

"Solar architecture is not about fashion, it is about survival" (Lord Norman Foster, London)

PlusEnergyBuildings and Norman Foster Solar Award

(From Gallus Cadonau, lawyer/managing director Solar Agency Switzerland, Waltensburg/Zurich)

I. Europe's heated buildings as PlusEnergyBuildings

1. What is a PlusEnergyBuilding@?

A PlusEnergyBuilding (PEB) is a heated apartment or business building that produces more energy by a solar utilisation of its roof

or façade than it averagely needs over the year for heating/cooling, warm water and household and/or operating current¹. The most important prerequisite for PEB was

shown by Lord Norman Foster with his Chesa Futura in St. Moritz in 2002: a good Minergie-P/ passive house heat insulation! (See fig. 1, left)

First law for PEB: energy efficiency according to Minergie-P standard



2. How does a PlusEnergyBuilding@ work?

To build a PlusEnergyBuilding (PEB) is simple: A good Minergie-P/passive house heat insulation, a solar installation on the roof and you already get a PEB producing more energy than it needs on the annual average². Therefore, a well insulated, budget-priced house can be converted into a zero-energy or PlusEnergyBuilding without any problem. Some examples show today's level of building technology and what can be done already.

Fig. 1, left: The clever solar prize winners eliminated the big energy losses of 85 to 95% of heated buildings in an economical and sustainable manner by an optimum Minergie-P insulation. That this can be done in an elegant way was shown by Norman Foster in St. Moritz in 2002. The Chesa Futura does not only have the usual Minergie-P heat insulation of about 35 cm, but a heat insulation of 50 cm or 47% more than Minergie-P insulation. How energy losses in a 12-family house can be reduced by 93% from 223,000 kWh/a before refurbishment to 15,800 kWh/a after refurbishment is shown by architect Karl Viridén in the historic city centre of Basel (Fig. 2, right: Swiss Solar Prize 2009, p. 36 ff.)

Second law for PEB: renewable energies!



Fig. 3: Energy self-supply of 100-260% by renewable energies: In Kempthal/ZH near Winterthur architect Beat Kämpfen proved how it is possible to build a budget-priced, elegant zero-energy business house with cheap amorphous solar cells. The 44.6 kW-PV-installation produces 40,000 kWh/a, and covers 100% of the annual energy need of the service building (Swiss Solar Prize 2007, p. 32). With monocrystalline solar cells of Sunpower ($\eta = 19\%$), such as offered by Solar Agency Research 2010 in Basel, it would be able to produce about 105,000 kWh/a on the roof, i.e. an energy self-supply of 260%.

¹ **PlusEnergyBuilding:** According to the regulations for PlusEnergyBuildings the total average annual energy production over 18 months is at least 1.00 kWh/m²a higher than the total annual energy need of the PEB (see Art 3 of the regulations, PlusEnergyBuildings and system boundaries, www.solaragentur.ch -> Schweizer Solarpreis/Reglemente). This PEB definition originated from a European cooperation of technical universities and their professors such as University of Glasgow, Mackintosh School of Architecture in Glasgow; Institut. DL/CNRS, ParisTech, Paris, technical universities of Berlin and Stuttgart, Swiss academies and professors in Berne, the North-western part of Switzerland/Muttenz, Genève, Lausanne and Winterthur as well as other experts.

² Kurt Frei, Director Flumroc AG gave a popular and concise definition for PEB (see. Swiss Solar Prize 2009, p. 11).

³ **New Monte Rosa Lodge SAC,** Mountain Lodge of the future, Lauber IWISA, p. 1/2, Naters/VS, Sept. 2009; Federal Institute of Technology Zurich (ETHZ) with Prof. Dr. Marc Angéil, head of architecture department, ETHZ, Prof. Dr. Meinrad, K. Eberle, project leaders „150 years of Federal Institute of Technology Zurich“; Prof. Dr. Lino Guzzella, Institute for dynamic systems and control engineering, department of mechanical engineering and process engineering, ETHZ; Prof. Andrea Deplazes, Professor for architecture and construction, book presentation and introduction into the exhibition of Febr. 23, 2010: „The building will supply its energy by at least 90%“, see www.ausstellungen.gta.arch.ethz.ch/ausstellungen/neue-monterosa-huette-sac; Technical School Central Switzerland, HTA, New Monte Rosa Lodge, energy and building technology, 21.12.2006 with the restriction: „The energy self-supply will be more than 90%, wherein cooking energy is not considered.“ (page 70)

3. The power of solar energy in the building sector is massively underestimated

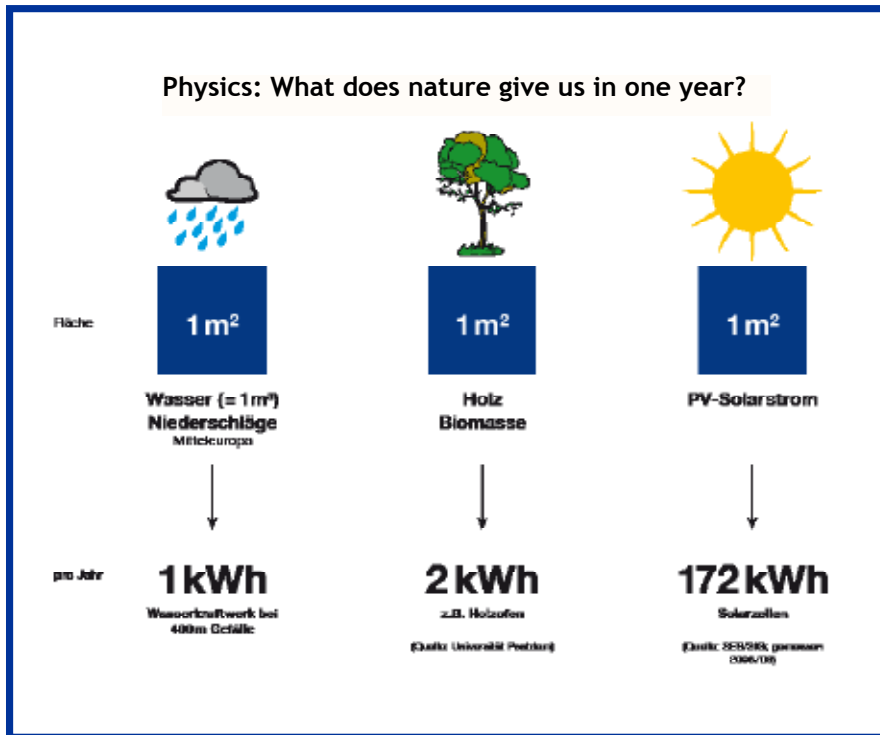


Fig. 4, left: What nature gives us in Europe each year per square meter

- **Water power:** In Central Europe, the amount of rainfall is approximately 100 cm per year or 1 meter. 1 m² therefore accumulates 1 ton of water per year (1 m² x 100 cm = 1000 litre of water). In order to produce 1 kWh/a, a ton of water has to fall about 400 m and power a turbine with a generator.
- **Biomass:** There are approximately 10 million m³ of wood growing each year in the European forests. If not used for constructing purposes, part of the wood can be used energetically. On 1 m² of (unfertilized) wood grows an annual biomass with an energetic value of 2 kWh/a.
- **Solar energy:** In 2008/09, the roof of the SES/SIG industrial building in Geneva generated a solar production of 585,000 kWh/a (fig. right). The mono-crystalline solar surface of Sunpower has a surface of 3,395 m². This corresponds to an electricity production of 172 kWh/m²a.

Conclusion 1: Amount of energy per square meter and storage: The measured electricity output of the mono-crystalline solar cells of Sunpower of 172 kWh per square meter in Geneva is therefore 172 times bigger than the electricity output of water power per square meter; in order to produce the same amount of electricity as one square meter of solar cells in Geneva, 172 tons of water have to fall over 400 m to power a generator. In order to produce the same amount of electricity in a year as the SES/SIG roof (without solar utilisation of the façade), a water amount of a lake of 585,000 t of water and a falling depth of 400 m would be necessary. The energetic, strategic advantage of water power lies in the storage of water. Because only by using water power for storage purposes it is possible to ensure a full energy-supply around the clock.

Conclusion 2: Five times more energy on the roof: The annual solar production of 172 kWh per square meter is five times higher than the total energy demand of a Minergie-P/passive house with an energy index of 30 to 35 kWh/m²a (energy index: annual energy demand per heated square meter in apartment buildings). With an electricity output of 172 kWh/m²a, a Minergie-P/passive house of four to five floors can be completely supplied with the needed energy without using the solar radiation on the façade. If the façade is used as well, it is possible (with today's level of technology and according to location and utilisation of the building) to produce the total energy need for heating, warm water and household current for buildings up to 150 m height from an intelligently used building envelope. Only prerequisite: Minergie-P/passive house standard, intelligent architects and skilled workers (see PEB: www.solaragentur.ch).

4. Building refurbishments and monuments



Fig. 6: In 1998, the world-renowned star architect Lord Norman Foster refurbished the historic Reichstag in Berlin dating from 1896. Thanks to an elegantly integrated 37.5 kW-PV-installation and a block heating station operated with organic rape of 2.35 MW, the Reichstag is today almost exclusively operated with renewable energies, and CO₂ emissions were reduced by 94%.



Fig. 7: With the PEB-refurbishment of Christoph Ospelt in Vaduz, the total energy consumption of 50,200 kWh/a was reduced to 7'000 kWh/a or by 86%. The PV-installation is producing 12,700 kWh/a, which leads to a solar energy excess of 5,700 kWh/a or 82% of the total energy need. Compared to the total need, the building has an energy self-supply of 182%: With the solar excess of 5,700 kWh/a between three and four solar-operated electric cars can drive 12,000 km annually.

5. Monte Rosa Lodge with alternatives for the future

Situation: The dossier of the Monte Rosa Lodge lead to several discussions in the technical commission and the Swiss Solar Prize jury before a decision was made: Comfort and architecture are highly mentionable, but the published „energy self-sufficiency of 90%“ and the level of building technology must be examined critically.³ The unique architecture with a convincing completion of the interior and advantages in comfort were mentioned in the laudation and presentation of the Solar Prize on p. 38/39. However, U-values of heating need, energy indexes, need of electricity and cooking energy were questioned. The jury also wanted to verify if a higher self-sufficiency was possible and if the building corresponded to the actual level of technology. Therefore, battery and hydrogen storage incl. risk potential were to be analyzed. The proceeding took place by granting the right to a hearing of the involved parties. The Solar Prize jury reserved the right to consult independent experts and scientists such as the EPMA for hydrogen questions as well as expert and public studies or expert opinions such as the EMPA-certified IEA SHC Task 37 “Solar façade for building refurbishments with low energy consumption” of Aug. 27, 2004. The jury thanks the representatives of the Monte Rosa Lodge for giving access to the files and the mutual proceeding in order to answer the above-mentioned questions.

Level of technology: It has to be considered that the SAC Monte Rosa Lodge is supposed to be open only in summer, i.e. 28 weeks per year. In order to get objective, comparable values, the SIA norm 380/1 is applied. The actual level of building technology (Art 9, paragraph 2 energy law) is determined by applying the “accepted rules” of technology. Rules of technology are accepted if they „derived from practical experiences“, and „were accepted by the relevant expert groups and applied successfully“.⁴

Proceeding and alternatives: The Monte Rosa Lodge is a challenge for engineers and the performance of solar architecture since the SAC lodge should practically be self-sufficient. As it appears from the documentation, about 24,000 kWh/a of energy for board and lodging are transported to the lodge by helicopter (and not 5,700 kWh/a as initially reported). In order to answer the question if a self-sufficient Monte Rosa Lodge was technically feasible and economically possible, four alternatives of energy efficiency according to SIA 380/1 were considered for a comparable SAC lodge. For the verification, all conditions (room, façade, building and business conditions) were taken as given without any alteration. A calculation for 365 days according to SIA 380/1 leads to the following results and alternatives:

- A - Actual situation (insulation: 30 cm/U-value: 0.13)
- B - Heat insulation with U-value such as restaurant “Kl. Matterhorn” (insulation: 52 cm/0.09 U-v)
- C - As alternative B plus EMPA-certified „solar active façade” (EMPA, 27.08.2004)
- D - As alternative C plus optimization of construction, windows, household appliances etc.
- E - As alternative D plus PV-utilisation of façade (SE and SW) (+335 m2 of PV).

Verified result according to SIA 380/1 (365 days):

Alternatives (in kWh/a)	A	B	C	D	E
Total energy demand:	90'000	80'000	65'000	41'700	34'700
Energy self-production:	42,100	42,100	42,100	42,100	60,300
Energy supply:	47'800	37'800	22'900	23'900	0,0
Level of self-sufficiency:	47%	53%	65%	100%	174%

Options: From status quo to PlusEnergyBuildings - more solar energy than in the Sahara

Since 2000, there have been built 15 PEB in 8 cantons (AG-3, BE-3, BL-1, BS-1, GR-3, SZ-2, SG-1, VS-1) with access to the infrastructure of energy, water, waste water etc. These 15 PEB are working without any problems so far. From the climatic conditions in the building area of Monte Rosa, the jury experts conclude that it is possible to build a PEB also in a high alpine region; the solar radiation in these regions is for example much better than in the Sahara. If the SAC Monte Rosa Lodge was operated not only 28 weeks per year, but year-round, its self-sufficiency would drop from 65% to 47% (alternative A). If the lodge was insulated according to alternative B such as the solar restaurant “Kl. Matterhorn”, its self-sufficiency would increase to 53% (alternative B). With a solar active façade certified by EMPA, the self-sufficiency could even increase to 65%. If all alternatives (B+C+D) were combined (including an optimization of construction, windows, doors, thermal bridges etc.), it would theoretically be possible to get a thermal self-sufficiency of 100%; this, however, is only theoretically, since operating and cooking current have to be transported as well.⁵

Alternative E: PEB with a self-supply of 170% calls for energy storage

Alternative E is based on the energy-efficient alternative D with additional optimizations in the building and the building technology such as LED lights, improved cooling system, better cooking devices, less standby losses etc. with a differentiation between habited and unoccupied-times. It also considers an optimization of solar utilisation on the South-eastern and South-western façade and the roof surface such as asked for by the jury. With a storage perspective, a solar utilisation of the South-eastern and South-western façade with 190 m2 and of the roof with 145 m2 makes sense. The total energy need can be reduced to about 34,700 kWh/a, and the PV output can be increased to 60,300 kWh/a or by 174% (net surface). In the present autarkic situation, solar energy excesses can not be fed into the grid, but must be stored adequately. With an optimized PV utilisation (instead of aluminium surface), it is possible to produce 18,200 kWh/a more solar electricity and therefore have a solar electricity excess of 25,600 kWh/a.⁶

Alternatives for energy storage: According to the EMPA report of Prof. Dr. A. Züttel/Dr. M. Biemann, EMPA, of July 15, 2010, about 14,000 kWh/a of the solar electricity excess can be used for cooking by a hydrogen-hybrid solution (instead of using propane gas). From fuel cells it is possible to gain about 7,000 kWh/a of electric energy for cooking or for operation and 7,000 kWh of heat energy. Of course it is also possible to increase battery capacity correspondingly from 14 to 75 kWp and its weight from 4.2 t to 27 t. The energy-independent apartment building Jenni in Oberburg/BE used such a storage system for 11 years (1989-2000). Thanks to such an additional energy production it would be possible to cook more meals, have more overnights,

run the showers or secure water supply or waste water disposal without any energy transports per helicopter.

EMPA experts: hydrogen with little danger. The EMPA experts point out that about 500 billion hydrogen (H2) is produced and commercially used each year. It can therefore not be referred to an eminent danger of H2. Personal safety is assured at all times. The EMPA experts also point out that oxygen is considerably more flammable than hydrogen. In metal-hybrid form, hydrogen can be stored far better. Similar to propane gas, it can be used as a renewable cooking gas (with a ceramics-like hotplate).

Conclusion and PEB options: In order to better use the solar electricity excess, hydrogen or battery storage would be possible on the spot. The jury considers the comment of the EMPA as convincing, feasible and credible. Based on the calculations of the jury experts as mentioned above, the question of the solar prize jury of June 3, 2010, if an increase in energy-efficiency and an optimization of solar energy were possible, can therefore be clearly answered with yes. Furthermore, contrary to an aluminium façade, the grey energy of PV installations is “paid back” after 4 years. Thanks to PV, the grey energy of the whole SAC building can be paid back within 4 to 5 years.

Alternative E should be considered at least for new SAC buildings. It corresponds to the actual level of technology 2009/2010 applied in the building refurbishments and new buildings that are awarded the Swiss Solar Prize 2010. The Swiss branch of building technology is virtually waiting for such interesting orders...

4 Contract of work, Prof. Dr. Gauch, Freiburg, March 1996, N. 846 and 851. PlusEnergyBuildings (PEB) have been awarded since 2000; in 2010 alone, 11 PEB registered for the Swiss Solar Prize and for the Norman Foster Solar Award. Expert groups agree that PEB correspond to the actual level of technology and some politicians have the opinion that “future buildings should all be PEB” (see Swiss Solar Prize 2010, p. 35).

5 This value is only theoretical and for thermal provisions - without cooking energy or electricity.

6 With 71 kWp instead of 16 kWp it is possible to produce 60,300 kWh/a on roof and façade of the Monte Rosa Lodge without needing the solar installation of 56 m2 on the rock western to the lodge.

II. Why a „Norman Foster Solar Award“ for PEB?

No other architect summarized the necessity of solar utilisation as concise as Lord Norman Foster who designed the most famous and fascinating buildings during the last 40 years worldwide.

The mentioned buildings such as Chesa Futura in St. Moritz, Reichstag dating from 1896 and Faculty of Law of the University of Cambridge (1990 - 1995) are complemented by many other buildings in which Lord Foster set the standards for energy efficiency.⁷

1. Technology, aesthetics and functionality are perfectly combined

After the renovation and energetic refurbishment of the Reichstag in Berlin, the former President of the Bundestag Wolfgang Thierse defined Foster's buildings as follows: „They distinguish themselves by a perfect technolo-

gy, aesthetics and functionality. Foster's buildings have their own and incomparable beauty and fascinate the viewer. They are uncompromisingly modern, but are still respecting the past. They integrate into the environment, but still stick out“. (Berlin, 01.06.2005)

2. Sun and aesthetics with Art 18a RPG (Swiss law for landscape planning)

The branch of building technology in Central and Northern Europe has been showing us since many years that solar installation can be perfectly integrated (Swiss Civil Code 642) into roof and façade. Buildings that correspond to the Minergie-P-/passive house standard do not only cover their whole energy need - they produce ever higher excesses of solar electricity for the public grid. In 2007, our co-president, NC Marc F. Suter, and Coun-

cil of State Dr. Eugen David succeeded in cooperation with many other allies to anchor a "careful integration" of solar installations into roof and façade of buildings in Art 18a RPG (Swiss law for landscape planning). According to this article, which came into force on 1.1.2008, „solar installations that are carefully integrated into roof and façade" are therefore granted authorisation.⁸

It is obvious and logical that an exemplary solar architecture is associated with the name Foster. It is a great honour to us and to the Swiss and European branch of solar building technology that we are able to award those PlusEnergyBuildings with the best solar architecture with the first Norman Foster Solar Award on September 3rd, 2010.⁹

III. PlusEnergyBuildings replace 22 nuclear power plants

1. PEB: Level of building technology 2010

Since 1990, Art 89 of Switzerland's Federal Constitution (BV) has been regulating the promotion of renewable energies and energy efficiency. According to Art 92 EnG (Swiss Energy Law) buildings in Switzerland must conform to the level of technology. The Minergie-P standard established itself in Switzerland by 2002 with the German passive house standard.¹⁰

The new, solar operated Minergie-P PEB show an energy self-sufficiency of 109 to 182%. Additionally to their complete self-supply, they are able to deliver between 9% and 82% of solar excess to the public grid; the average of all PEB has a self-supply of 136% (see PEB box with Norman Foster Solar Award). This building standard corresponds to the new level of technology and can be applied all over Switzerland and Central Europe.¹¹

Norman Foster Solar Award for PEB	
1. Principality of Liechtenstein	182%
2. Canton Berne (BE)	170%
3. Canton Aargau (AG)	164%
4. Canton Schwyz (SZ)	153%
5. Canton Aargau (AG)	153%
6. Canton Valais (VS)	121%
7. Canton Berne (BE)	115%
8. Canton Grisons (GR)	112%
9. Canton Grisons (GR)	111%
10. Canton Schwyz (SZ)	110%
11. Canton St. Gallen (SG)	109%

2. Buildings make up for 50% of the energy need

In the OECD countries, the building sector is using about 50% of the total energy need - in Switzerland 125 TWh/a. If new buildings are all PEB, they would be able to cover the total energy need of all Swiss buildings of 125 TWh/a. In 2008/09, innovative entrepre-

neurs, solar prize partners and solar prize winners built apartment and business buildings with an energy self-supply of not only 100% but 136% on the average! This corresponds to a substitution potential of 170 TWh/a, or 22 big nuclear power plants of 7.5 TWh/a (e.g. NPP Gösgen).

3. Solar energy reduces grey energy

The expression "grey energy" describes the need of energy including all pre-processes for the fabrication of a product. In 100 years, a traditionally tiled roof or a façade in aluminium or glass does not produce one single kWh that would be necessary to pay back the production energy (energy pay-back time). A payback of the grey energy of a building and its solar installation is only possible with solar energy. In 6 to 36 months the total energy needed for the fabrication of the solar installation is produced; usually even a multiple of it. From an energetic point of view, PlusEnergyBuildings are therefore the only buildings able to payback their grey energy. This is shown by the example of the Monte Rosa: With an optimum PV utilisation according to alternative E (South SE/SW and roof = 457m² gross surface Ø 159 kWh/m²a), 315,000 kWh are needed for the production of the PV installation. After 4.3 years (72,800 kWh x 4.3 = 315,000), the PV installation will have produced its production energy - in 25 years it produces 1,820,000 kWh and is therefore "paying back" 1.5 GWh of grey energy. The aluminium façade will still have 31,500 kWh of grey energy and does not reduce the grey energy of Monte Rosa at all.

4. How to finance PEB?

How can PEB be financed? The answer is simple: In 2008, Switzerland paid 13.4 billion Swiss Francs or more than 1,700 CHF per in-

habitant for oil and gas imports from Russia and the Arabic countries. During the past 5 years (2005-2009), Switzerland paid 52.1 billion CHF for energy imports. Let's fight for a Switzerland that is investing the biggest possible part of these billions into a domestic creation of values, into the Swiss building sector, for tenants and landlords, for the local building industry, for domestic renewable energies and jobs instead of burning non-renewable energies.

5. PEB are able to produce traffic energy

In order to substitute the energy output of 22 big nuclear power plants of 7.5 TWh/a (e.g. NPP Gösgen) in Switzerland on the long-term, all future heated buildings must be authorized and built in a way that they averagely conform at least to today's level of technology of PEB. With a renewal rate of buildings of 1.5% per year, this would lead to a substitution of 2.5 TWh/a (1.5% of 170 TWh). In 10 years, therefore, 25 TWh/a (10 x 2.5 TWh/a) or the total annual production of all 5 Swiss nuclear power plants could be substituted. Until 2078 (without new technologies or additional research), 170 TWh/a (2.5 TWh x 68 years) or 22 NPP and practically all fossil fuels (oil, gas, coal) could be substituted - if the PEB building technology of 2008/2010 was applied (see box "Norman Foster Solar Award for PEB"). PEB would produce enough solar electricity to supply the complete sector of individual traffic.

⁷ See Lord Norman Foster: Sustainable Architecture in the 20st Century, Swiss Solar Prize 2005, p. 3, as well as his speech at the 15th Solar Prize Award at EPFL, Lausanne 2005, when he pointed to the correlation between energy, landscape and city planning as well as traffic. Best integrated installation: Aerni AG, Arisdorf/BL, industrial building Scheidegger AG, Kirchberg/BE and solar house F. Meyer, Lausen/BL.

⁸ See Art 18a RPG and building proceeding for solar installations, Swiss Solar Prize 2009, p. 58/59 and Swiss Solar Prize 2008, p. 40/41.

⁹ See also part „Norman Foster Solar Award“.

¹⁰ See Swiss Solar Prize 2002, p. 46 ff.

¹¹ Since the „published norms“ (e.g. SIA) are often out-dated after a short time, an optimization is only possible by applying the "accepted rules" of technology. Rules of technology are accepted if they „derived from practical experiences“, and „were accepted by the relevant expert groups and applied successfully.“ (See contract of work, Prof. Dr. Peter Gauch, Freiburg, March 1996, N846 and N851 as well as decision of the Federal Court BGE 117 IB 28, E6a).

¹² Swiss energy statistic 2009, p. 49.

IV. Worldwide energy demand in the building sector

A. OECD building sector: 50% of total energy consumption in TWh/a (rounded values)¹³

Annual energy consumption	%	CH	D	F	GB	EU	China	USA	World
Final energy consumption in TWh/a	100%	250	3,200	2,600	2,100	18,000	20,000	24,000	130,000
Building sector ¹⁴ Heating, cooling, building equipment (= 38%) Warm water (= 5%) Electricity, lighting, communication (= 7%)	50%	125	1,600	1,300	1,100	9,000	10,000	12,000	65,000
Mobility/traffic	32%	80	1,000	850	700	5,800	6,200	8,000	42,000
Industry/process heat	14%	35	450	350	300	2,500	3,000	3,300	17,000
Further energy need	4%	10	150	100	100	700	800	700	6,000

Level of building technology 2010: In the OECD countries, the building sector is using about 50% of the total energy need - in Switzerland 125 TWh/a. In Germany: 1,600 TWh/a, France: 1,300 TWh/a, GB: 1,100 TWh/a; and EU: 9,000 TWh/a.

B. Building sector covers the total energy need of buildings (50% of total energy consumption)

Annual energy consumption	%	CH	D	F	GB	EU	China	USA	World
Final energy consumption in TWh/a	100%	250	3,200	2,600	2,100	18,000	20,000	24,000	130,000
Building sector (TWh/a)	50%	125	1,600	1,300	1,100	9,000	10,000	12,000	65,000
PlusEnergyBuildings (PEB) can substitute the potential of nuclear power plants (NPP):	AKW	16	210	170	145	1,200	1,300	1,600	8,700

Level of building technology 2010: If new buildings are all PlusEnergyBuildings (PEB), they would be able to cover the total energy need of the building sector - in Switzerland 125 TWh/a - corresponding to the production of 16 big nuclear power plants of 7.5 TWh/a (= NPP Gösigen). In Germany: 1,600 TWh/a = 210 NPP, France: 1,300 TWh/a = 170 NPP, GB: 1,100 TWh/a = 145 NPP; EU: 9,000 TWh/a = 1,200 NPP etc.

C. Building sector covers 136% of the total energy need of modern buildings 2010 (= 70% of the total energy consumption of OECD countries)

Jährlicher Energiebedarf	%	CH	D	F	GB	EU	China	USA	World
Gesamtenergiebedarf in TWh/a	100%	250	3,200	2,600	2,100	18,000	20,000	24,000	130,000
Gebäudesektor: Substitutionspotential in TWh/a (= 136%)		170	2,180	1,770	1,400	12,200	13,600	13,300	88,400
PlusEnergieBauten (PEB) substituieren das Potential von Atomkraftwerken (AKW):	AKW	22	290	230	190	1,600	1,800	2,200	11,800

In 2008/09, innovative entrepreneurs, solar prize partners and Swiss solar prize winners built apartment houses and business buildings with an energy self-supply of 109-182% - i.e. 136% on the average! This corresponds to a substitution potential of 170 TWh/a (136% x 125 TWh/a), or 22 big nuclear power plants. In Germany: 2,180 TWh/a (136% x 1,600 TWh/a) = 290 NPP; France: 1,770 TWh/a = 230 NPP; GB: 1,400 TWh/a = 190 NPP; EU: 12,200 TWh/a = 1,600 NPP; China: 13,600 TWh/a = 1,800 NPP; USA: 16,320 TWh/a = 2,200 NPP and global: 88,400 TWh/a = 11,400 NPP. In 2010, there were about 420 NPP in operation worldwide.

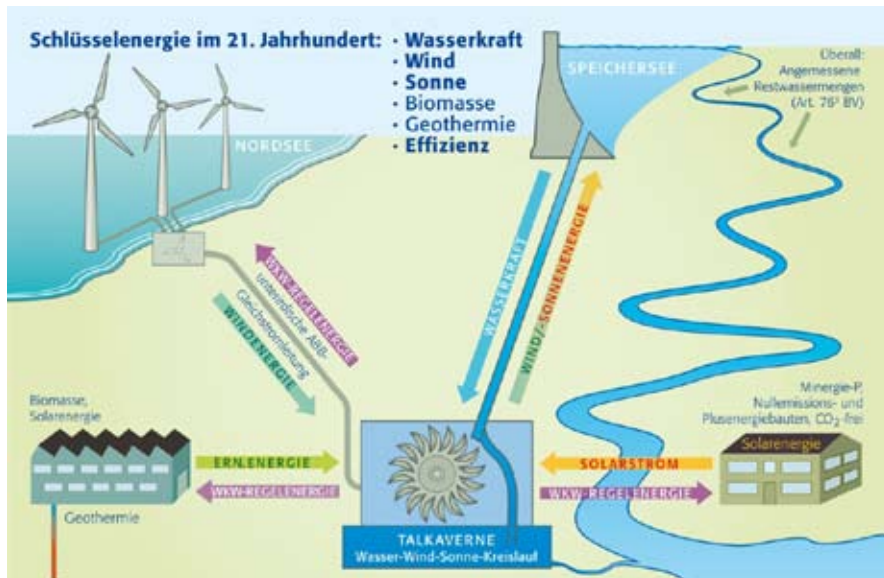
¹³ Sources: International Energy Agency (IEA), World Energy Outlook 2002/09, Paris; BP-energy-statistics 2009; Eurostat 2009/2010; US-Department of Energy, 2009; Office Federal de l'Énergie, Gesamtenergie Statistik 2005/2009; Scientific American, November 2009, Prof. Mark Jacobson//Delucchi, A Plan for a Sustainable Future, p. 58-65; University of Stanford, 2009, Spektrum der Wissenschaft, December 2009, p. 80 - 87; Prof. Leon Glicksman, Building Technology Group, Department of Architecture, MIT, Boston; Swiss Solar Prize 2005, p. 10; Dr. Koen Steemers, Director of the Martin Centre for Architecture, University of Cambridge, Swiss Solar Prize 2005, p. 10; Konferenz kantonaler Energiefachstellen, (Gebrauch erneuern - Energieverbrauch halbieren), test results of 2,900 Swiss Solar Prize buildings (1896-2010). (Determination basis for final energy consumption)

¹⁴ Solar Minergy-P/Passive house standards: Houses do not only differ in style and form, there are also differences in the energy consumption values and energy indexes depending on the regional (and individual) building standards of heated buildings (US - Central Europe; there are also huge variations in the production methods and the statistical investigation, e.g. hydro-power in Norway or coal electricity in China/US etc.). Furthermore, the figures depend on the local level of building technology, on the number of heating days as well as on climate conditions. The analyzed buildings built until 1990 have an energy need of 200 to 250 kWh/m²a or even more. For most of them, between 75% and 90% of the total energy need is used for heating and cooling. With the Minergy-P/Passive house standard this huge energy inefficiency in the building sector with energy losses of 70 to 95% can be substituted or eliminated in practically all cases without any loss of comfort. - A solar PV-performance of 15% to 30% of the former energy need (30 to 75 kWh/m²a of solar electricity) is usually enough to cover the total energy need of approximately 20 to 50 kWh/m²a of an energy efficient, heated Minergy-P/passive house building. Economically and ecologically it does not make any sense to build PV or other power plants such as wind, geothermal, gas or even nuclear power plants to produce 80% of energy losses in the building sector. It makes complete sense, though, to build PlusEnergyBuildings and to use wind energy etc. for a solar operation of electric cars in individual traffic or for selling clean solar electricity to the grid. By doing so, buildings that cannot be refurbished to PEB can be supplied with clean, renewable energy. - All these above mentioned reasons therefore confirm the energy thesis of Prof. Mark Jacobson of the University of Stanford (see Scientific American, November 2009, p. 60 ff.), whereby in 2030 we will not need a global performance of 16.9 TW as estimated by the IEA and the US Energy Information. On the contrary: a global performance of 11.5 TW such as prognosticated by Jacobson will be more than enough. And if the PEB building standard is applied consistently, even a global performance of 6 to 8 TW until 2030 will be more than sufficient (see G. Cadonau, Power for the World, Pan Stanford Publishing Pte. Ltd., Singapore, September 2010, Chapter 5.3: Stanford: "Clearly, Enough Renewable Energy Exists and PEB-Conclusion: PV, wind, hydropower and biomass can cover more than 100% of the of the total energy need).

V. Ecologic pump storage power plants supply the regulating energy for PEB

1. Special thanks go to RE Power that agreed to sponsor the first Norman Foster Solar Award and PEB Solar Prize with 100,000 CHF.

2. Ecologic pump storage power plants



Ecologic pump storage power plants are mostly using the low-priced excesses of wind and solar energy instead of nuclear or coal energy to pump the water from the bottom (valley storage) to the mountain storage. By doing so, today's production fluctuations in wind energy of 10 to 20 GW can be absorbed and existing storages can be operated more efficiently. Pump storage power plants guarantee an ecologic energy supply for PEB day and night, in summer and winter if the pumping is done with renewable energies. In Europe, more and more regulating energy is needed. In the Alps, the problems of hydro-peaking can be reduced and "adequate constitutional minimum flows" can be guaranteed everywhere.