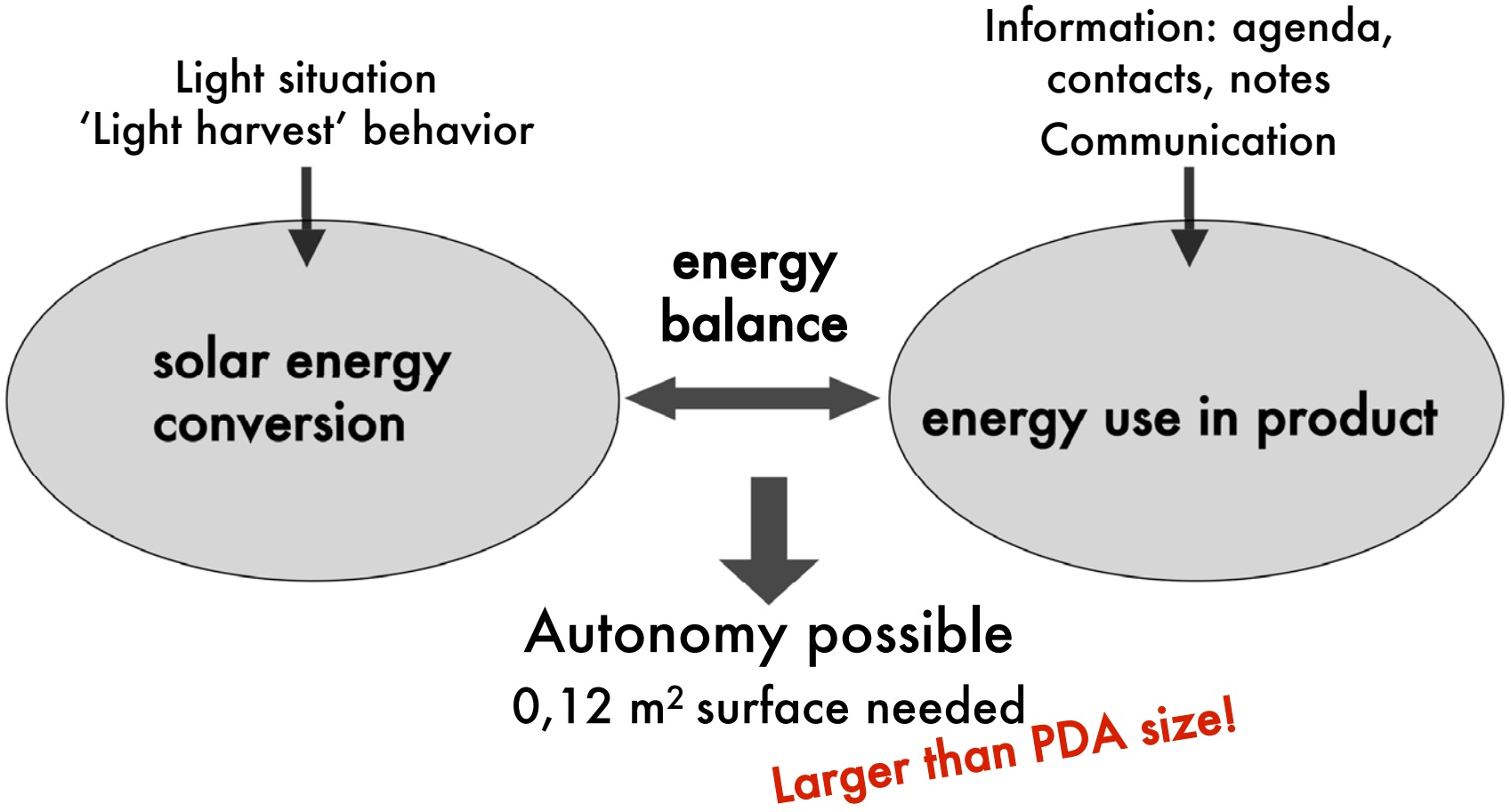
Optimized energy matching



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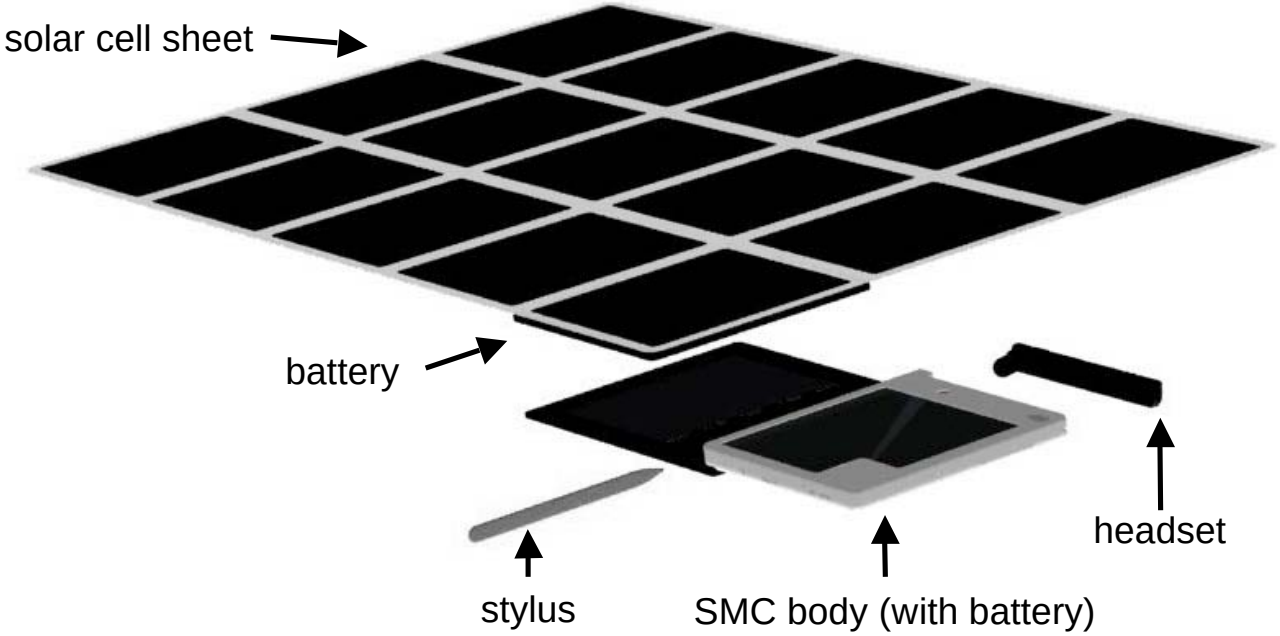

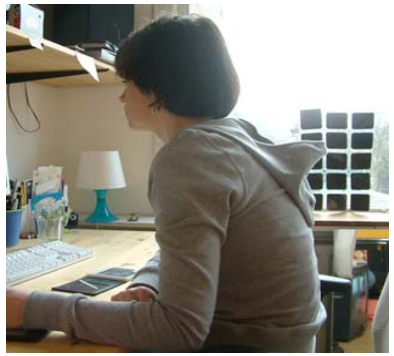

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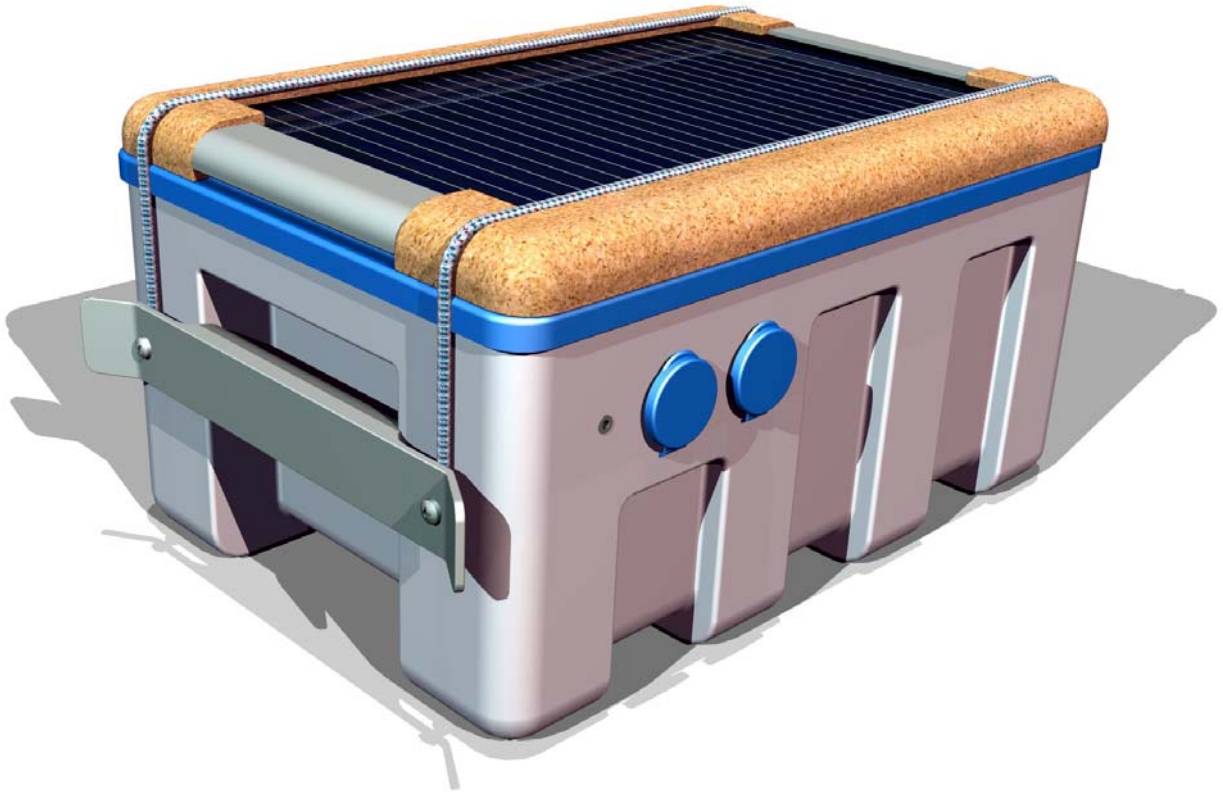
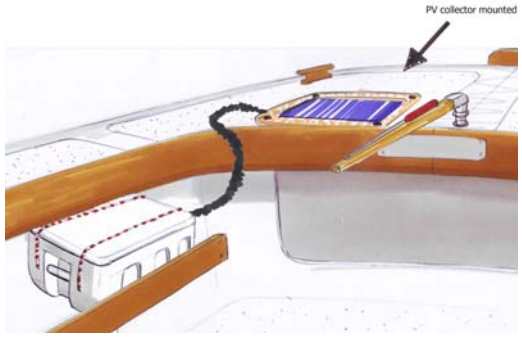
Solar Power Station®





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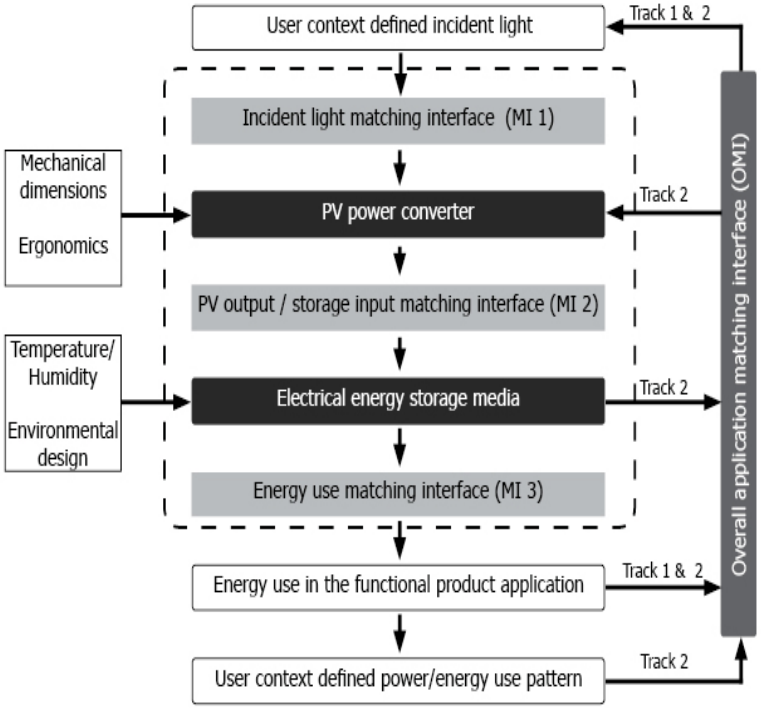

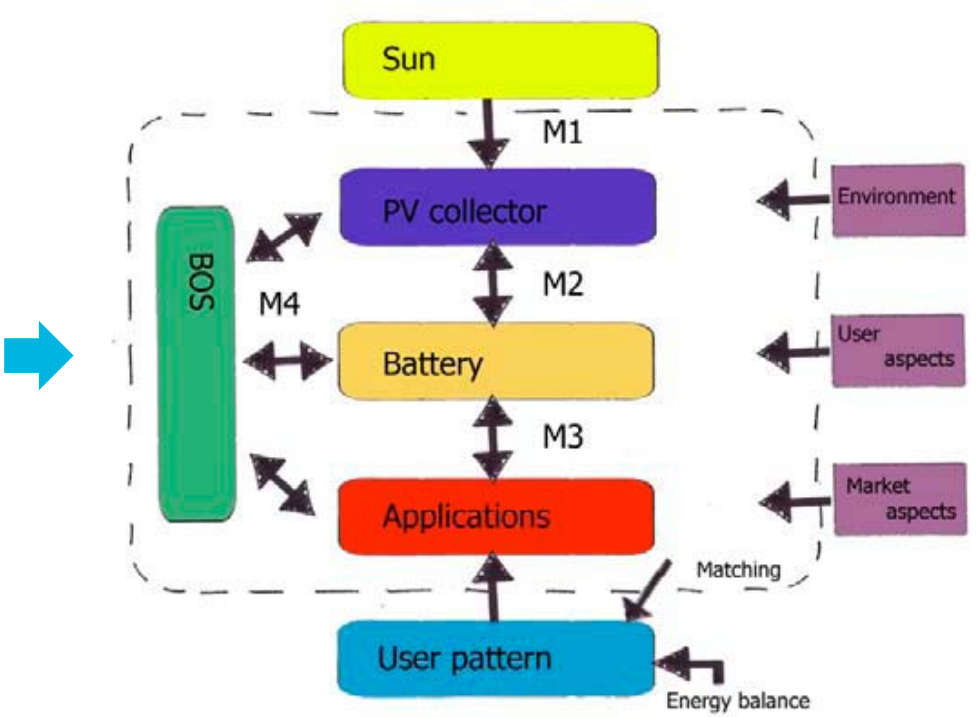

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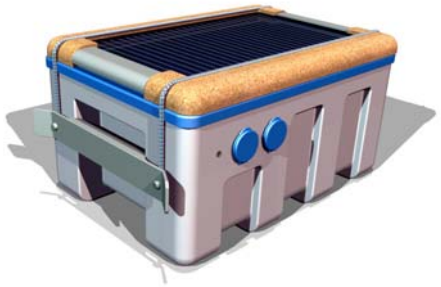
PV system design



Energy use scenarios

Target energy consumption pattern			
Bilge water	Rent-a-boat	Touring	Trekking
5 Wh/day	37 Wh/day	88 Wh/day	14 Wh/day

3 days x 37 Wh/day =	111 Wh maximum required energy
10% Balance of System :	120 Wh required
120 Wh * 1/90% =	133 Wh energy storage capacity
	↳11 Ah in a 12V system
Battery capacity:	22 Ah (deep discharge)
	↳ battery selection LA Gel battery, **10 kg**

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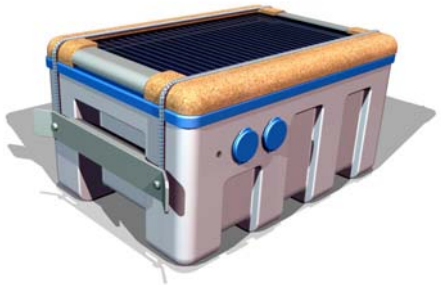
Energy Matching



PV collector should collect: (133*1/90%)/3days = 50Wh/day

Worst month yield: 290Wh/m2/day

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m²/day)													
Lat 53 Lon 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	0.64	1.39	2.70	4.30	5.64	5.74	5.57	4.62	3.13	1.69	0.85	0.52	3.07

PV surface: 50/290 = 0,17 m2

CIS panel with 140 Wp/m2 yield on average

Required PV module size: 24 Wp

Select from available modules: 25 Wp CIS module

600x400x40 mm, 4,5 kg

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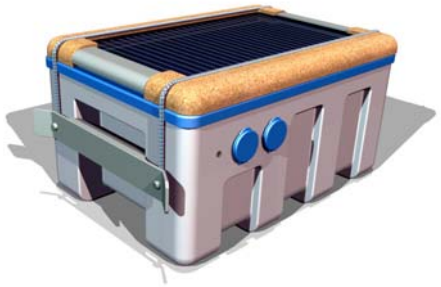
Optimized matching



Not 1/1 energy collection/consumption

Smaller module, compensated with bigger battery capacity

Total energy load:	17 Wh/day
Battery capacity:	5 Ah
Compensation smaller module:	↳ 10 Ah (app. **4 kg**)
PV module:	6 Wp PV (app. **0,04 m²**, **1 kg**)

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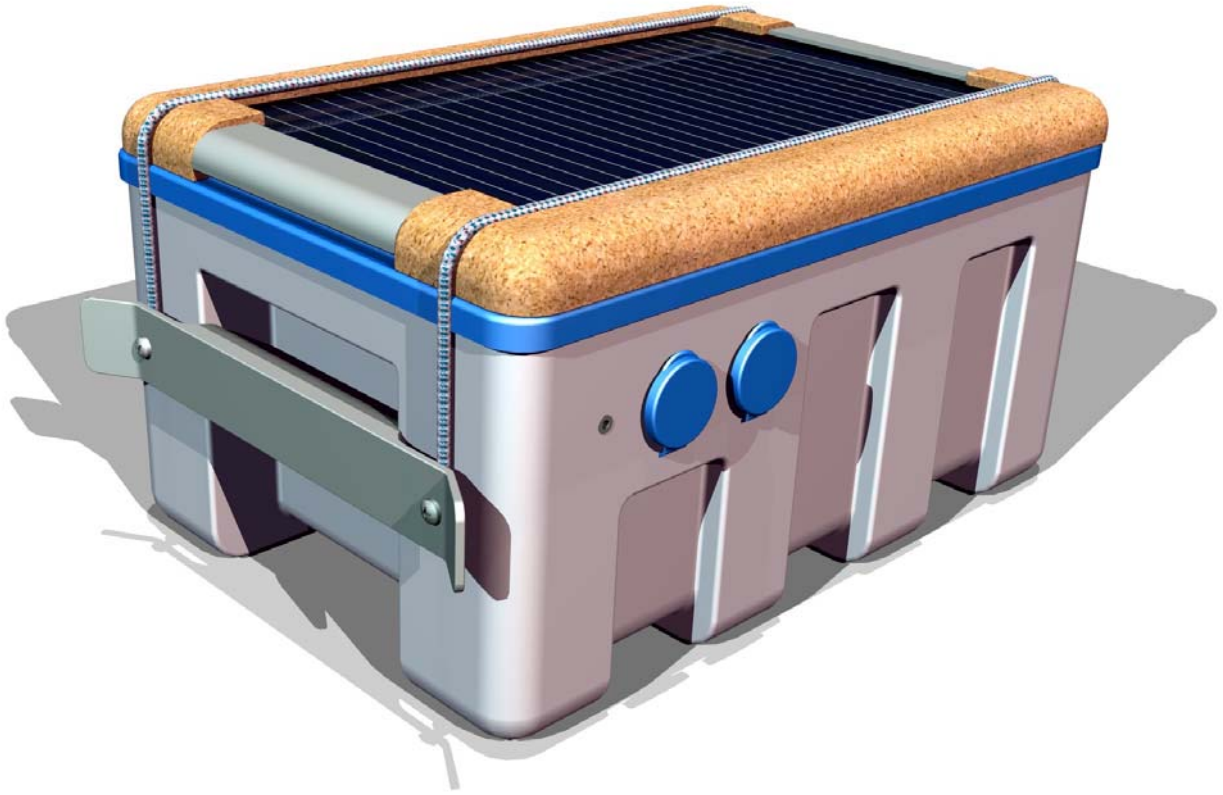

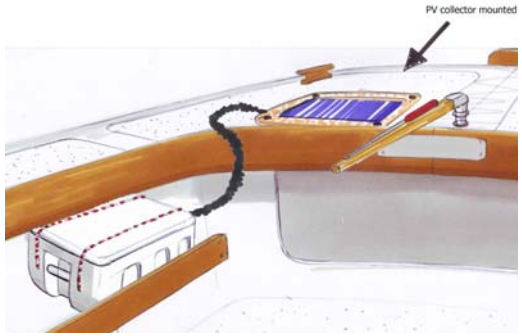

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Design approach - analysis of projects

Pupil locator

Solar Mobile Companion

Ball light

Bicycle lighting

Solar Blox®

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Main findings

- Energy Matching Model (EMM) most used in analysis phase
- EMM for generation and evaluation of ideas/solutions
- EMM representation adjusted by designer
- EMM as guide contributes to transparent and efficient design process
- Self-made spreadsheets for energy matching calculation
- Product benchmark used superficially - to gain insight in PV application and use of product (2 projects)
- Product inventory used in all projects

Conclusions

- Many of guidelines of the Delft Design Method are used in the design projects
- Guidelines application contributes to transparency and efficiency in the design process

- Knowledge, information (transfer) should be tailored more to design practice (how to & sustainability aspects)

- Further development of guidelines and tools is desirable, e.g.
  - Standardized energy matching spreadsheets
  - Specific product benchmark guidelines

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