EMPA
Materials Science & Technology

«From PV Systems to Energy Solutions»

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TNC Advanced Energy Concepts

SOL ccem.ch swisselectric research

Preliminary Remark:

From PV Systems to Energy Solutions …

This presentation is not a report of recent TNC project.

- Here are some considerations reflecting my 40 years of experience in solar power, housing technology and building efficiency.
- I will make here my own proposal for the possible steps of the PV community and the industry to help improve energy and ecological wise the existing building stock in Europe.

The big agenda:

- Published opinion, energy politics and the society
- A proposal for a 4 dimensions Energy Solution Provider
- Conclusions

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«From PV Systems to Energy Solutions»

Agenda

- Outlook the Swiss energy future 2013 - 2050 with PV?
- Can we afford a feed in tariff?
- What makes photovoltaic in buildings so important?
- Why do we need a joint Swiss/European plan to allow high PV penetration in the power grid?
- How do we emerge from lower cost PV [€/kWh] market to a Energy Solution Provider?
- Why power to heat, power to storage and power to wheel?
- Seven conclusions …

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TNC stands for: Solar Power and Building Efficiency
Our themes for more than 26 years

➜ Development and Implementation

- 1989 first Photovoltaic system on a highway noise barrier (BFE P&D)
- 1996 developing the world's first solar power exchange model for the ewz, Elektrizitätswerk der Stadt Zürich
- Using bifacial technology (two-sided solar cells) as a noise barrier alongside roads 1994 and rail track 2008 (European patent)
- 1997/1999 responsible for the process development and implementation of the first national building renovation program by the Swiss federal government as part of Energy 2000 strategy.
- Implementation of the Swiss national building renovation program „Das Gebäudeprogramm" for 16 States (Kantone) Mio €. 220/a
- Activity leader IEA PVPS Task 13 Performance & Reliability of PV Systems

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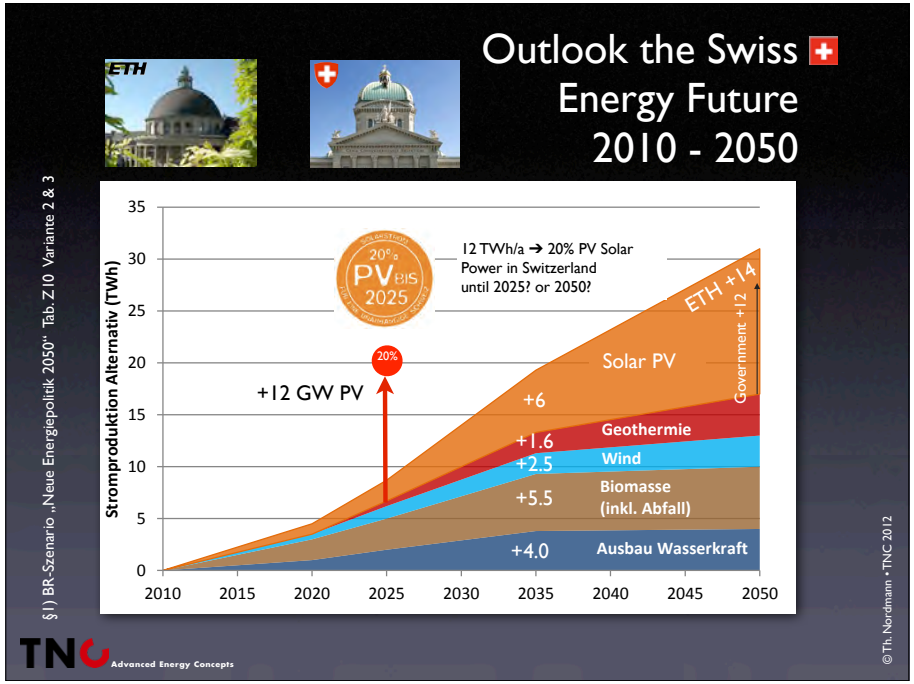
Outlook the Swiss Energy Future 2010 - 2050
§1) BR-Szenario „Neue Energiepolitik 2050" Tab. Z10 Variante 2 & 3
Stromproduktion Alternativ (TWh)
12 TWh/a → 20% PV Solar Power in Switzerland until 2025? or 2050?
20% PV BIS 2025
+12 GW PV
Solar PV
+6
ETH +14
Government +12
Geothermie
+1.6
Wind
+2.5
Biomasse (inkl. Abfall)
+5.5
Ausbau Wasserkraft
+4.0
2010 2015 2020 2025 2030 2035 2040 2045 2050
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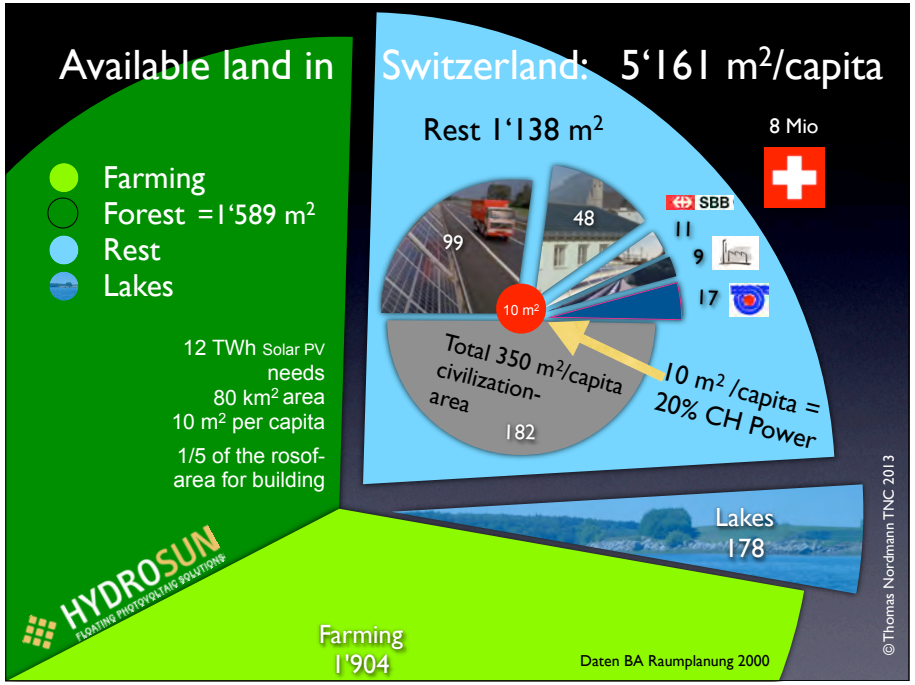
Available land in Switzerland: 5'161 m²/capita
Farming
Forest =1'589 m²
Rest
Lakes
12 TWh Solar PV needs 80 km² area
10 m² per capita
1/5 of the rosof-area for building
Rest 1'138 m²
8 Mio
99
48
SBB
11
9
17
10 m²
Total 350 m²/capita civilization-area
182
10 m²/capita = 20% CH Power
Lakes 178
HYDROSUN FLOATING PHOTOVOLTAIC SOLUTIONS
Farming 1'904
Daten BA Raumplanung 2000
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Published Opinion
Samstag, 19. Oktober 2013
MEINUNG & DEBATTE
Neue Zürcher Zeitung
25
Deutsche «Energiewende» ist kein
für den Rest der Welt
Geplante und ungeplante Wenden
DER SPIEGEL
WAHL-ENDSPURT
LUXUS STROM
Warum Energie immer teurer wird – und was die Politik dagegen tun muss
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The plan A: with 30 bn. CHF against the „Stromlücke"
Lösungsvorschlag der Stromverbundunternehmen
The «non exit» would cost until 2035 min. 30 billion CHF !
Investitionen bis 2035 in:
Volumen in Schweizer Franken
Produktions-zuwachs
Erneuerbare Energien inkl. Wasserkraft 8 – 10 Mrd. 5 Mrd. kWh
2 bis 3 Kernkraftwerke 10 – 12 Mrd. 20 Mrd. kWh
bis 5 Gaskombikraftwerke 2 Mrd. 3 Mrd. kWh *
Netzausbauten 2 – 3 Mrd. —
3 Pumpspeicherkraftwerke 3 Mrd. Füllen der Leistungslücke bei Nachfragespitzen
Total 25 – 30 Mrd. 25 – 30 Mrd. kWh
* Stand 2035 mit Gaskombikraftwerken als Lieferanten von Spitzenenergie (während der Übergangszeit: 10 Mrd. kWh jährlich)
Quelle: Swisselectric 2007

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Two more reasons: Why the business case for Swiss hydro pump-storage has collapsed?

Exchange rate: € to Swiss CHF

2008 1 € = 1.50 CHF > 123%

2013 1 € = 1.22 CHF > 100%

The lack of incentives

- The EU industry must provide rights for the CO_2, emission of which allows companies to trade with each other.
- Due to the low today price of € 4/t of carbon dioxide incentives for climate-friendly investments are lacking.
- Targeted the EU Commission had a value of 30 € - but the economic downturn of recent years suppressed demand & price.

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Your cost for electric power in Dübendorf (2013)

Quelle: Eidgenössische Elektrizitätskommission ElCom 22-10-2013

Grid operator: Glattwerk AG, Dübendorf

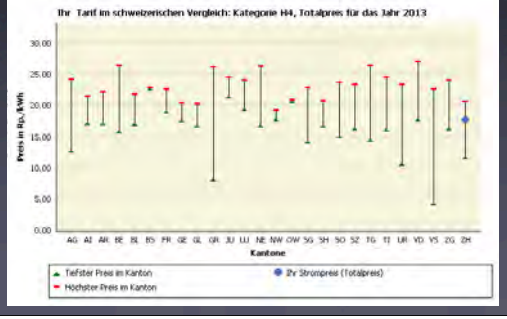
H4 = 4'500 kWh/year: 5 people-apartment with electric cooker and tumbler

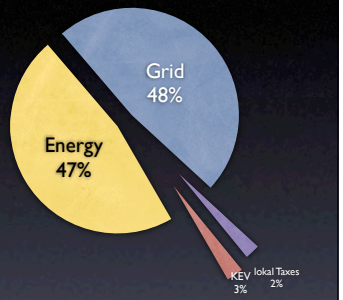
Gemeinde:	Dübendorf	
Netzbetreiber:	Glattwerk AG	
	2013	+/- 2012
Netznutzung:	8.52	-1.73 %
Energie:	8.34	+5.04 %
Abgaben an das Gemeinwesen:	0.40	0.00 %
Förderabgaben (KEV):	0.45	0.00 %
Total:	17.71	+1.43 %

Die Preise sind in Rp./kWh exkl. MWST angegeben.

Von diesem Betrag sind **13.6% Fixkosten**, die nicht über den Stromverbrauch beeinflusst werden können.

17.71 Rp/kWh = CHF 796.95/year incl. MWSt



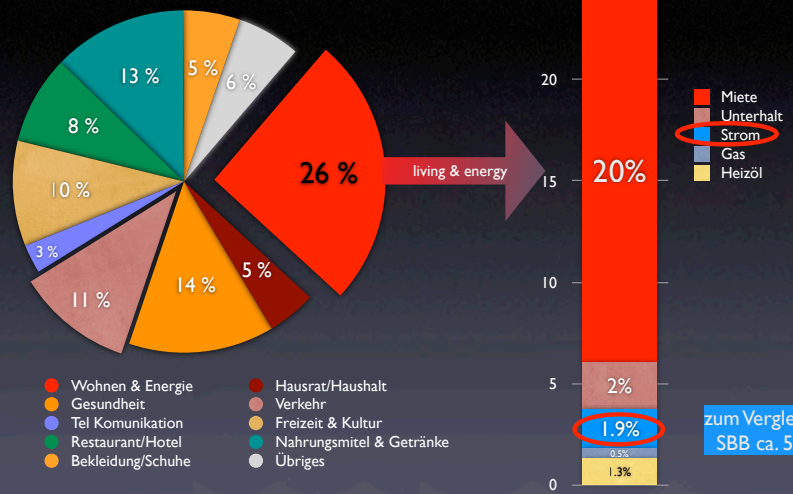


Cost for electric power H4
796.95- CHF/year incl. MWSt

- KEV in Dübendorf 0.45 Rp/kWh
- CHF 21.87 Fr/year & apartment
- CHF 1.82/month

How do we use our income?

Landesindex der Konsumentenpreise (Bundesamt für Statistik • Gewichtung 2010)



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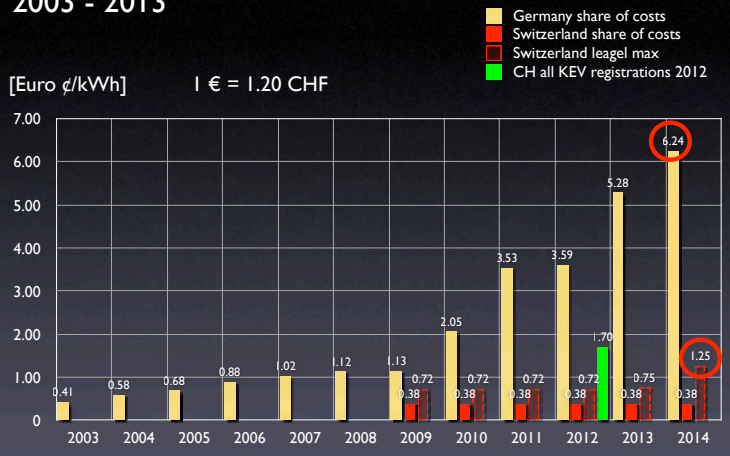
Share in the costs Germany and in Switzerland 2003 - 2013

12/2012 PV 32.4 GW marketshare 4.6%

12/2012 0.4 GW marketshare 0.5% • f = 81 to D



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What makes Photovoltaic in buildings so important? Why should we start with the existing building stock?

- EU Buildings → ≈25% of power, ≈36% CO_2 emission!
- CH Buildings → ≈31% of Power, ≈36% CO2 emission
- Buildings allows longterm investments 25+ years.
- Credible owners have access to low interest capital.
- Domestic buildings pay high electricity rates.
- The thermal and electrical improvement of European domestic building-stock is €100bn long-lasting decentralized market.
- PV modules are an important, but small part of the total investment.
- A important challenge:
  How can the owner (legally) share the cost with the renting party?

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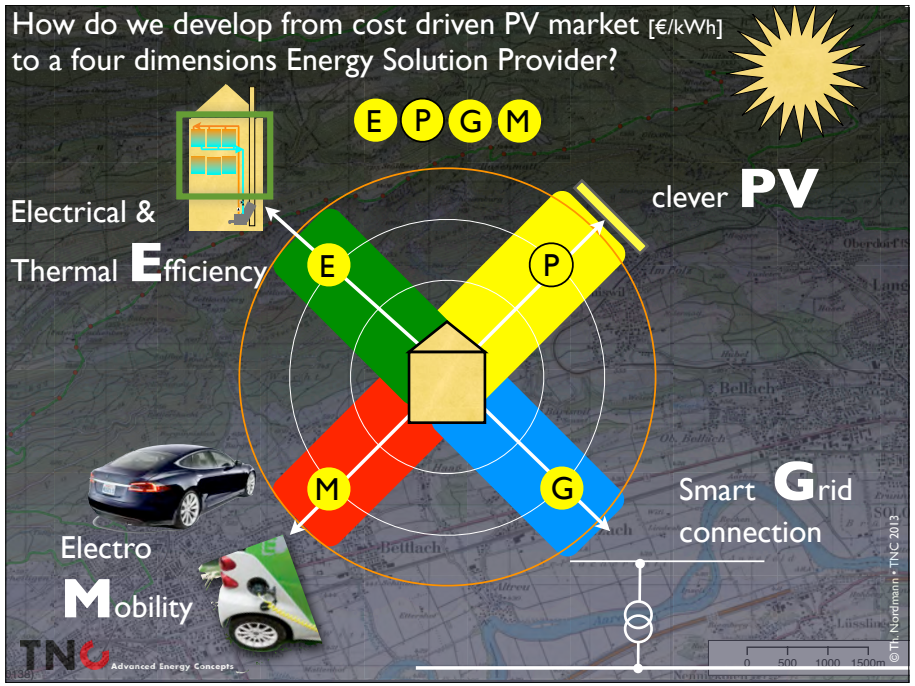
How do we develop from cost driven PV market [€/kWh] to a four dimensions Energy Solution Provider?



E Electrical Efficiency in buildings …

E Thermal Efficiency in existing buildings …

< 50 kWh/m² ERA
< 5 l/m² ERA [fuel oil]

ERA = Energy Reference Area [m²]

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E Electrical & Thermal Efficiency in new buildings
Passive house, Minergie +
First really Zero-Energy Office-Building Switzerland – MINERGIE®-P-ECO-certified - healthy work – wood construction – roof-integrated PV – Energy Globe Award Switzerland 2008 – European Award for building-integrated solar energy technology 2008 Architecture

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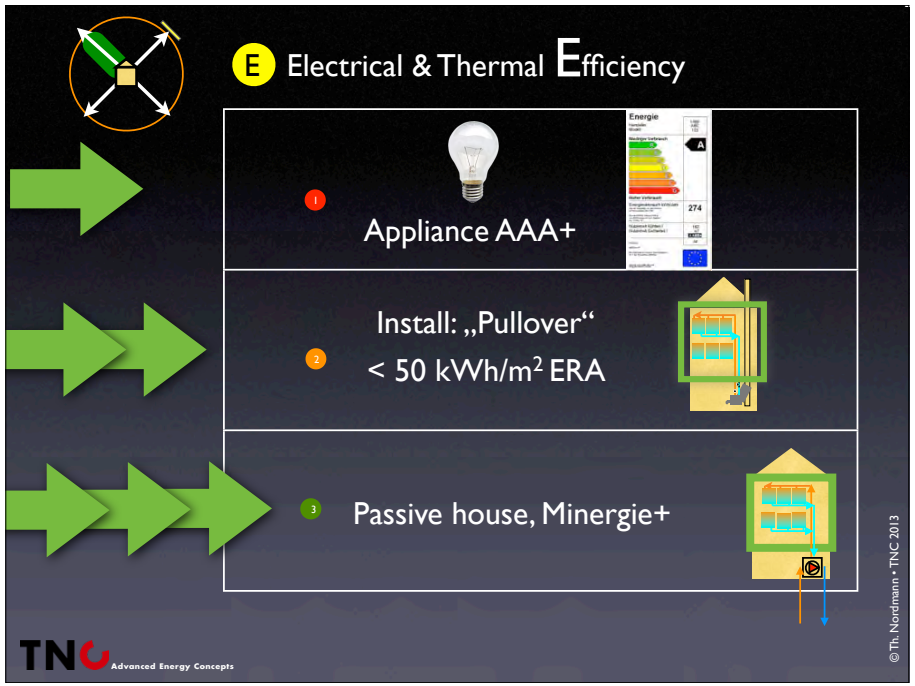
E Electrical & Thermal Efficiency
Appliance AAA+
Install: „Pullover“
< 50 kWh/m² ERA
Passive house, Minergie+
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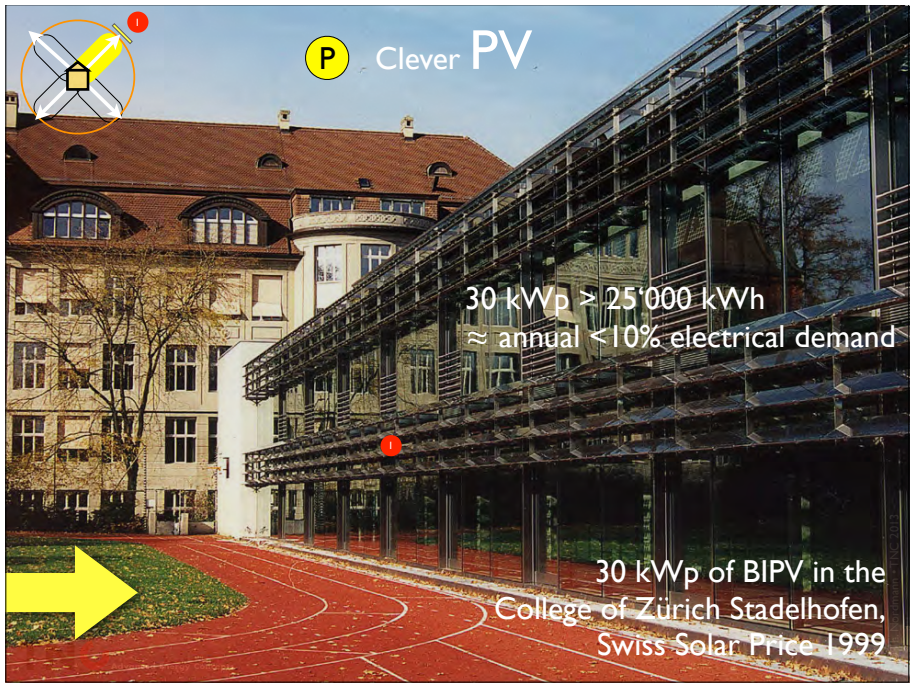
P Clever PV
30 kWp > 25'000 kWh
≈ annual <10% electrical demand
30 kWp of BIPV in the College of Zürich Stadelhofen, Swiss Solar Price 1999

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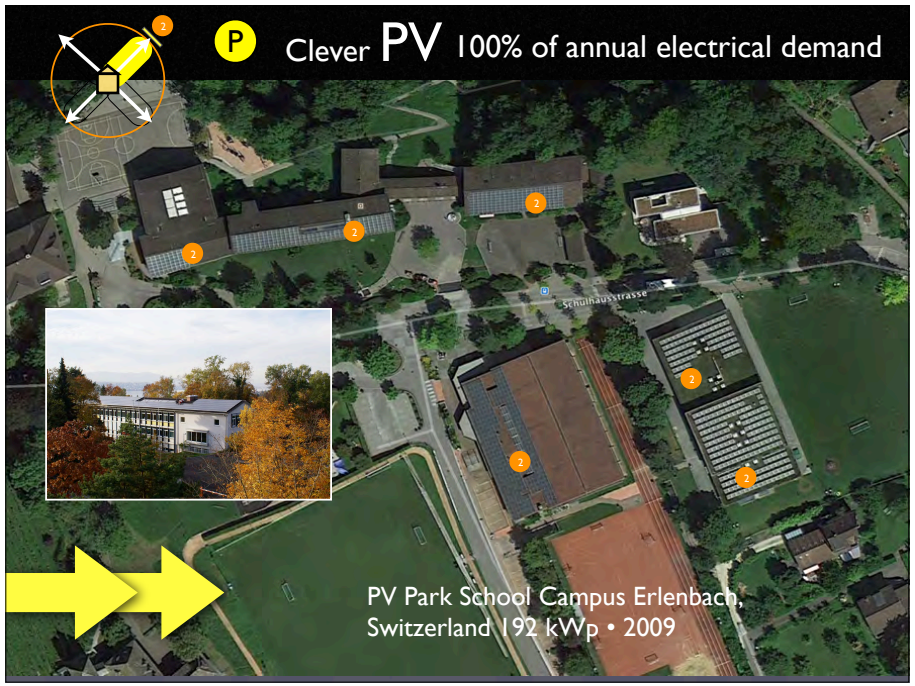
P Clever PV 100% of annual electrical demand
PV Park School Campus Erlenbach, Switzerland 192 kWp • 2009

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P Clever PV > 100% Annual electrical demand incl. E-W module

noon

north ← → south

roof-module fill factor = 30…50 %
yield = 100%

east ← → west

roof-module fill factor = 100 %
yield = 90%

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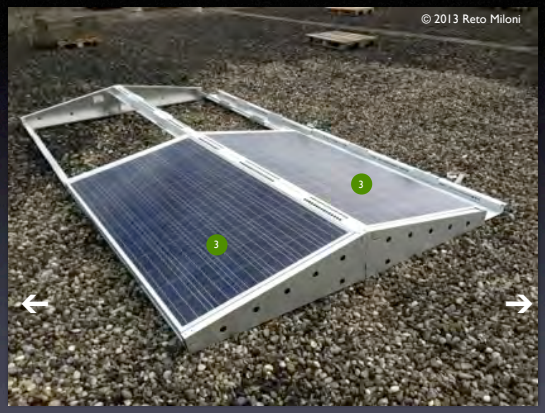
P Clever PV > 100% annual electrical demand plus O-W module lay out



west ← → east

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P Clever PV

S

1 < annual 50% electrical demand

S

2 ≈ annual 100% electrical demand

W E

3 > 100% annual electrical demand incl. E-W module lay out

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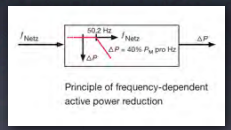
G Smart Grid connected

Inverter with grid services

50.2 Hz!



Energy Management under the renewed EEG 2012

Inverter with grid services are already mandatory in some member states with high PV penetration (i.e. Germany, Italy).

Installed PV Capacity	EEG 2009	EEG 2012
Pmax ≥ 100 kW	Energy management - remotely controlled	Energy management – remotely controlled
30kW ≤ Pmax ≥ 100 kW	No energy management requirements	Energy management – remotely controlled
Pmax < 30 kW	No energy management requirements	Either remotely controlled or fixed 70% feed-in limitation

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G Smart Grid connected

Power to heat
time shift of + 2h … 12h
~ 45 %

- TV, Audio & PC
- Hot Water
- Refrigerator
- Laundry, Dryer, Dishwasher
- Cooking
- Lighting
- Others

15 %
17 %
12 %

Hot Water 8h/24h

65°C
≈15%

Refrigerator 24h/24h
Refrigerator 8h/24h

2 - 8°C
≈17%

Laundry …

6h/24h

24h/24h

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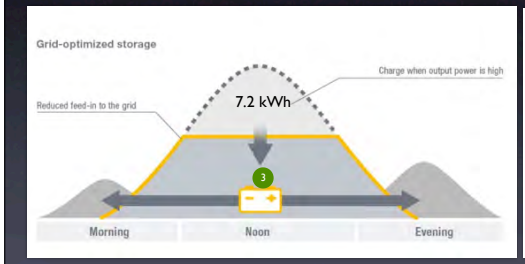
G Smart Grid connected

Local battery storage

> 25% daily demand shift for 24h



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G Smart Grid connected

Inverter with grid services

Power to heat
Time shift
± 2h -12h

>25% /day
Local battery storage

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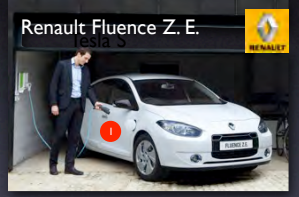
M Electro-Mobiles you can buy today …

electric-drive

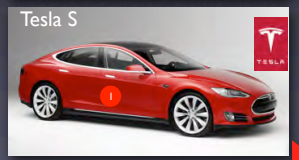
- 15 kWh/100km ➜ 1.7 litre gasoline/100 km
- 2 people • range 145 km/charge
- Power 55 kW/75 PS • Weight 995 kg
- Battery 17.6 kWh Li-Ion • Rent €/month 73.-
- Secured battery capacity up to 10 years
- Price: € 20'000.-

Renault Fluence Z. E.



- 14 kWh/100km ➜ 1.6 litre gasoline/100 km
- 5 people • range 185 km/charge
- Power 70 kW/95 PS • Weight 1`610 kg
- 22 kWh battery Li-Mn, O_2 • Rent €/month 78.-
- Secured battery capacity up to 10 years
- Price: € 24'500.-

Tesla S



- 15 kWh/100 km ≈ 1.7 litre gasoline/100 km
- 5 people • range 375 km/charge
- Power 225 kW/302 PS • Weight 2'100 kg
- Li-Ion battery 60 kWh
- 8 years and/or 160'000 km warranty
- Price: € 70'100.-

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Where do you charge your Electro-Mobile?

- 15 kWh/100 km ➜ 3'000 kWh/20'000 km
- Charging η > 80%
- You need a PV installation with 3 - 4 kWp
  Cost 2013 ➜ € 7'000.- … € 12'000.-
  ➜ now you have a full tank for next 25 years!

4 - 5 kW
4'500 kWh/Jahr

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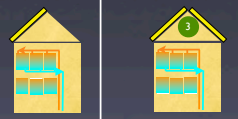
Electro Mobility

Buy your electro-mobile today!	
Charge your car battery storage (15 - 60 kWh) and double your PV Installation	
Double your PV self consumtione	

(PV) self-consumption makes good technical and economical sense.

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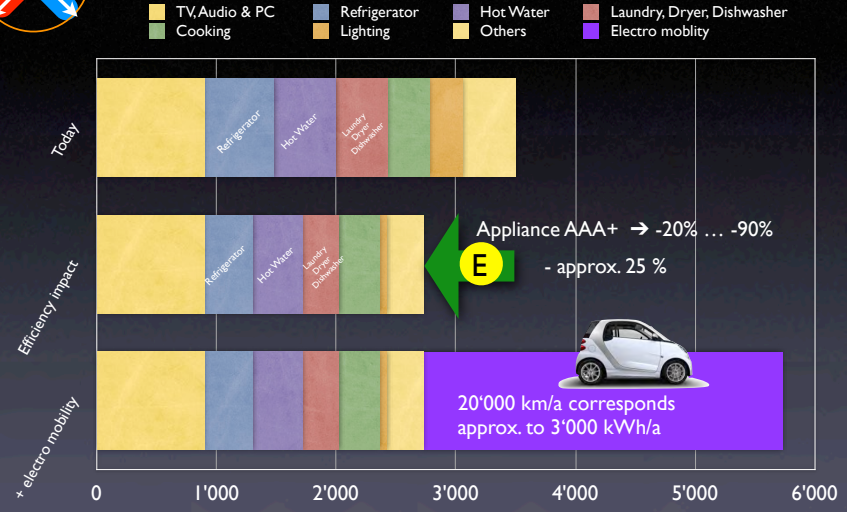
Power demand ø 2 pers. household (Germany) ~3500 kWh



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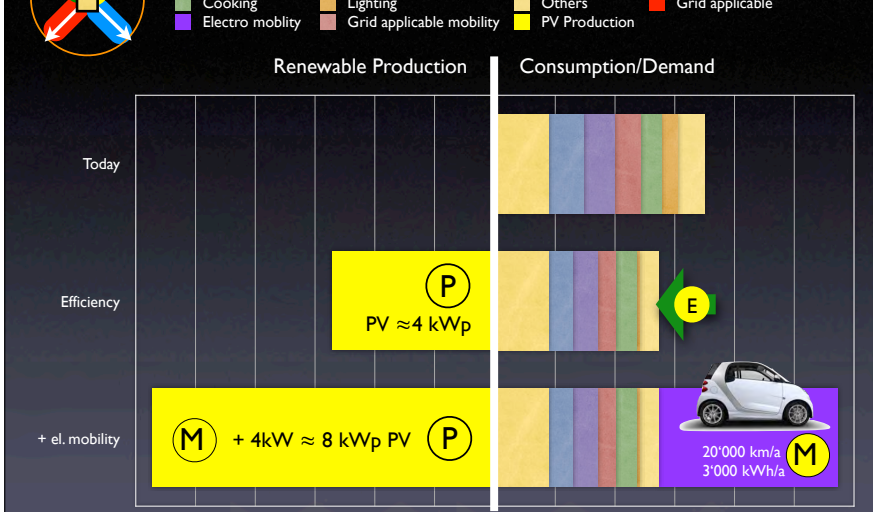
ø Two pers. household (Germany) ~ 3500 kWh



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PV self-consumption makes good technical & economical sense

G Smart Grid connected

Production	PV 4 kWp	PV 4 kWp
	Consumer Residential buildings	Electro Mobil
Power to heat, power to storage and power to wheel.	Thermal storage Battery storage 7.2 kWh Battery Grid claimable «power to heat» 45% time equality 20% «power to storage» 30%	Battery storage 18 kWh Battery Grid claimable «power to wheel»

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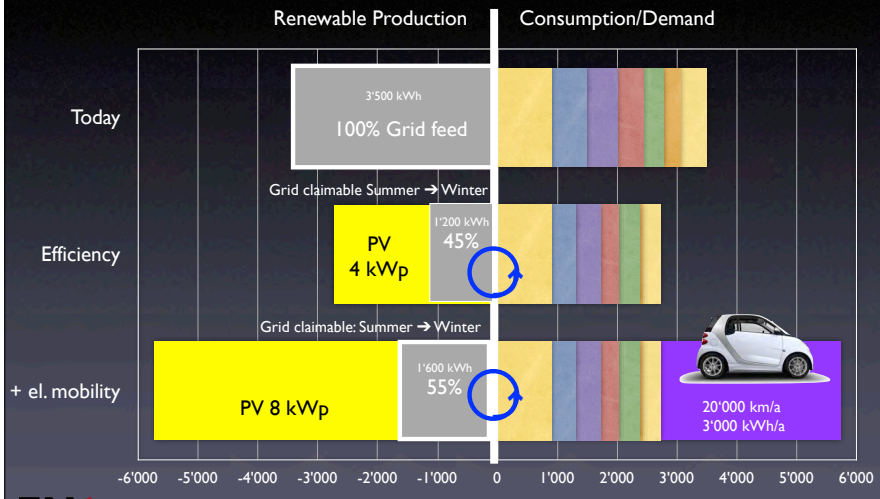
Ø Two pers. household (Germany) ~ 3500 kWh

TV, Audio & PC · Cooking · Electro moblity · Refrigerator · Lighting · Grid applicable mobility · Hot Water · Others · PV Production · Laundry, Dryer, Dishwasher · Grid applicable



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Your four dimensions Energy Solution Provider

E P G M

Electrical & Thermal Efficiency

1. Appliance AAA+ -20% ... -90%
2. < 50 kWhl/m² ERA
3. Passive house, Minergie +

Electro Mobility

1. Buy your Electromobile today
2. Charge your Electromobile with PV
3. Double your PV self consumption

clever PV

1. ≈ Annual 50% electrical demand
2. ≈ Annual 100% electrical demand
3. > 100% Annual electrical demand + E -W module lay out

Smart Grid connected

«power to heat»
«power to storage»

1. Inverter with smart grid services
2. «power to heat» time shift 2h -12h
3. > 25 % /day battery storage

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Conclusions I

Monday
We need PV when retrofitting the building stock.
PV offers attractive solutions and processes to improve energy solutions for buildings and allows almost CO_2 free individual mobility.

Tuesday
Successful energy solutions have to address the thermal **and** the electrical efficiency.

Wednesday
For clever PV in buildings we aim to distribute PV uniformly over 6 hours by orienting modules east and west with marginal losses in yield.
Thanks to the economical progress and self consumption we can use PV systems, which produce 100% and more of the annual electrical demand.

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Conclusions II

Thursday
With market share of 5% – 20% of PV, the challenge is to provide smart grid connections of sustainable PV houses.
PV self-consumption makes good technical and - economical sense.
Enhance it by power to heat and power storage.
Inverters are able to provide further grid services.

Friday
Buy your electromobile today and charge it with PV ➔ Power to wheel
20'000 km/a means additional 4 - 5 kWp of PV with high self consumption.
Grid claimable services are in the same range as conventional buildings.

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Conclusions III

Saturday
The main challenge: we need a joint European plan to allow high PV penetration in the power grid.
The presented index may help develop such a common plan.

Sunday
Photovoltaic is part of the solution, and not a problem!
To keep PV attractive, we have to start developing todays PV systems into integrated parts of the energy solution.
Sustainable energy buildings with mobility can be a part of this solution.

E fficiency
clever P V
Smart G rid
M obility
!

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