The 8th International Conference on
Compressors and Refrigeration, 2017

# International Energy Efficiency in Buildings Standards



**Prof. Dr. Essam E. Khalil,F.ASME,F.AIAA,F.ASHRAE**

**Professor of Energy,Cairo University,Cairo, Egypt**
**Convenor ISO TC 205 WG2 ,**
**Co-Convenor ISO TC163 WG4 and**
**Member CEN TC371**

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# About the author

**Prof. Dr. Essam E. Khalil**
***Professor of mechanical engineering***
***at Cairo University, Egypt***
Since 1995 responsible for national energy code and energy performance of buildings in Egypt (→ Arab Energy Code). Fellow of ASHRAE, ASME and AIAA. Contributed to more than 680 published papers and 13 books in English



The author is co-convenor of
ISO/TC 163/WG 4 (joint TC 163 – TC 205 WG)
**Energy Performance Of Buildings Using Holistic Approach**

**Convenor of ISO TC 205 WG2**
**Member of CEN TC371**

# Content

1. Unique International Cooperation
2. Global Relevance
3. Importance of Energy Efficiency and Comfort in Sustainable Buildings
4. Sustainability Issues
5. Examples of Applications of new technologies

# Time line

1980

2000

2020

Bldng envelope & components

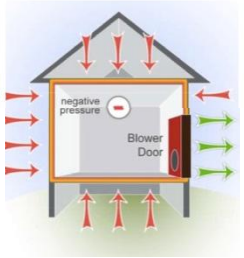
Bldng heating needs

Energy use for heating and cooling

Overall building energy performance

Energy producing built environment

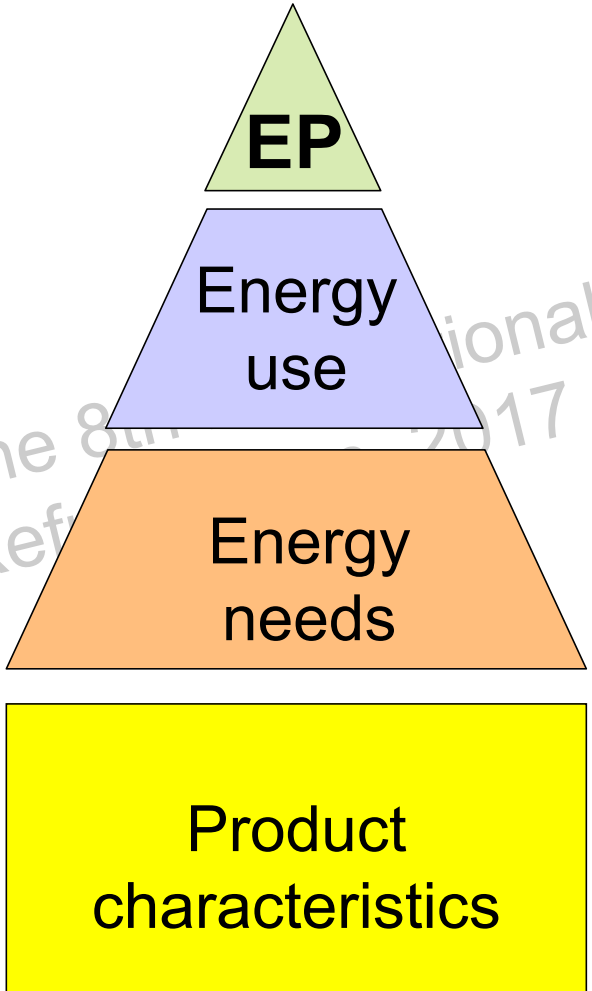






# Principle

## **EP**: Building Overall Energy Performance



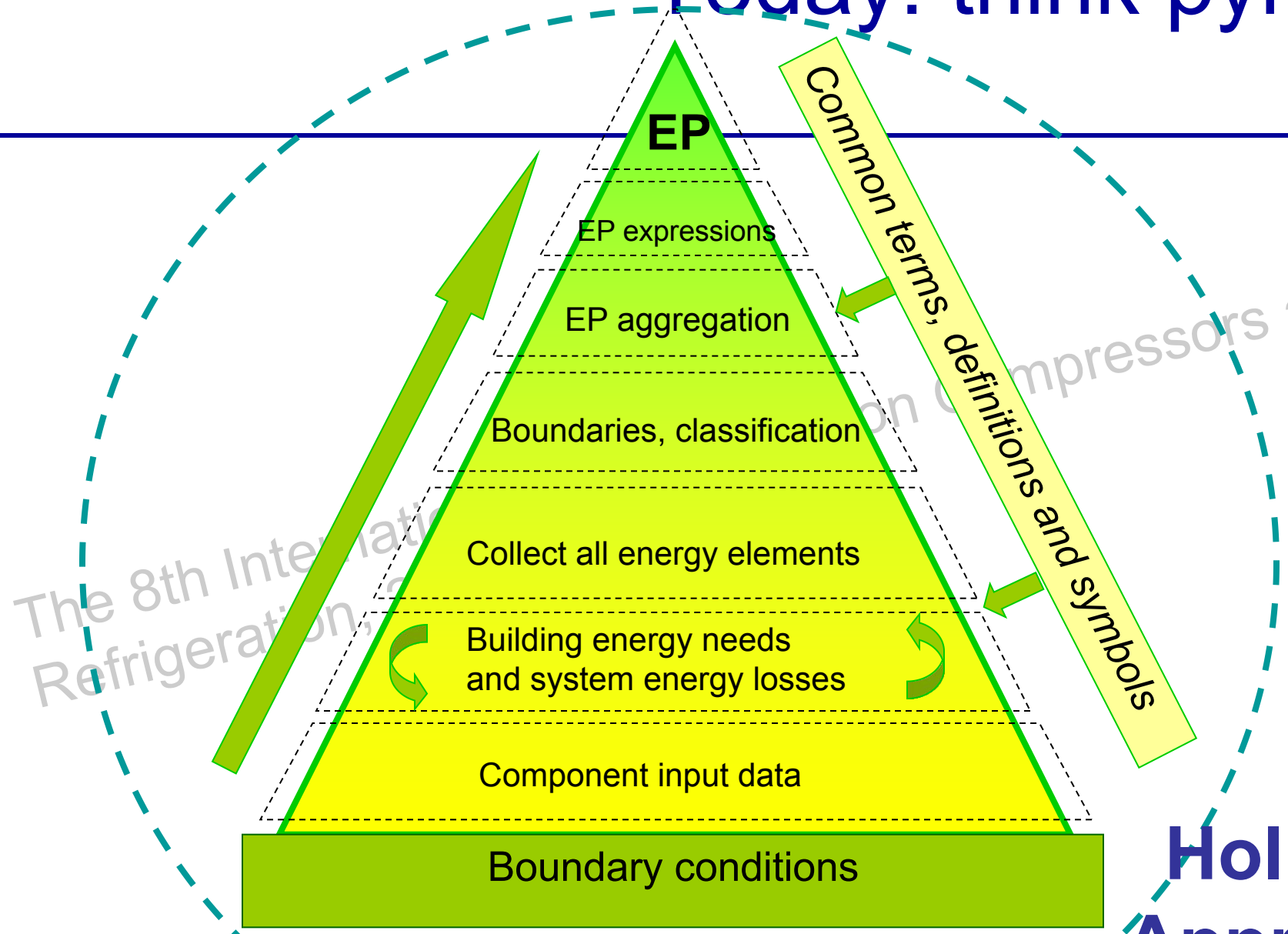

**From product standards to overall energy use**

***incl. technical building systems***

**Product is not longer evaluated as a product but as part of a system**

**Maintain the links between product testing and system evaluation**

# Today: think pyramid

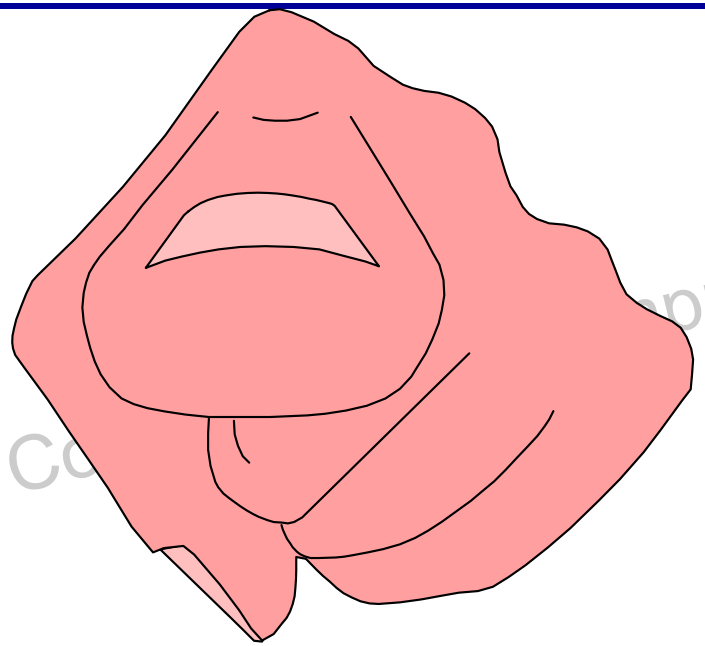



**Holistic Approach**

# OUR GOAL

***Our Task is to keep these lungs full with fresh air and comfortable by removing excessive humidity and to provide adequate amount of air at the conditions in which for health humans the lungs, and frequently the heart and lungs, are able to sufficiently oxygenate the blood and body tissue. Often, the ability to excrete CO2 as well.***

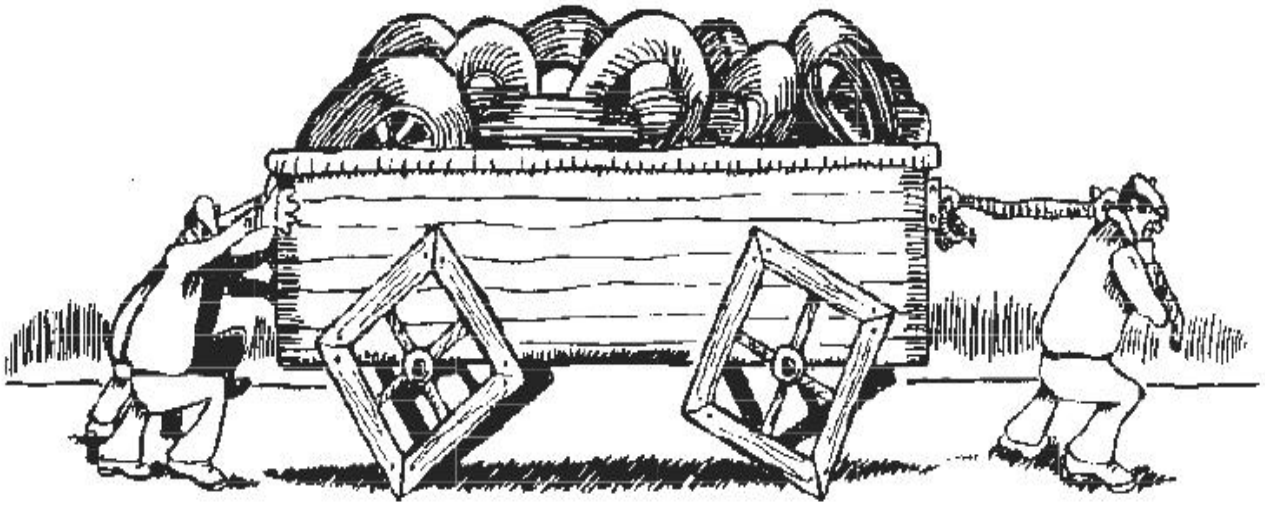
# *Can we make a difference?*

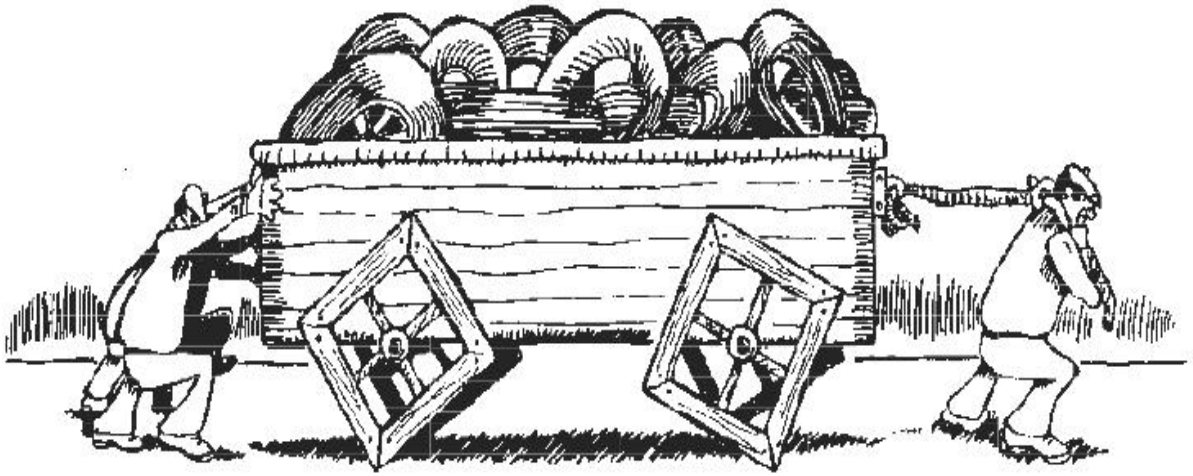




- Yes

# How do we engage and motivate Environmental Sustainability?
# How do we improve Energy performance?

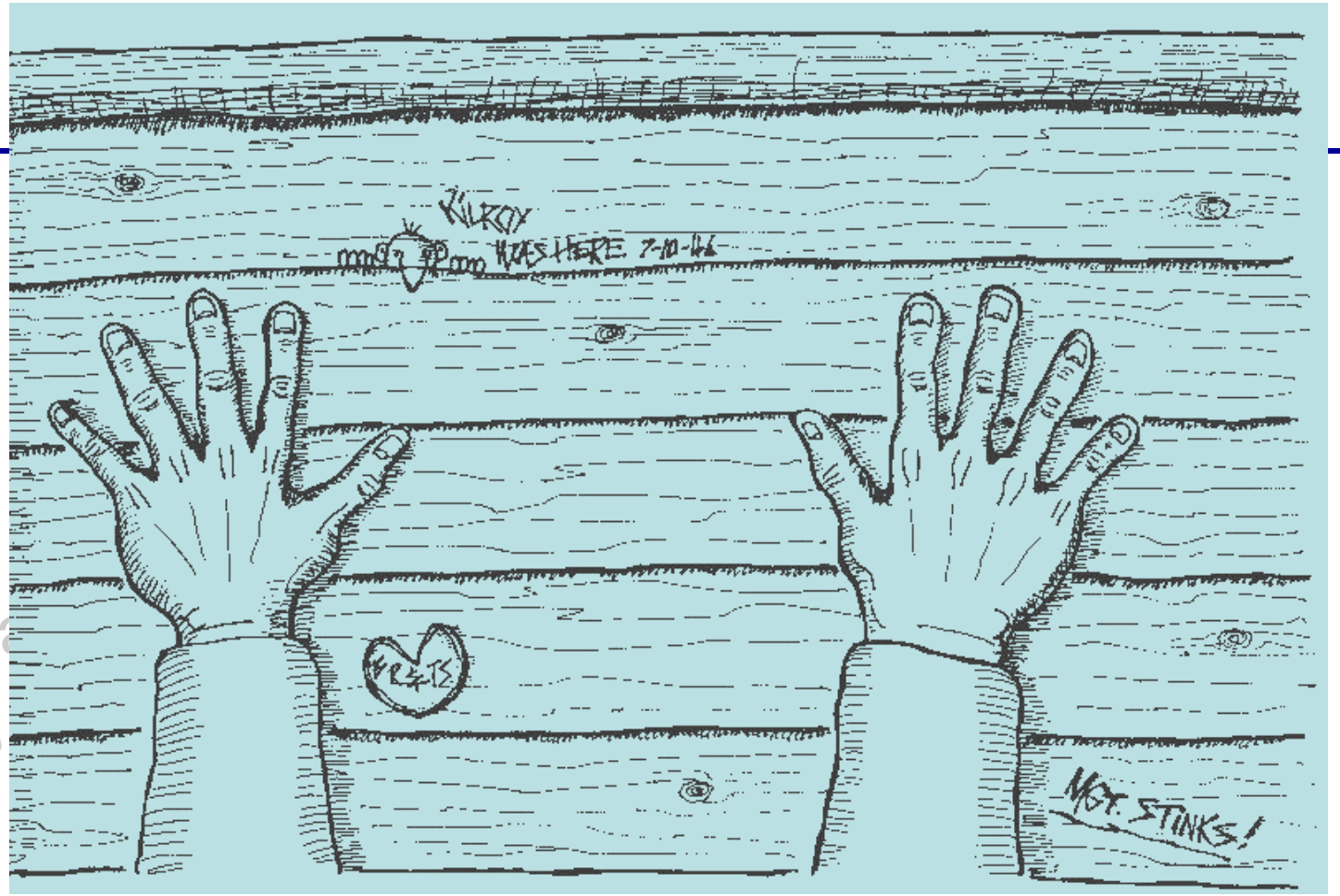




***Round wheels*** are already in the wagon **and doing nothing only increases the load!**

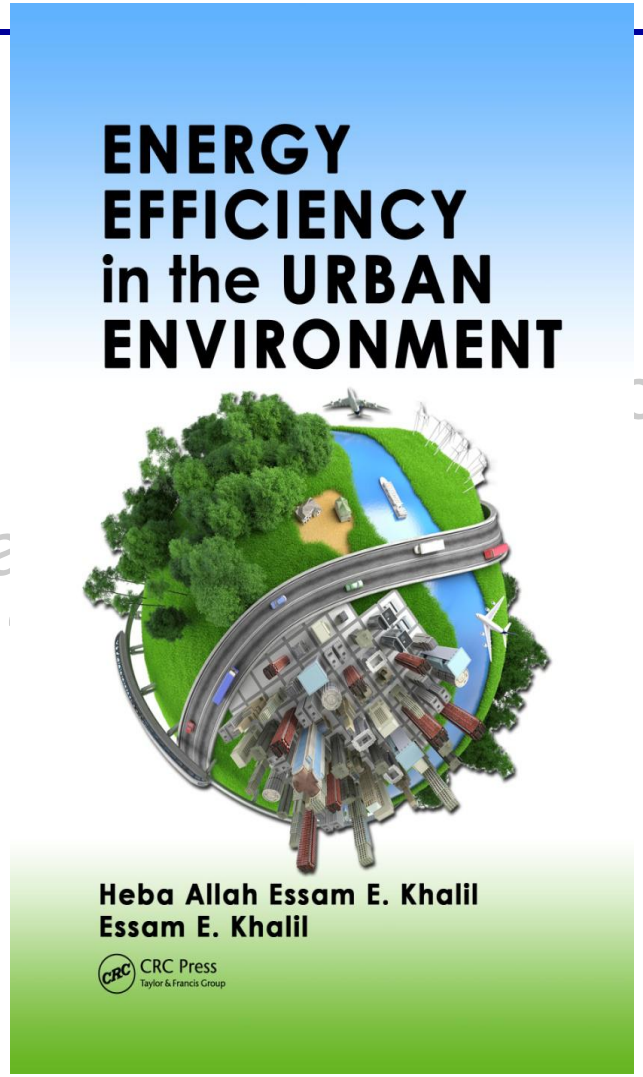
**The Round Wheels of today are the Square Wheels of tomorrow**

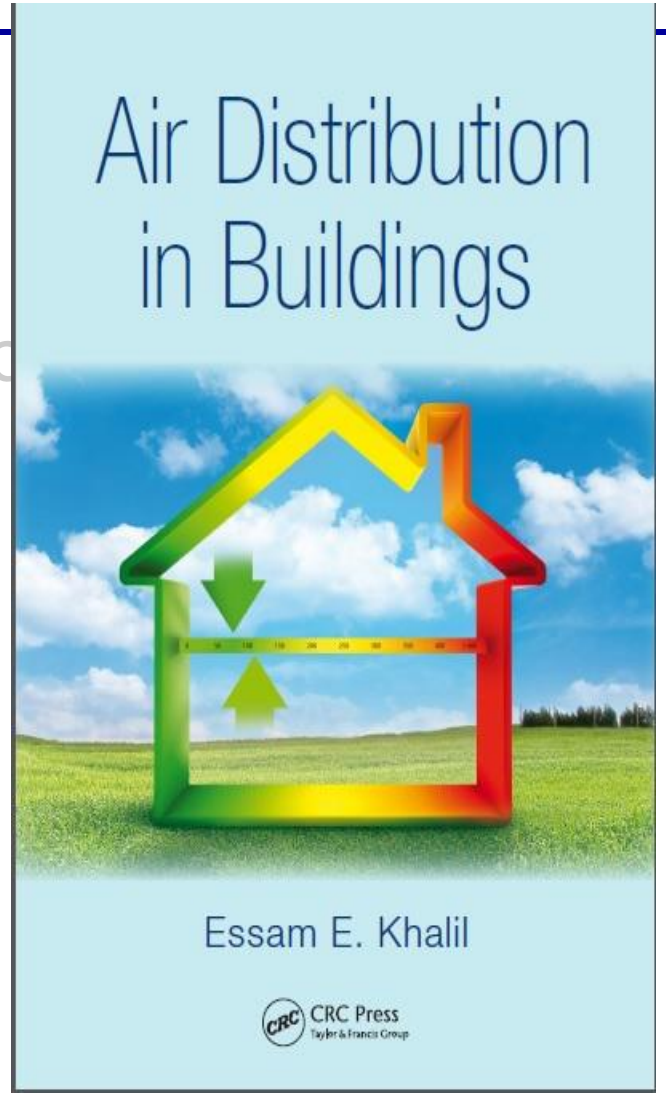
# View from Front of Wagon






# View from the Back of the Wagon

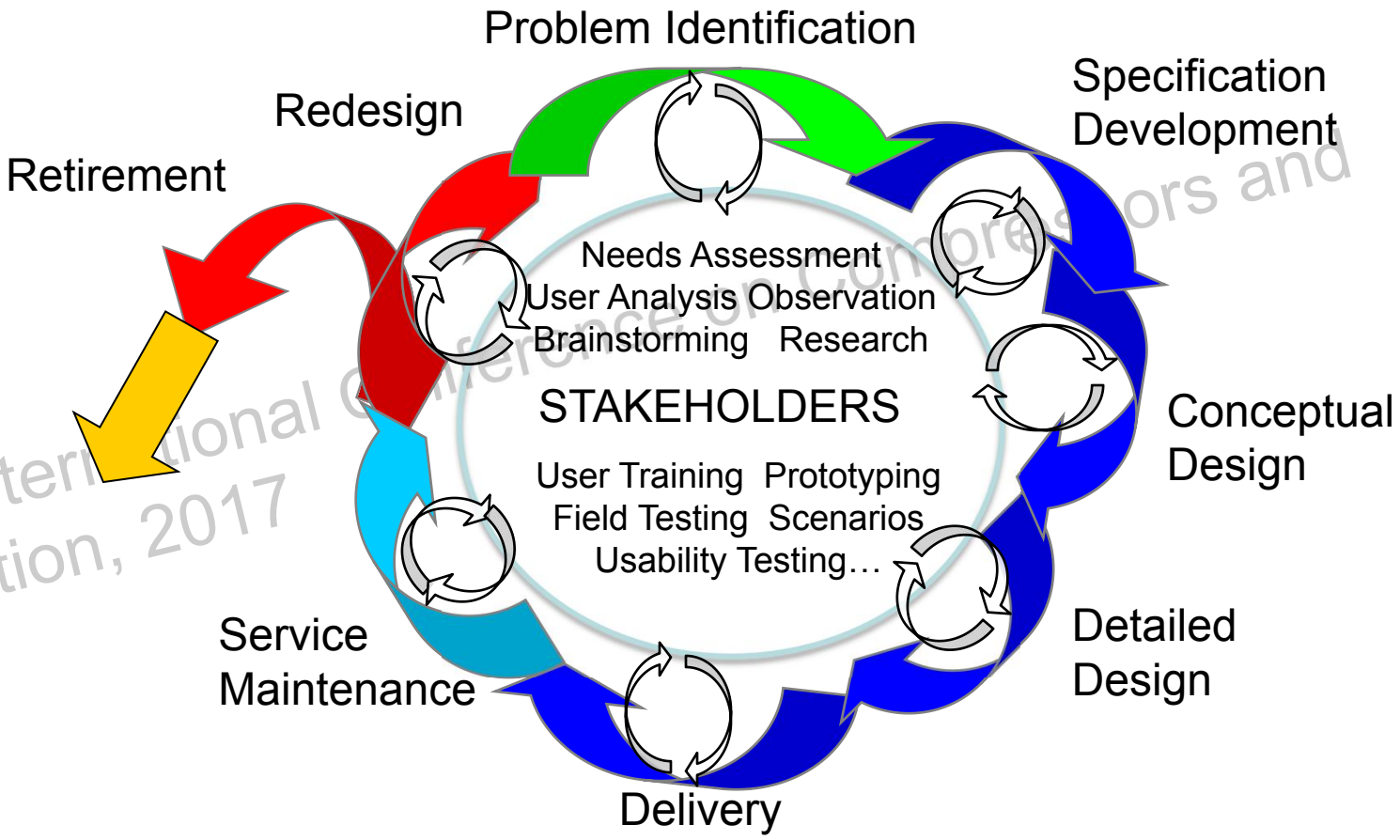


# Sustainability

- To keep going
- Run on its own without additional inputs
- “green”
- Low energy
- Low carbon footprint
- “giving back”– energy resource, water usage– taking wastewater for an irrigation system, etc.
- No unexpected costs
- Able to fix
- Renewable
- Re-inventable– may come a time it needs to be redone; may need to be disposed of (recycled/deconstructed)
- Adjust with changes– with new needs don’t need to buy a new one (e.g. new cell phone)
- Human element– ergonomics– not ruining someone else’s life (e.g. child labor; old computers in people’s backyards)
- Human leadership component
- Multi- functional
- Learning in the building and also from the building– green building as an opportunity to learn and also have a more eco-friendly building
- accountability

# Sustainable Design Cycle




codes
targets
awareness
incentives
utilities
Capacity building
POLICIES BRIDGING THE EFFICIENCY GAP
Market
Financial
Technical
Awareness
Institutional
barriers
Energy Efficient Buildings
Stakeholders:
• Architect
• Engineer
• Developer
• Owner
• Financer
• Realty Agent
• ESCO

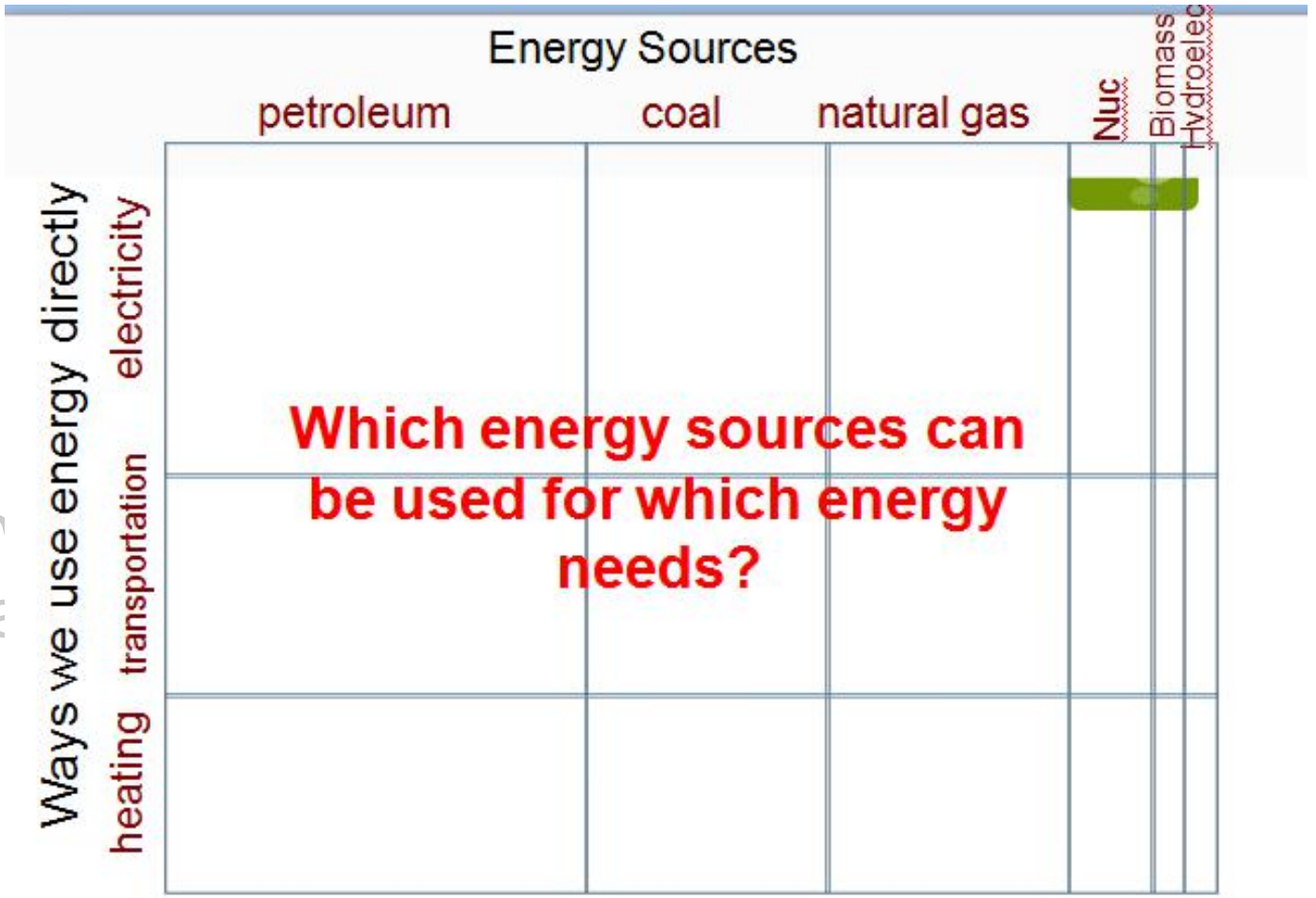
# Rationale

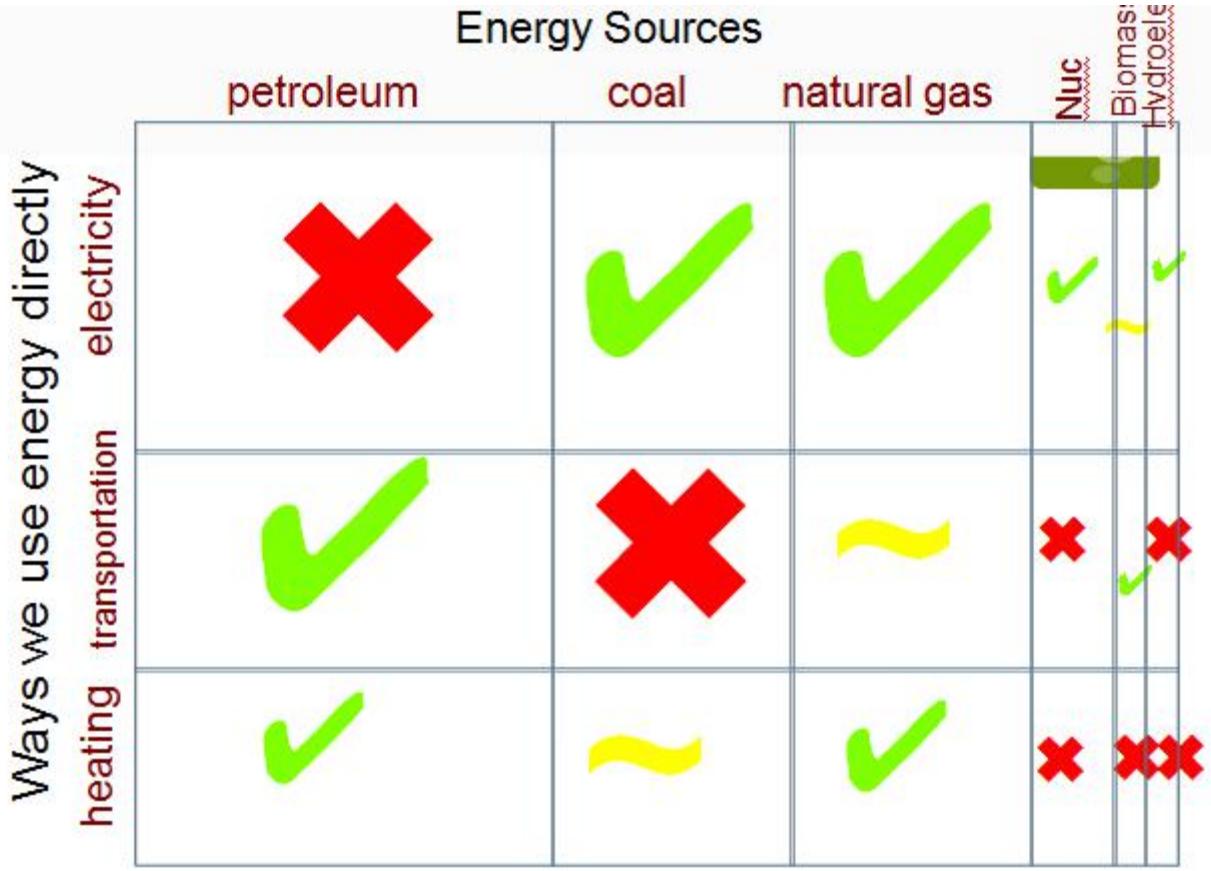
***How is maximum efficiency addressed by the holistic approach for the energy performance of buildings (EPB)?***

In the past, energy performance requirements were set at component level – minimum thermal insulation levels and minimum efficiencies of products. This, however, leads to sub-optimal solutions and creates a barrier to the necessary technology transitions.

Prof. Essam E. Khalil, Co-Convenor of the joint working group of ISO/TC 163 & ISO/TC 205.

The holistic approach to assessing the overall energy performance of buildings and the built environment, provided by the set of EPB standards (the ISO 52000 series of standards), is a key tool to overcome these barriers.





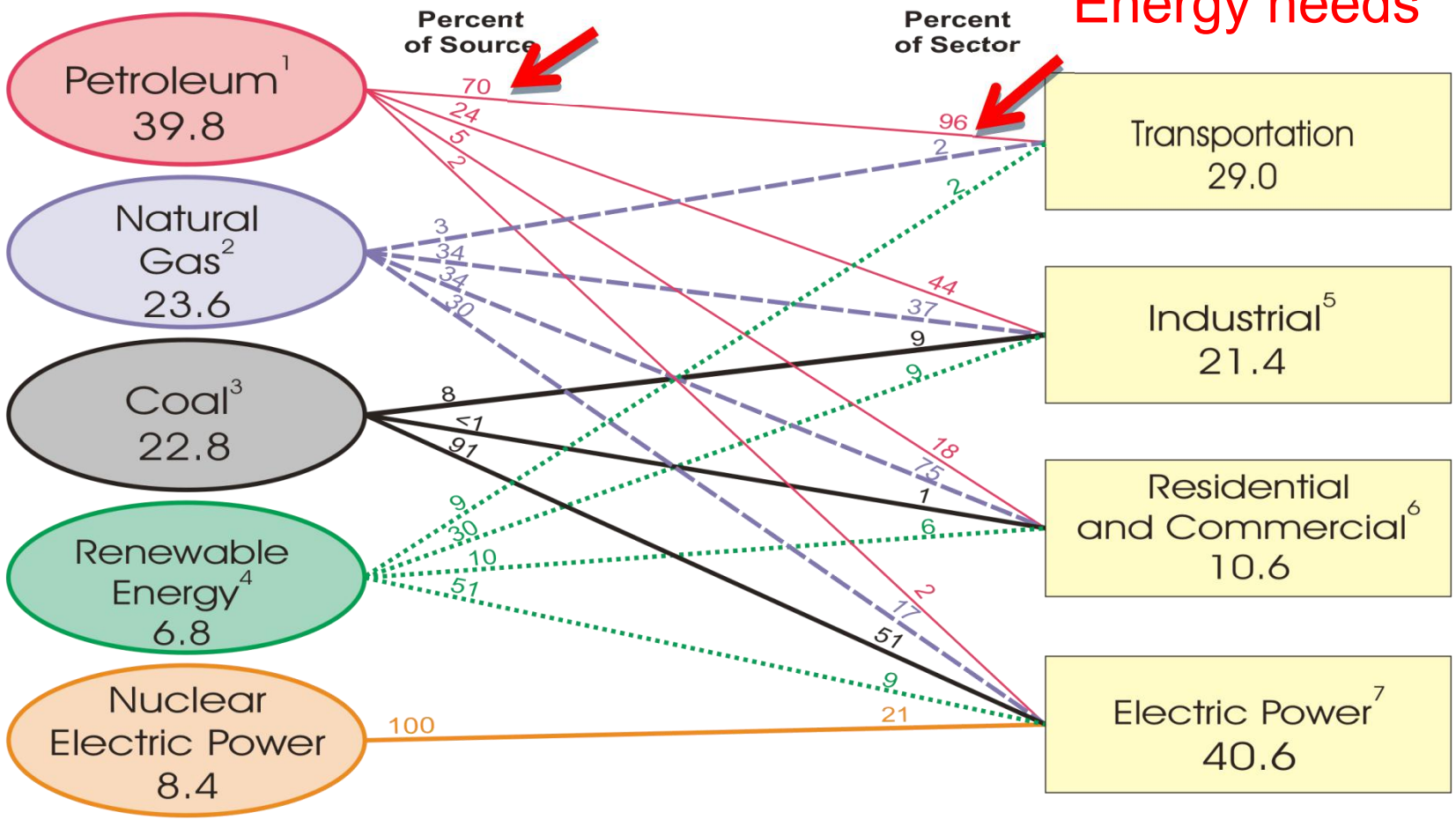

Not all energy sources can be used for all energy needs

# U.S. Primary Energy Consumption by Source and Sector, 200

(Quadrillion Btu)

Energy sources

Energy needs

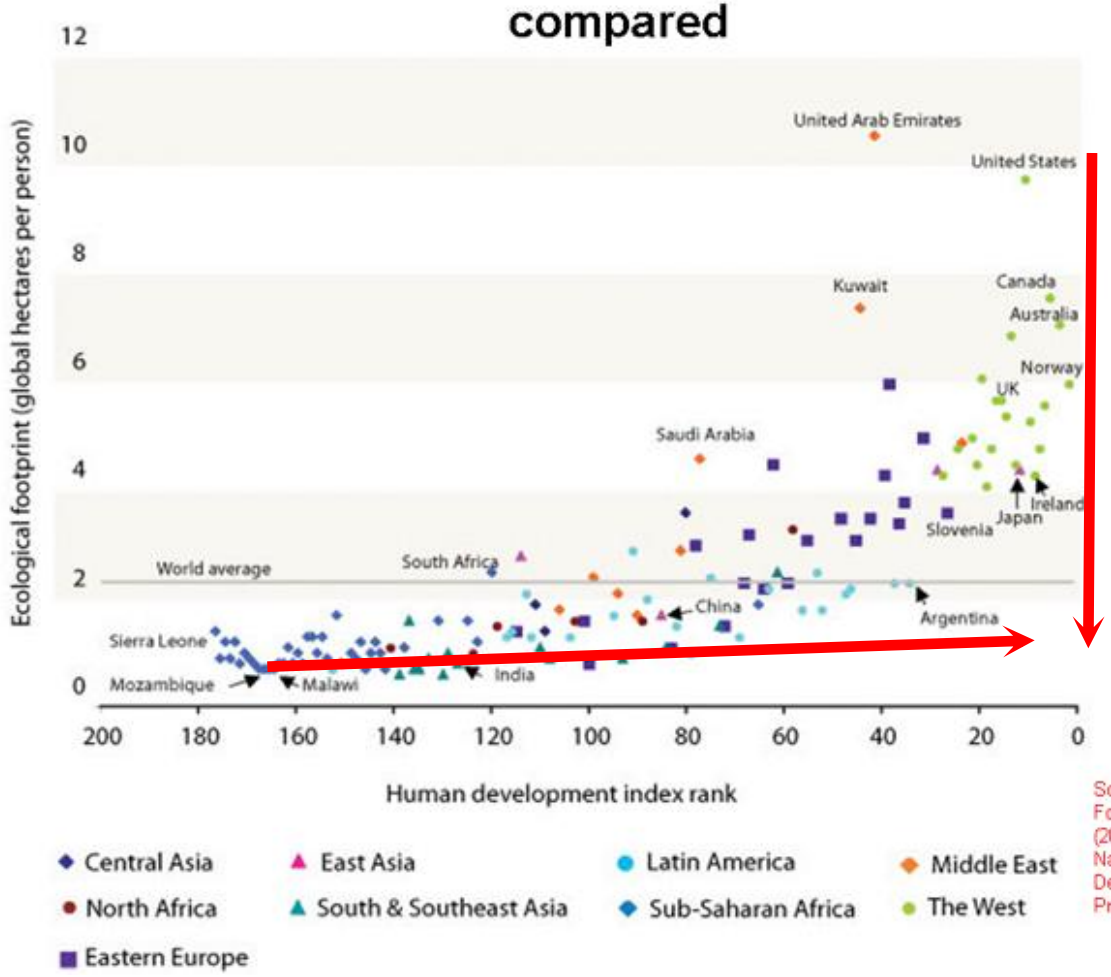



[1]Does not include 0.6 quadrillion Btu of fuel ethanol, which is included in "Renewable Energy."
[2]Excludes supplemental gaseous fuels.
[3]Includes less than 0.1 quadrillion Btu of coal coke net imports.
[4]Conventional hydroelectric power, geothermal, solar/PV, wind, and biomass.
[5]Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.
[6]Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.
[7]Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public.

Note: Sum of components may not equal 100 percent due to independent rounding.

Sources: Energy Information Administration, *Annual Energy Review 2007*, Tables 1.3, 2.1b-2.1f and 10.3.

## Human Welfare and Ecological Footprints compared

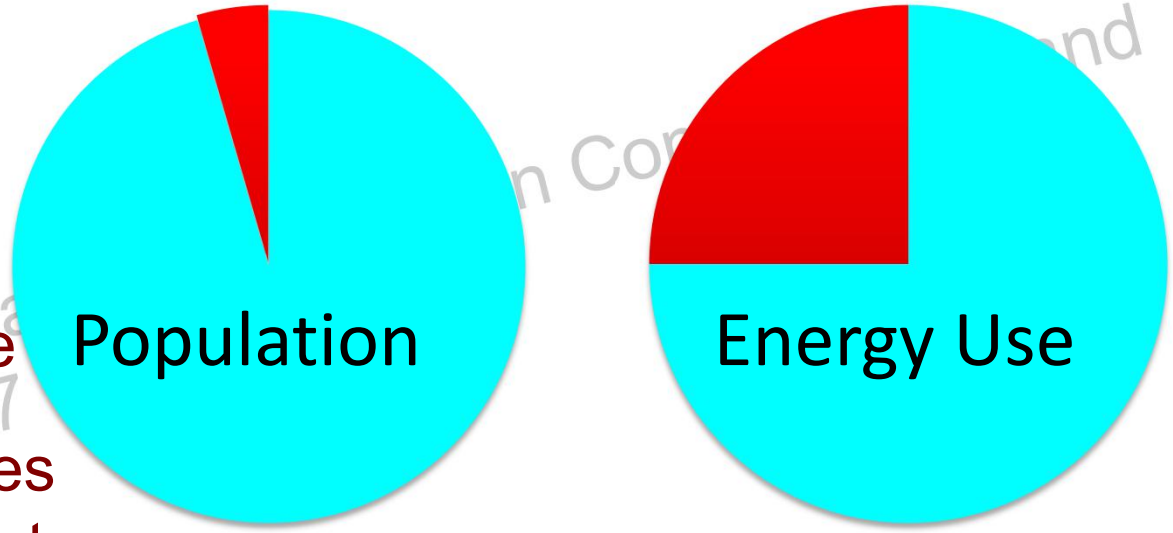



Source: Global Footprint Network (2006); United Nations Development Programme (2006).]

People in the US and on average are living as though we have 5 earths

More people across the globe want US standard of living

# Why sustainability?




Equity over time

Consumption rates match production rates

Consumption rates that do not exhaust resources

*Red = United States*

*Blue = Rest of world*

# Why does energy use vary?

1. **Building Design**
2. **Services Design & Performance**
3. **Occupants behavior**



Energy Efficiency

# Green Pyramid Rating System
## GPRS

***GPRS has four levels of Certification:***

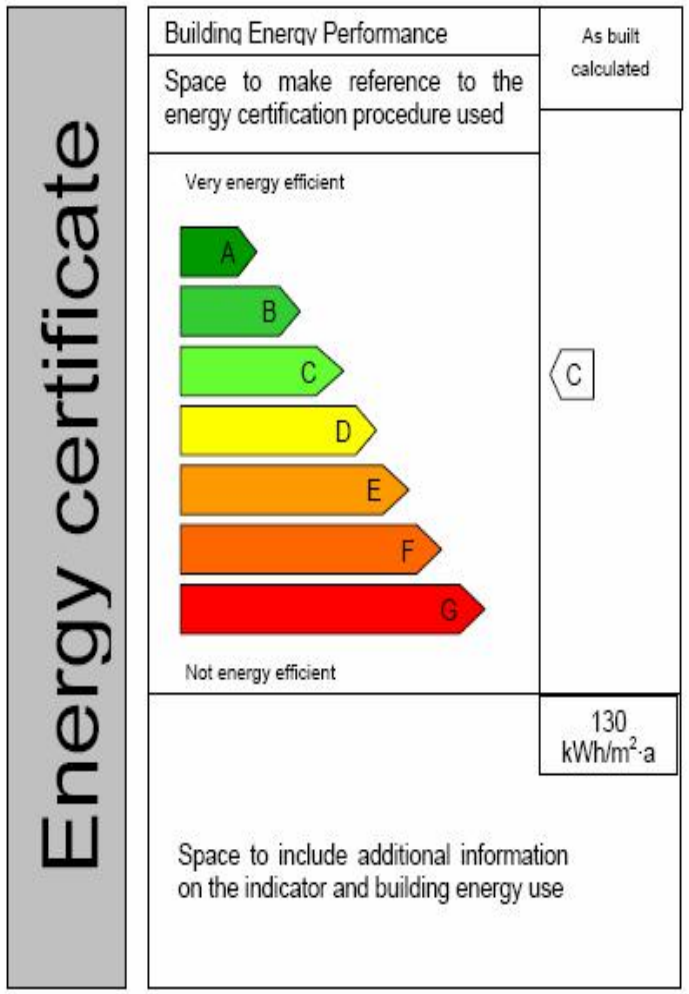

***> 80 credits***

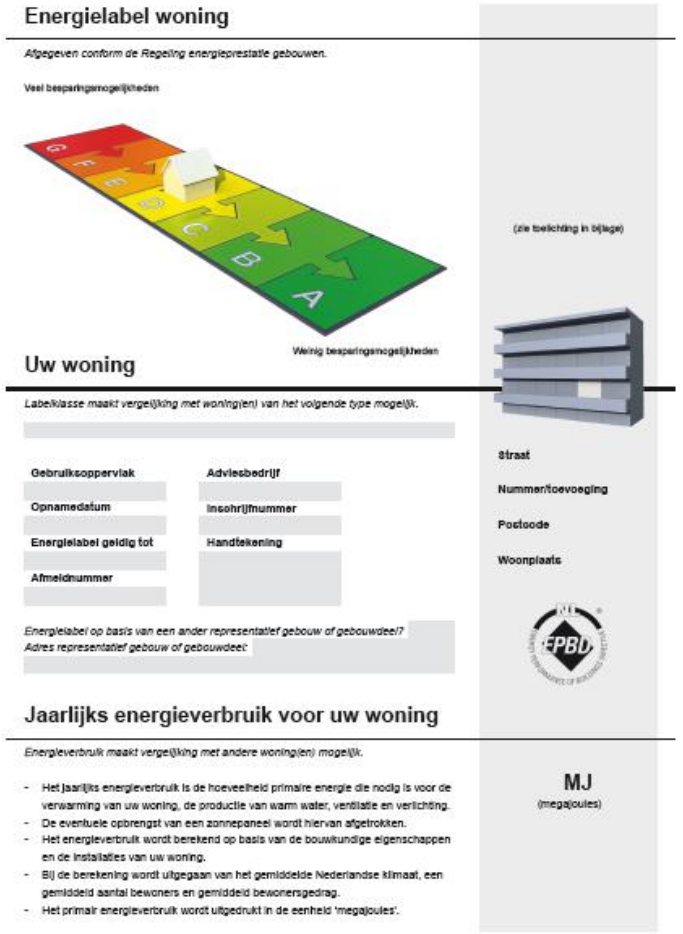
***60–79 credits***

***50–59 credits***

***40–49 credits***

# *Two examples of energy certificates including numerical indicator and ranking*

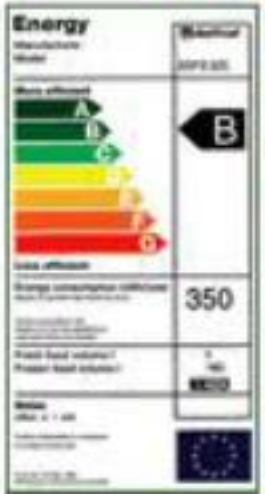


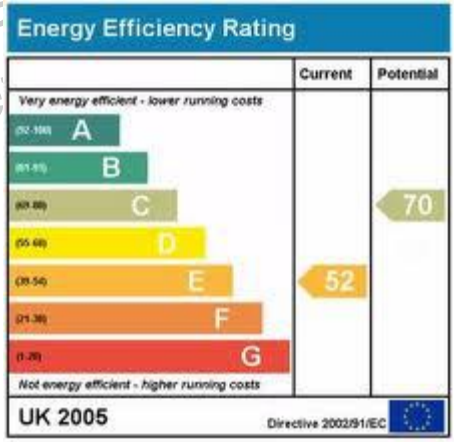

Mexico


India

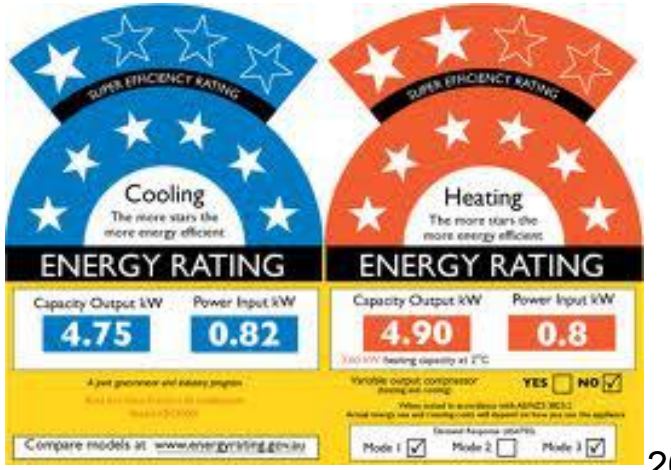

S. Africa



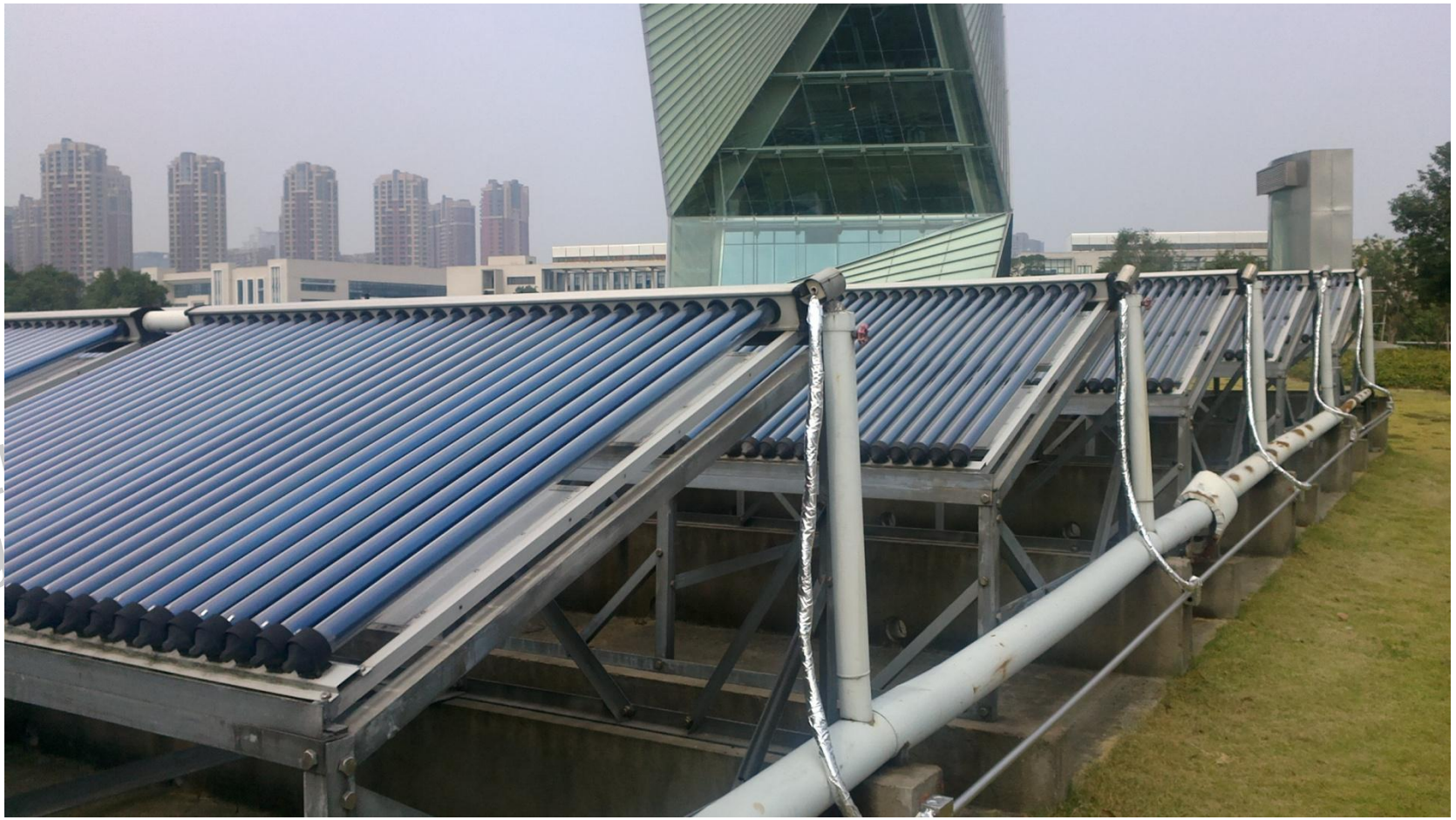

China



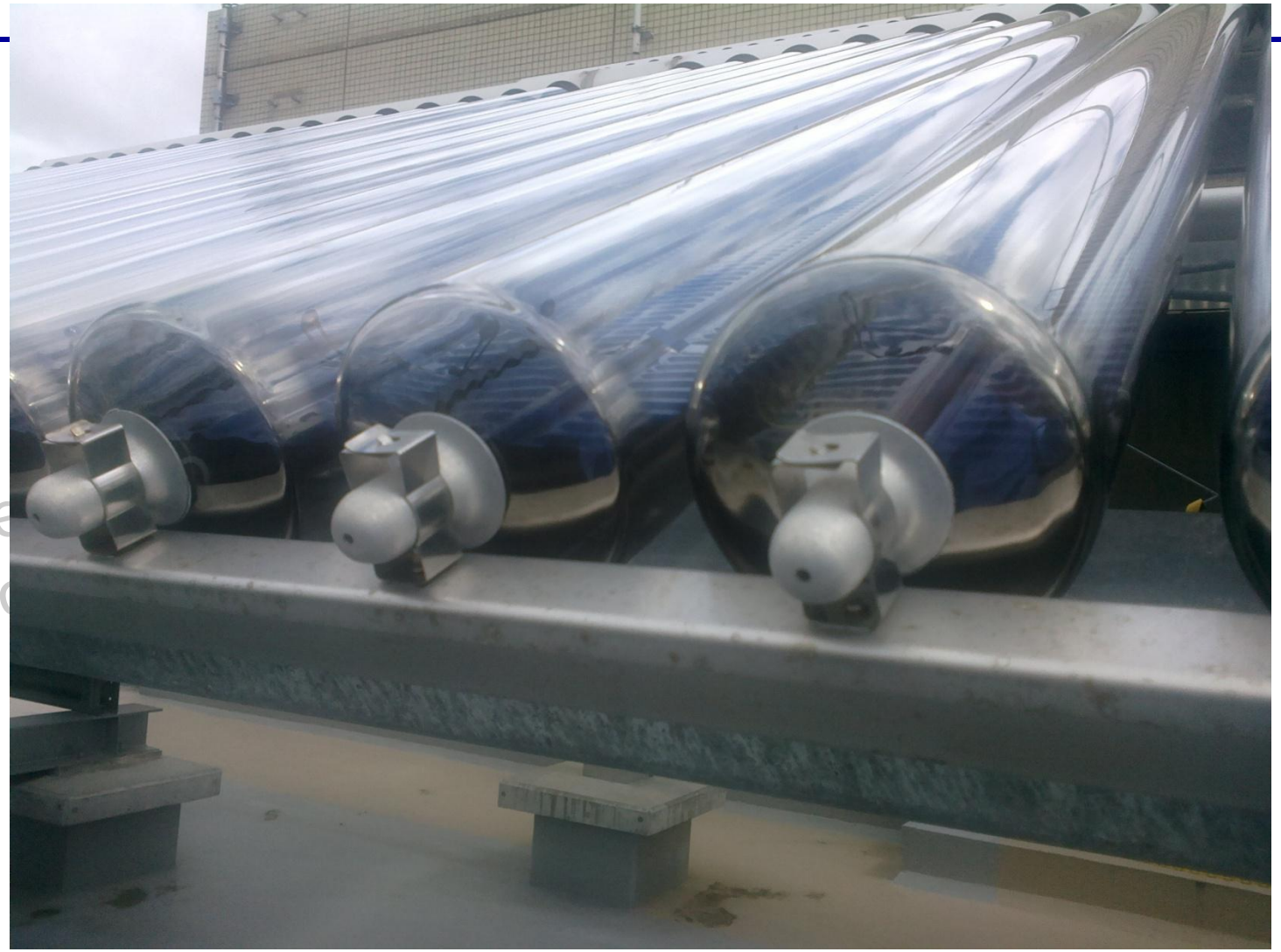


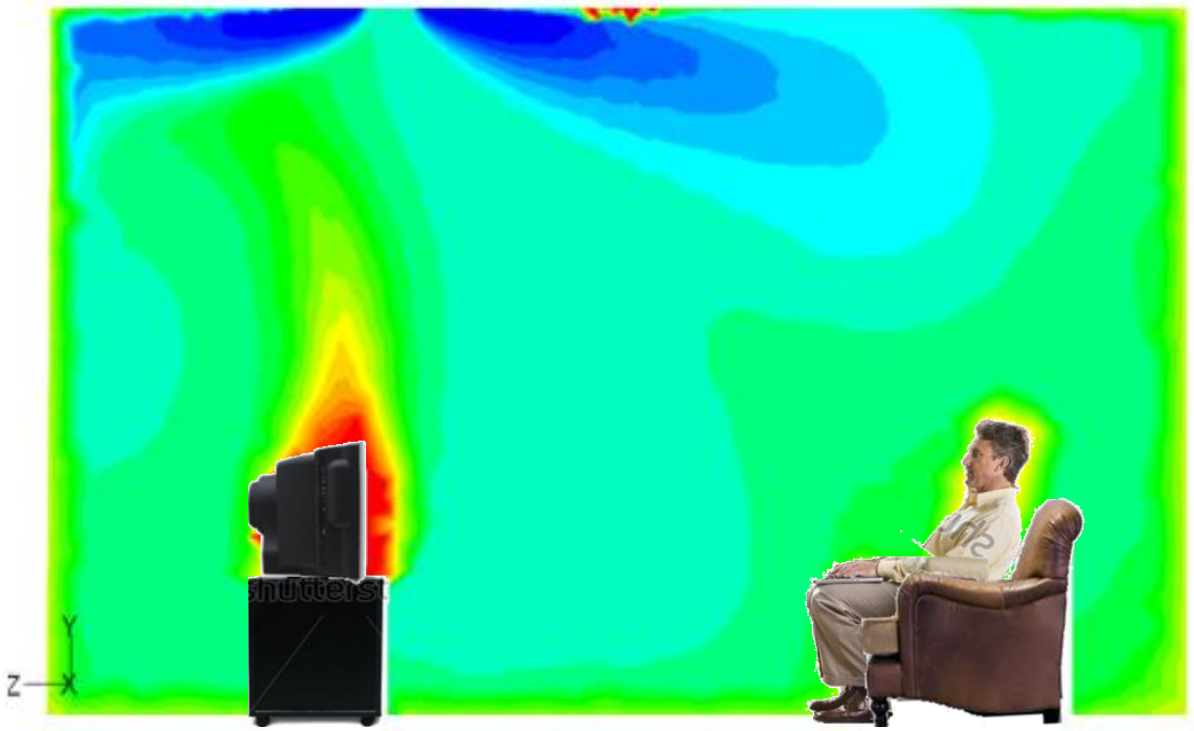
# Net Zero Energy, Ningbo, China

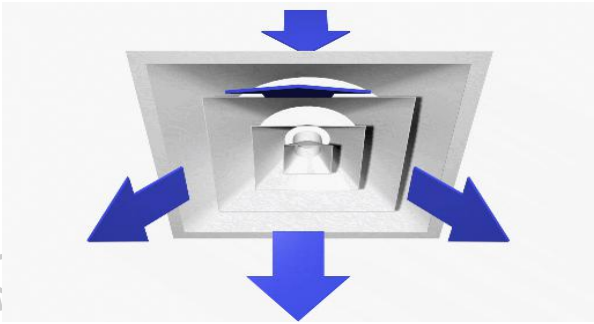


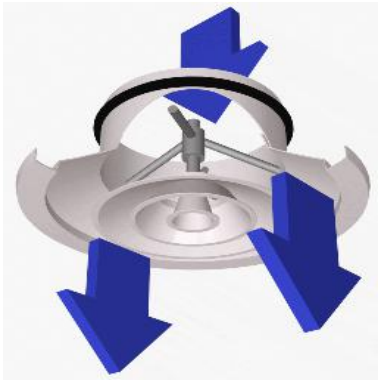
First Net Zero Energy Building, Cset, Ningbo, China

# Rooftop Solar Cooling with absorption Chillers, In Commercial Building in Japan



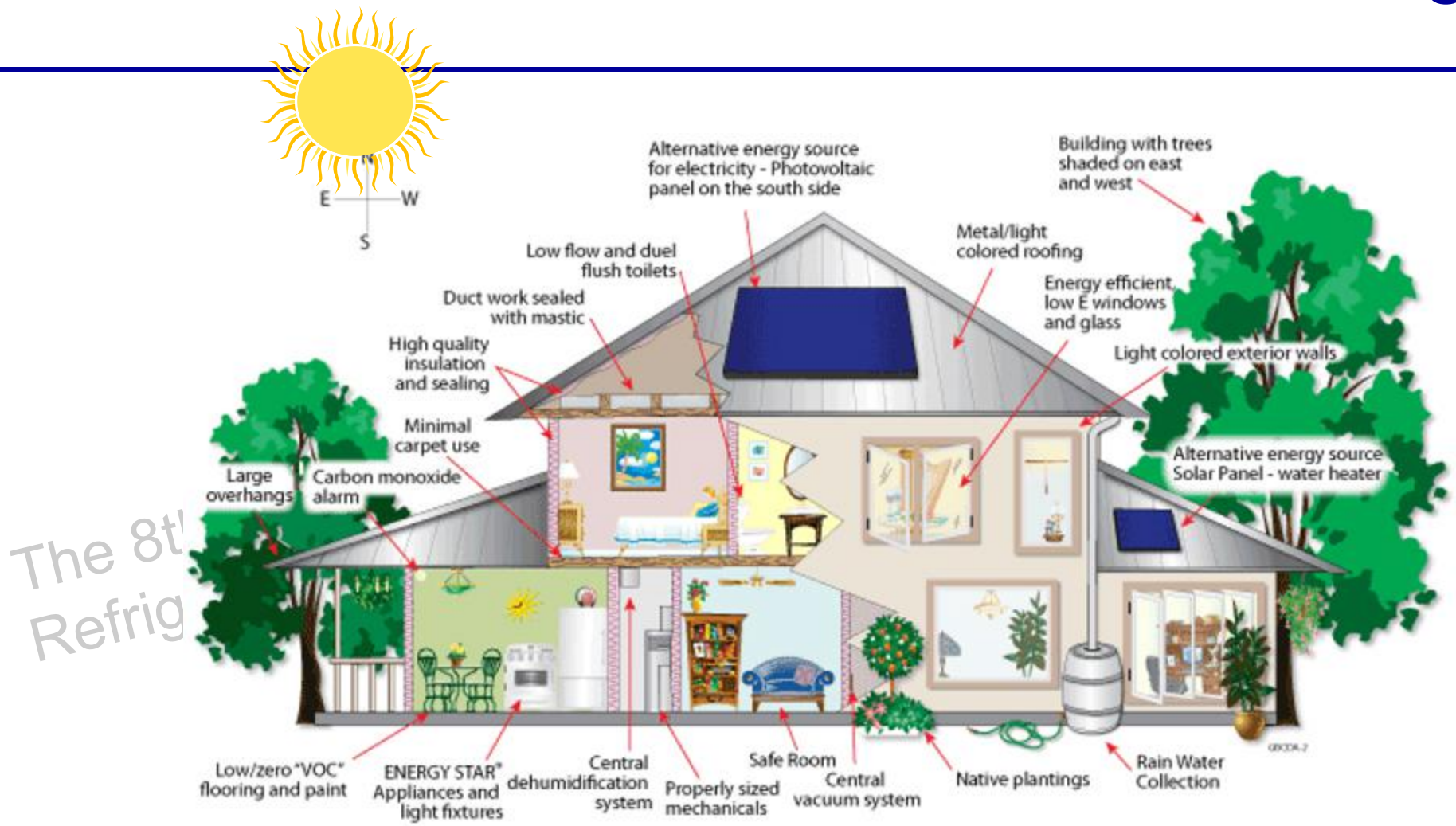


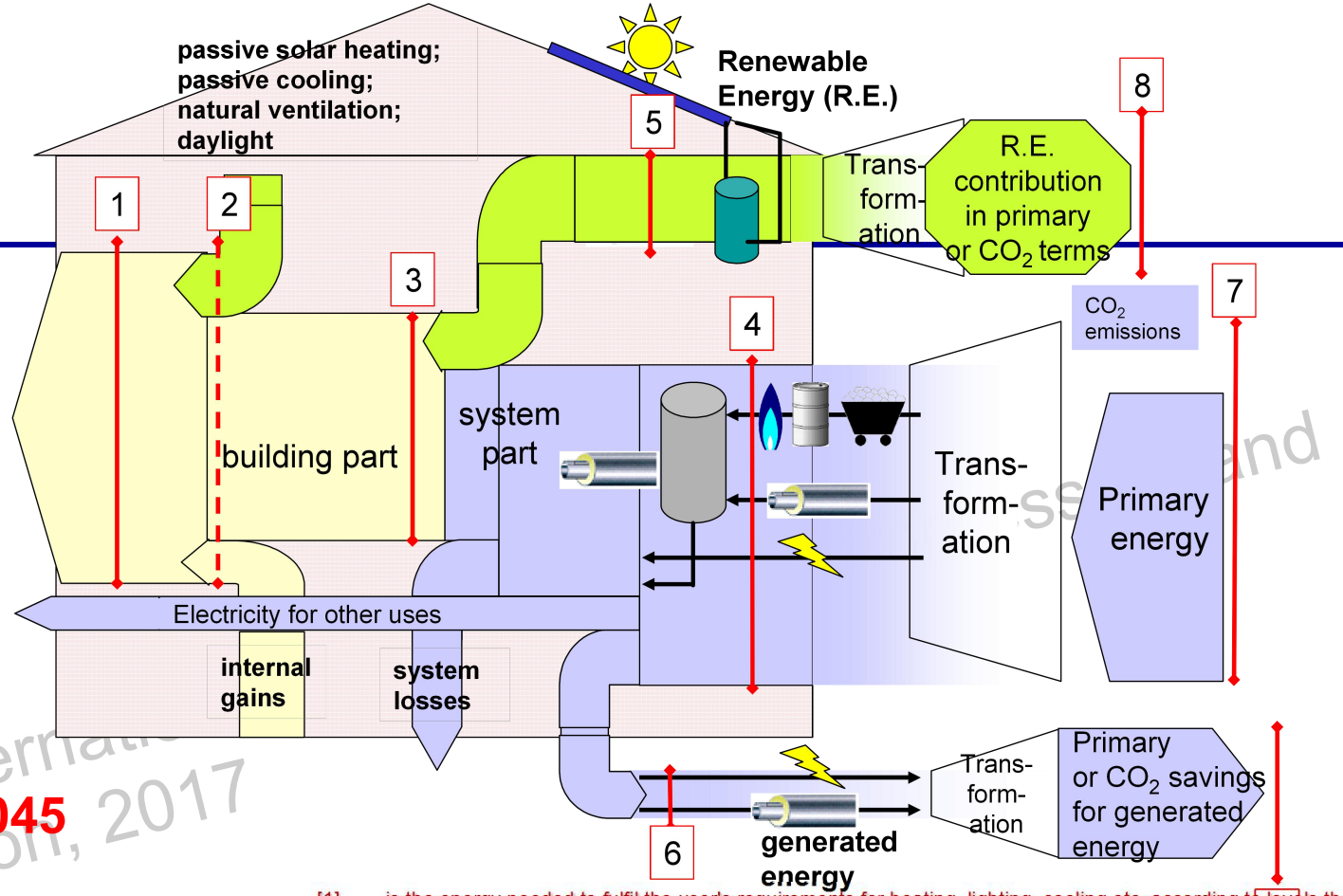




# Air Distribution in Living Environment

# What is Green Building








**ISO 23045**

**Key to symbols**

- electricity
- gas, oil, coal, biomass, etc.
- heat, cold

[1] is the energy needed to fulfil the user's requirements for heating, lighting, cooling etc, according to levels that are specified for the purposes of the calculation.

[2] is the "natural" energy gains – passive solar, ventilation cooling, delighting, etc. together with internal gains (occupants, lighting, electrical equipment, etc) these “gains” reduce energy demand in winter season but increase energy demand in summer season

[3] is the building's net energy use, obtained from ref.[1] and [2] along with the characteristics of the building itself. (in winter season [2] is lower than [1] but in summer [2]is greater than [1] )

[4] is the delivered energy, represented separately for each energy carrier, inclusive of auxiliary energy, used by heating, cooling, ventilation, hot water and lighting systems, taking into account renewable energy sources and co-generation. This may be expressed in energy units or in units of the energyware (kg, m³, kWh, etc).

[5] is renewable energy produced on the building premises.

[6] is generated energy, produced on the premises and exported to the market; this can include part of [5].

[7] represents the primary energy usage or the CO2 emissions associated with the building.

[8] represents the primary energy or emissions associated with on-site generation that is used on-site and so is not subtracted from [7].

[9] represents the primary energy or CO2 saving associated with exported energy, which is subtracted from [7].

# What can we use to balance the whole Building

## Passive Systems - Free - Maximize

- Fabric
- Thermal mass - heat store heat regulation
- Insulation preventing heat loss
- Natural ventilation
- Daylight - lighting and solar gain

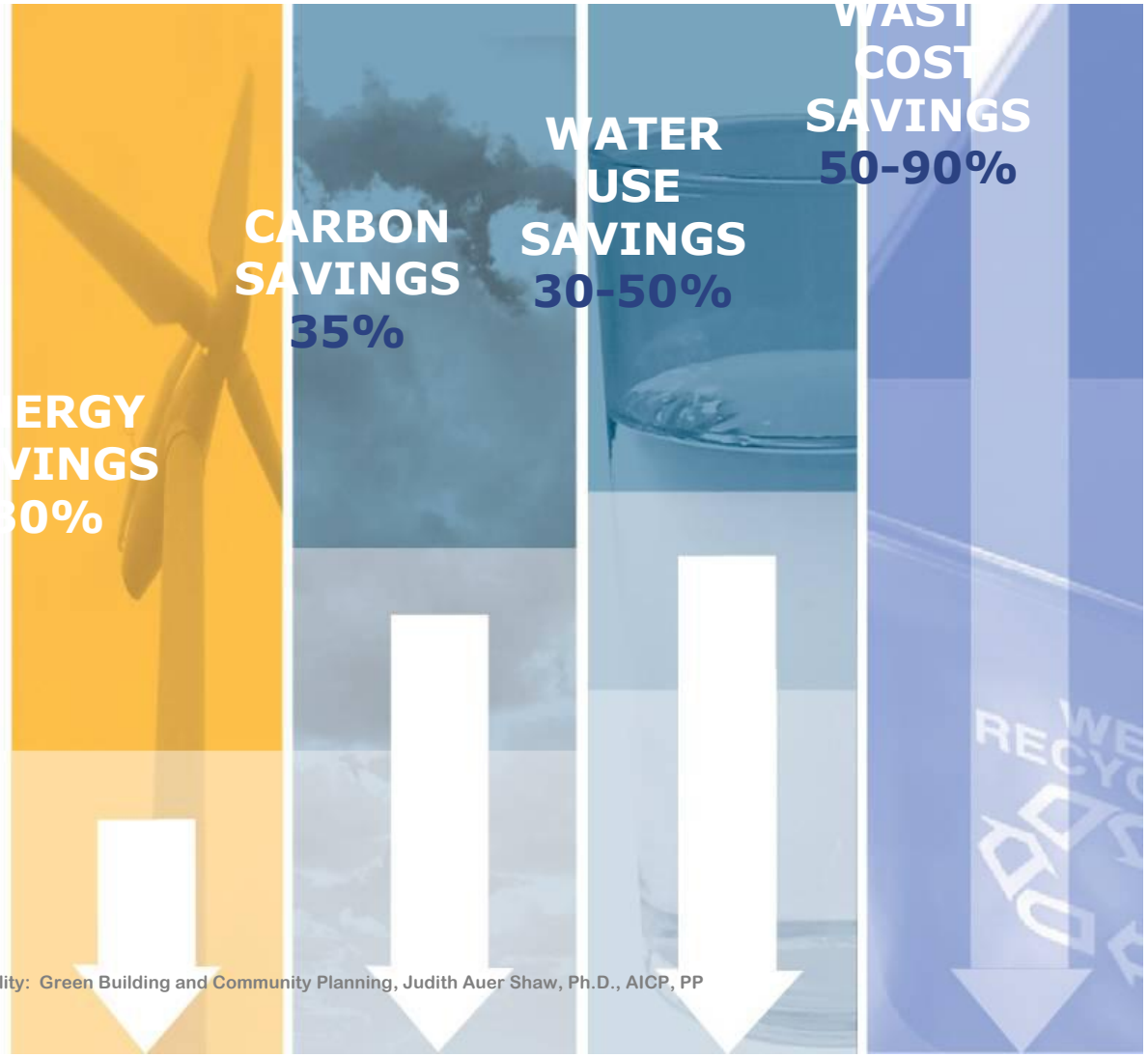
## Active Systems - Energy/CO2 input - Minimize

- Heating
- Artificial light
- Ventilation
- Cooling

## Renewable energy *should* helps

# Benefits of Green Building

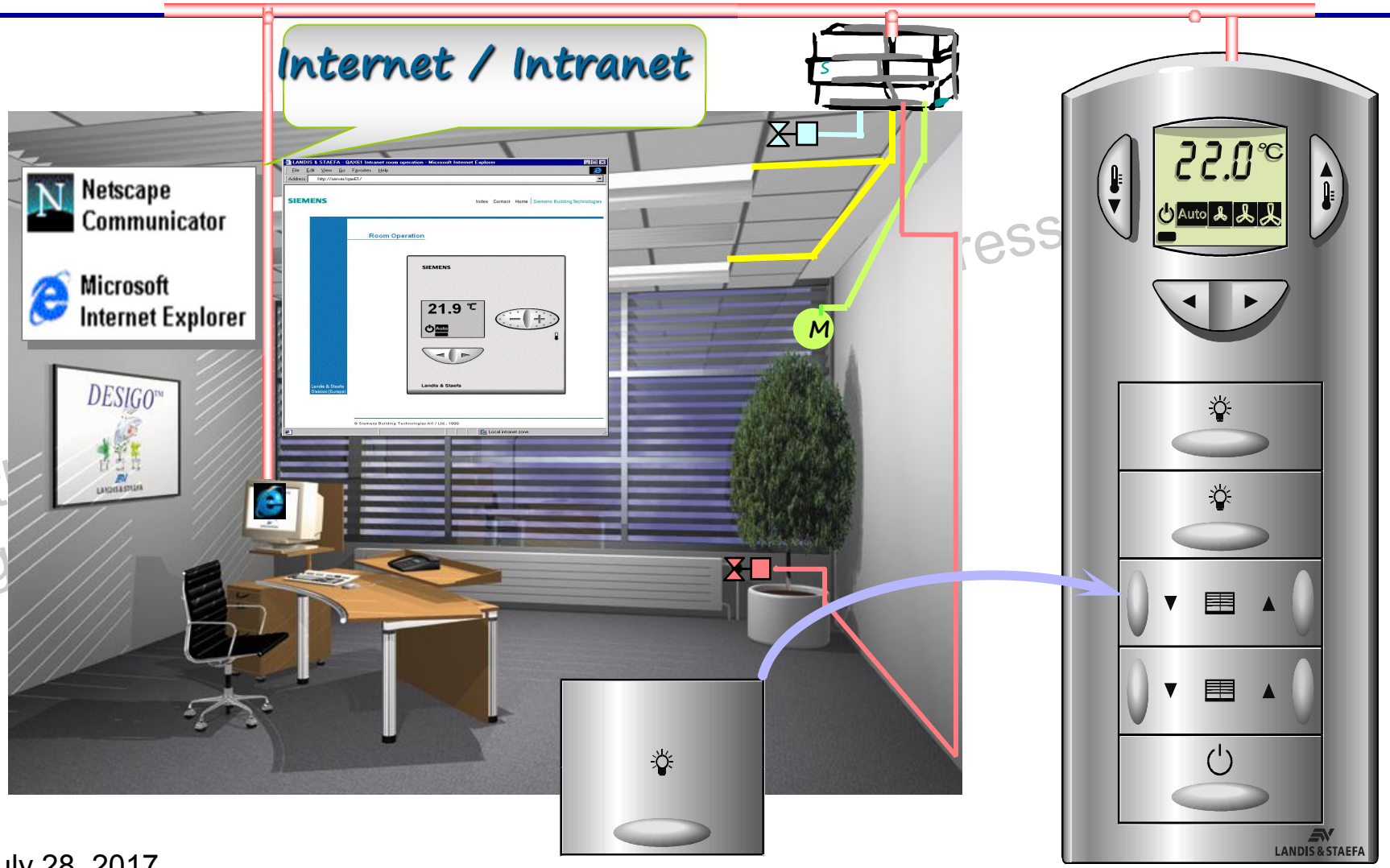
Average Savings of Green Buildings



# Buildings Rating System Categories

| | |
|---|---|
| Category 1 | Sustainable Site, Accessibility and Ecology |
| Category 2 | Energy Efficiency |
| Category 3 | Water Efficiency |
| Category 4 | Materials & Resources |
| Category 5 | Indoor Environmental Quality |
| Category 6 | Management |
| Category 7 | Innovation and and Added Value |

# Integrated Room Automation



# Green ICT Goals


Reducing the use of hazardous materials

Maximizing energy efficiency during the product's lifetime, and

Promoting recyclability or biodegradability of defunct products and factory waste.

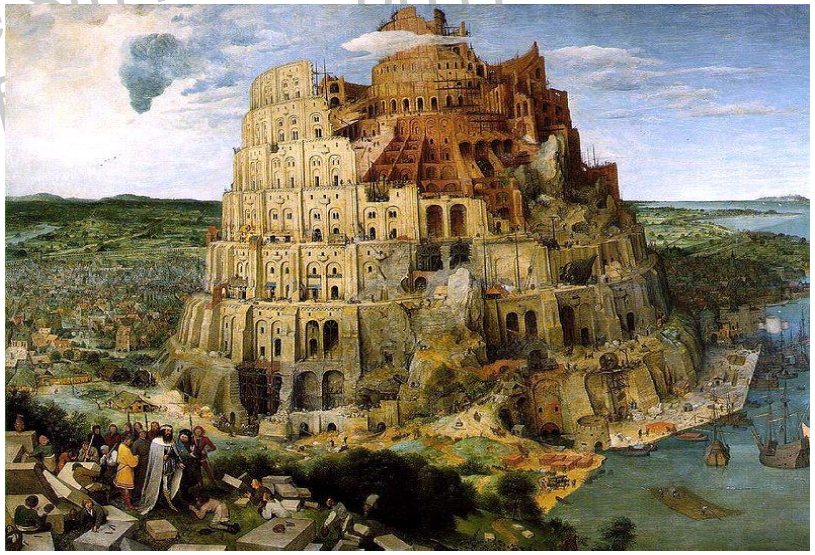
Use of ICT technologies with reducing all resources

# First set of key ISO standards published (1)

**ISO/TR 16344:2012**

**Energy performance of buildings -- Common terms, definitions and symbols for the overall energy performance rating and certification**





Few hundred terms, definitions, symbols, ..

**2.1.56**
**energy inspection**
examination of ... ems in a building

... conditioned area

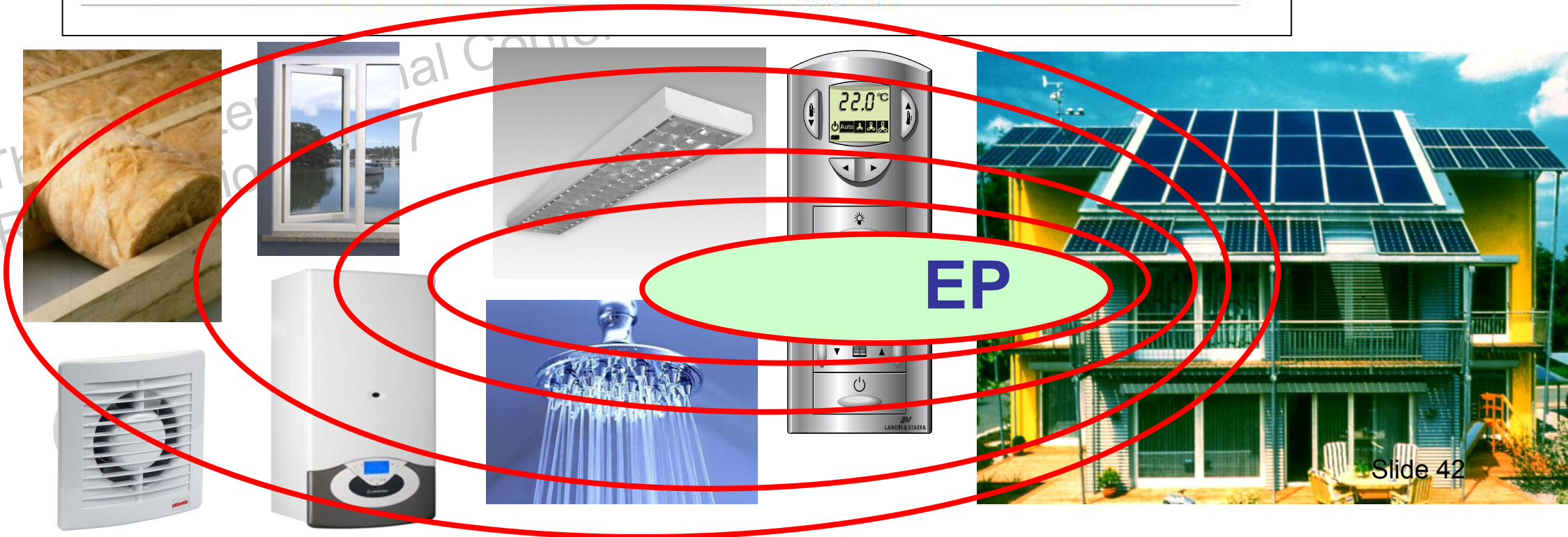
**energy performance of a building**
calculated or measured amount of weighted net delivered energy actually used or estimated to meet needs associated with a standardised use of a building, which may include, inter alia, energy used for cooling, ventilation, domestic hot water and lighting

**2.1.59**
**energy rating**
evaluation of the energy performance of a building based on the weighted sum of the calculated or m use of energy carriers

# First set of key standards published (2)

**ISO 16346:2013**

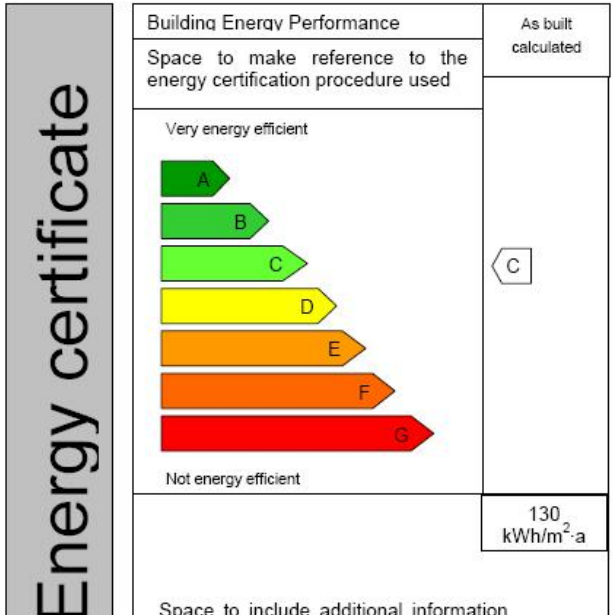
**Energy performance of buildings -- Assessment of overall energy performance**

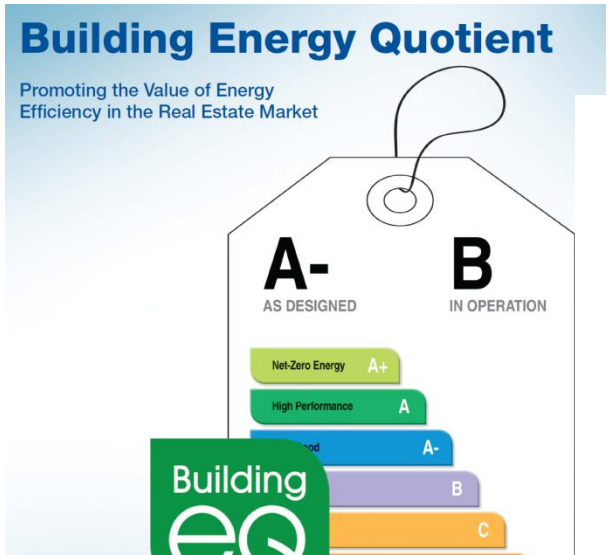


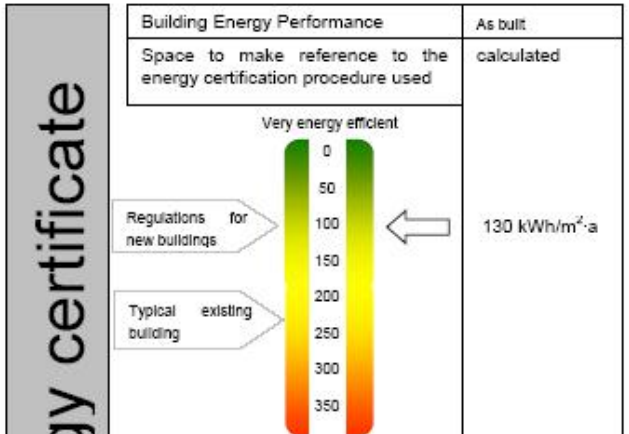
# First set of key ISO standards published (3)

**ISO 16343:2013**

**Energy performance of buildings -- Methods for expressing energy performance and for energy certification of buildings**



# Under construction

- In collaboration with other international initiatives (2014-2017):
- **Overarching modular structure**
  - With standards (in total > hundred) for individual systems and components




Assessment boundaries

Overall EP balance

Ways to express EP

Etc.

Building and building elements

Operating conditions

Climatic data

Heating systems

Ventilation systems

Domestic Hot Water systems

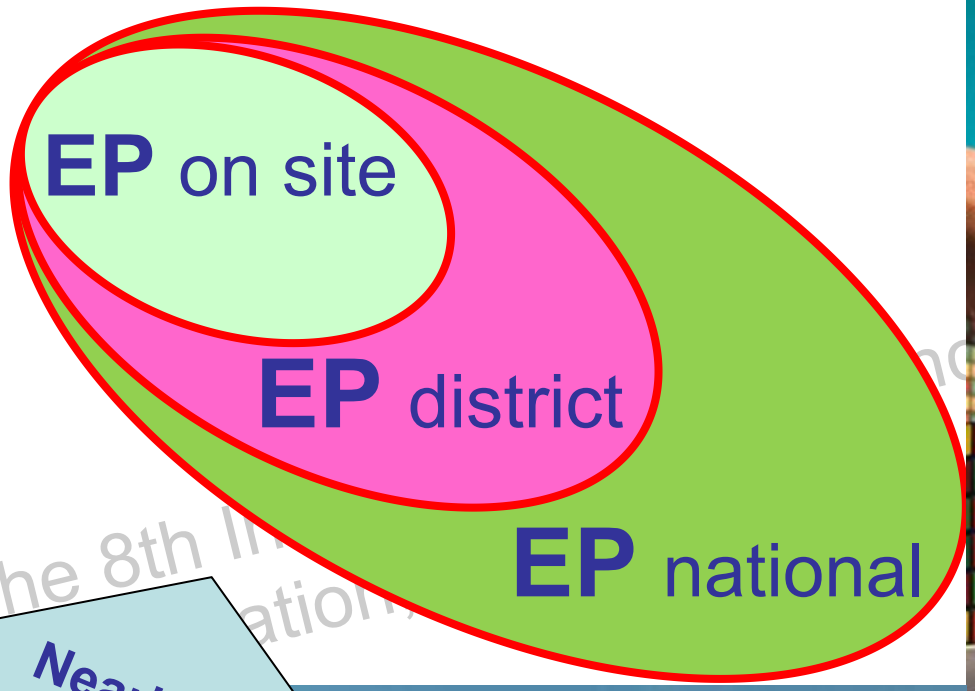
Cooling systems

Lighting and lighting systems

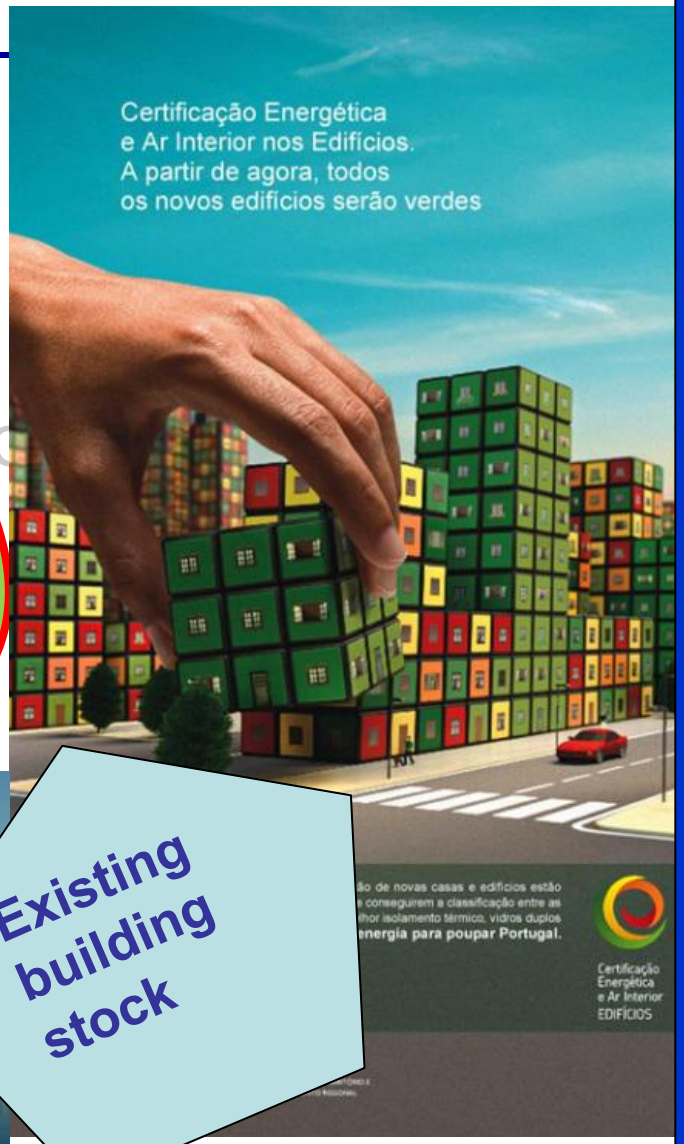
Building automation & Control

**ISO 52000**
**ISO 52001**
**ISO 52003**
**ISO 52004**
**ISO 52005**
**ISO 52006**
**ISO 52007**
**ISO 52008**
**ISO 52009**
**ISO 52010**
**…**
**ISO 52143**
**ISO 52144**
**ISO 52145**
**ISO 52146**

# Many aspects involved




Nearly Zero Energy Buildings




Existing building stock

ISO 52000
ISO 52001
ISO 52003
ISO 52004
ISO 52005
ISO 52006
ISO 52007
ISO 52008
ISO 52009
ISO 52010
ISO 52011
ISO 52012
ISO 52013
…
ISO 52143
ISO 52144
ISO 52145
ISO 52146
ISO 52147
ISO 52148
ISO 52149
ISO 52150

# ISO 52000-2

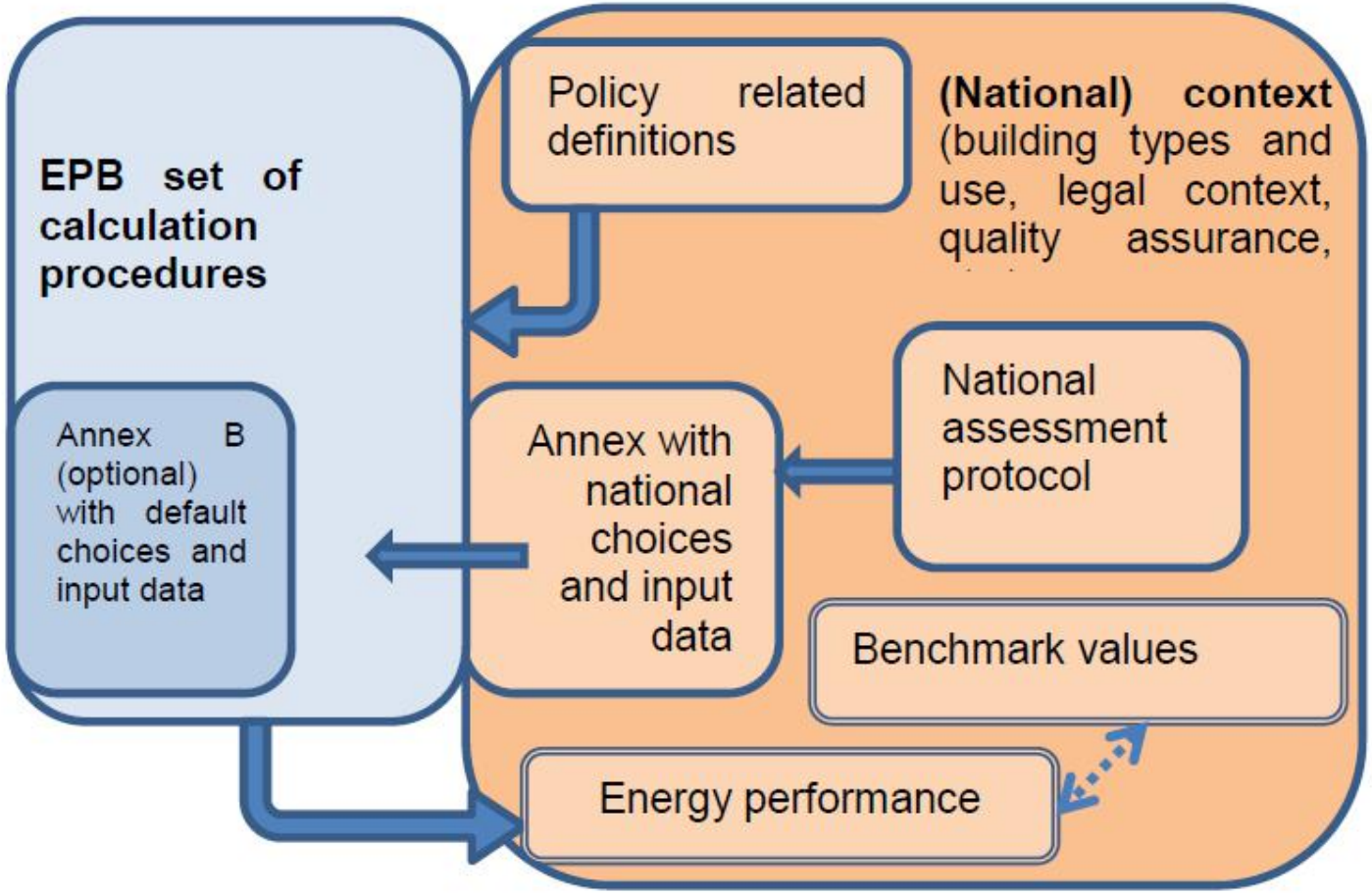



**Figure B.1 — Illustration of link between EPB set of standards and national context**

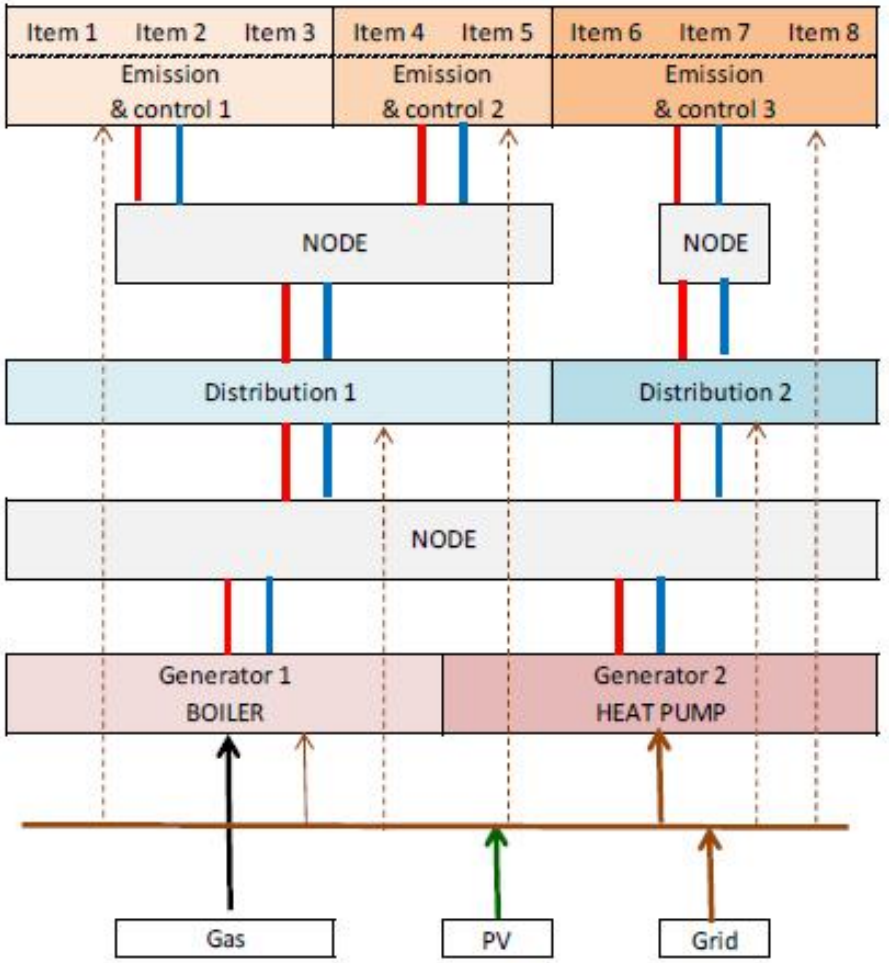
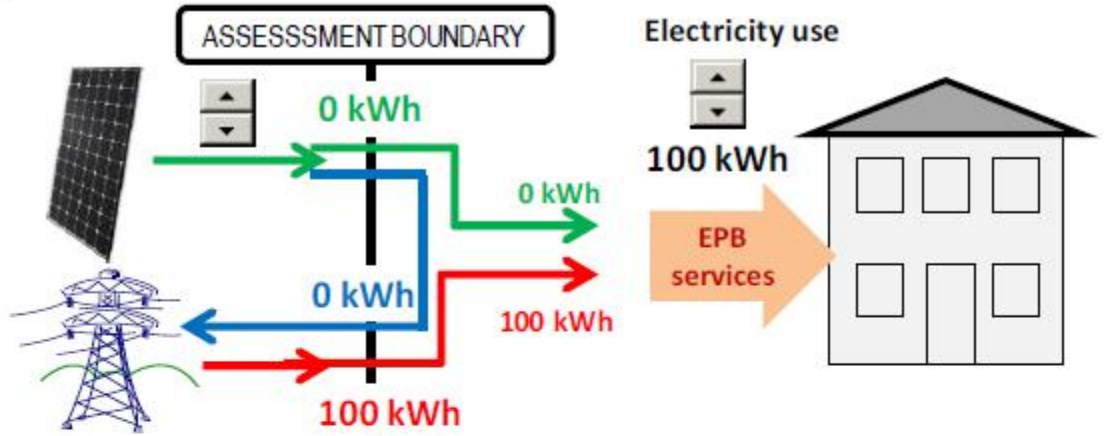
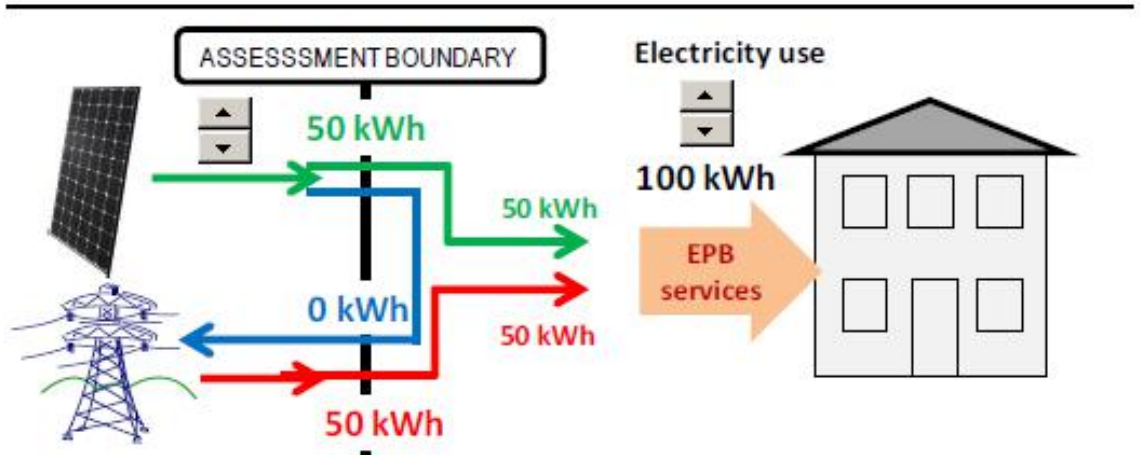



**Figure E.2 — Sample complex technical system**




| | | E | fPnren | fPren | EPnren | Epren distant | Epren on-site | EPtot | RER | RER |
|---|---|---|---|---|---|---|---|---|---|---|
| | | kWh | | | kWh | kWh | kWh | kWh | tot | nrb-os |
| + Delivered energy | PV | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | | |
| - Exported energy | PV | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | | |
| + Delivered energy | Grid | 100 | 2,0 | 0,5 | 200 | 50 | | 250 | | |
| *TOTAL STEP A* | | | | | *200* | *50* | *0* | *250* | *0,20* | *0,00* |
| Kexp | 1,0 | | | | | | | | | |
| TOTAL STEP A | | | | | 200 | 50 | 0 | 250 | | |
| + Exported energy | PV | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | | |
| - Avoided grid gen | Grid | 0 | 2,0 | 0,5 | 0 | 0 | | 0 | | |
| Energy performance | | | | | 200 | 50 | 0 | 250 | 0,20 | 0,00 |
| Energy available ext. | | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | n.a. | n.a. |

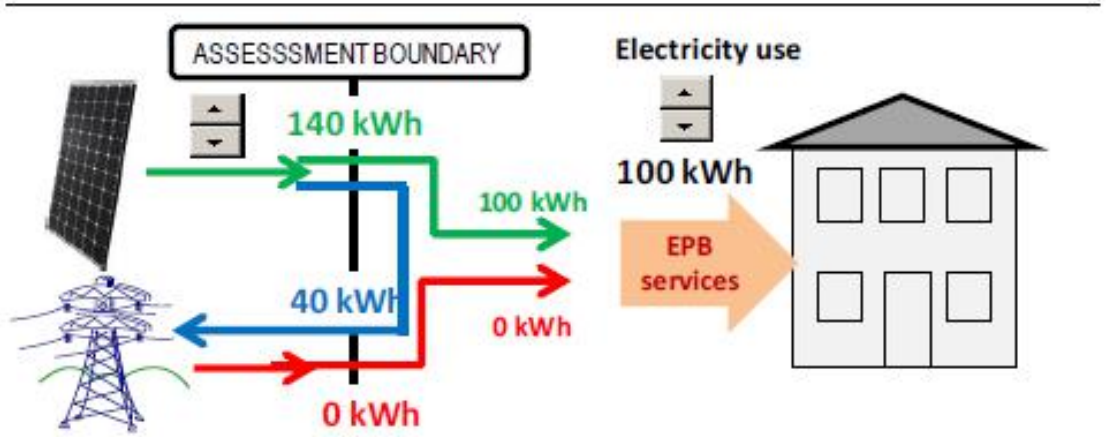
**Figure J.1 — All electric system all by the grid**




| | | E | fPnren | fPren | EPnren | Epren distant | Epren on-site | EPtot | RER | RER |
|---|---|---|---|---|---|---|---|---|---|---|
| | | kWh | | | kWh | kWh | kWh | kWh | tot | nrb-os |
| + Delivered energy | PV | 50 | 0,0 | 1,0 | 0 | | 50 | 50 | | |
| - Exported energy | PV | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | | |
| + Delivered energy | Grid | 50 | 2,0 | 0,5 | 100 | 25 | | 125 | | |
| *TOTAL STEP A* | | | | | *100* | *25* | *50* | *175* | *0,43* | *0,29* |

| Kexp | 1,0 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL STEP A | | | | | 100 | 25 | 50 | 175 | | |
| + Exported energy | PV | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | | |
| - Avoided grid gen | Grid | 0 | 2,0 | 0,5 | 0 | 0 | | 0 | | |
| Energy performance | | | | | 100 | 25 | 50 | 175 | 0,43 | 0,29 |
| Energy available ext. | | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | n.a. | n.a. |

**Figure J.2 — All electric system, 50% covered by PV**




| | | E | fPnren | fPren | EPnren | Epren distant | Epren on-site | EPtot | RER | RER |
|---|---|---|---|---|---|---|---|---|---|---|
| | | kWh | | | kWh | kWh | kWh | kWh | tot | nrb-os |
| + Delivered energy | PV | 140 | 0,0 | 1,0 | 0 | | 140 | 140 | | |
| - Exported energy | PV | 40 | 0,0 | 1,0 | 0 | | -40 | -40 | | |
| + Delivered energy | Grid | 0 | 2,0 | 0,5 | 0 | 0 | | 0 | | |
| *TOTAL STEP A* | | | | | *0* | *0* | *100* | *100* | *1,00* | *1,00* |
| Kexp | 1,0 | | | | | | | | | |
| TOTAL STEP A | | | | | 0 | 0 | 100 | 100 | | |
| + Exported energy | PV | 40 | 0,0 | 1,0 | 0 | | 40 | 40 | | |
| - Avoided grid gen | Grid | 40 | 2,0 | 0,5 | -80 | -20 | | -100 | | |
| Energy performance | | | | | -80 | -20 | 140 | 40 | 3,00 | 3,50 |
| Energy available ext. | | 0 | 0,0 | 1,0 | 0 | | 0 | 0 | n.a. | n.a. |

Figure J.3 — All electric system, excess PV production

Just some pictures left over

and

# Framework of the schedule and condition for building energy calculation in ISO DIS 18523-1 (non-residential)

## Framework of the daily schedule (normative)

| Items in daily schedule | | Description by hourly values for 0-24 hour |
|---|---|---|
| a) General information on occupancy and usage | Occupancy density | Hourly occupancy density |
| | Simultaneous usage ratio of a set of rooms | Hourly simultaneous usage ratio |
| b) Operation of technical building systems and requirement for their building services | Space heating and/or cooling | Hourly status of space heating and/or cooling system (in or out of service) |
| | | Hourly set-points of room temperature and/or humidity |
| | Ventilation for conditioned zone or space | Hourly status of ventilation system (in or out of service) |
| | | Hourly ventilation requirement |
| | Lighting | Hourly status of lighting system (in or out of service) |
| | | Maintained illuminance and height of working plane |
| | Domestic hot water | Hourly status of domestic hot water system |
| | | Hourly service hot water usage |
| | Ventilation for unconditioned zone or space | Hourly ventilation requirement |
| | | Set-point of room temperature (upper limit) |
| c) Internal heat gains (sensitive and/or latent) | Person (watt per unit floor area) | Hourly heat gains |
| | Lighting (watt per unit floor area) | Hourly heat gains |
| | Appliances (watt per unit floor area) | Hourly heat gains |

# Framework of the schedule and condition for building energy calculation in ISO DIS 18523-1 (non-residential)

Category of building (normative)

**⇒ For the conformity with 52000-1, this table shall be moved to an informative annex!**

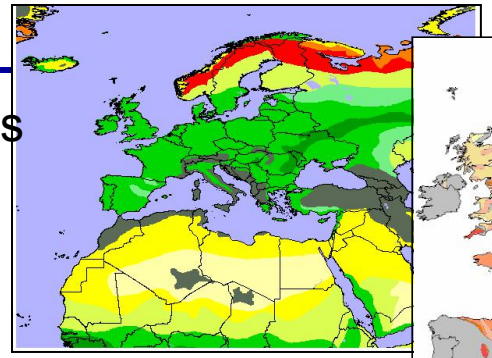
| Category of building | Representing zone(s) or space(s) for principal function(s) of building |
|---|---|
| 1. Office | Office room, Office room with heavy electrical load |
| 2. Hotel | Guest room, Banquet hall, Conference hall |
| 3. Hospital | Ward, Consultation room |
| 4. Shop | Large store, Small store, Supermarket |
| 5. Educational | Class room of junior and junior high school, Class room of high school, Lecture room of university, Study room, Experimental laboratory, Lecture hall and gymnasium |
| 6. Restaurant | Dining room of restaurant, Guest room of coffee house, Bar, Kitchen |
| 7. Library | Reading room, Book stack |
| 8. Museum | Exhibition room, Storeroom |
| 9. Gymnasium | Gymnasium, Spectator stand |
| 10. Theatre | Auditorium, Stage |
| 11. Religious | Assembly room |
| 12 Warehouse | Warehouse |
| 13. Factory | Production room |

Geothermal Energy

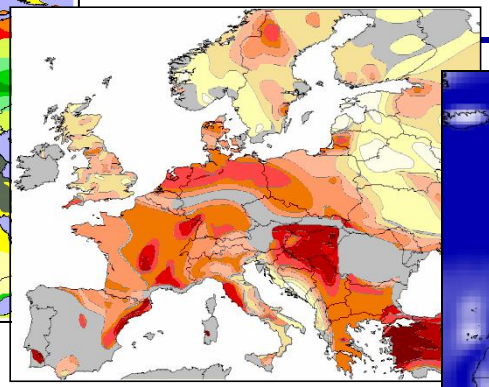
Wind Energy

Biomass

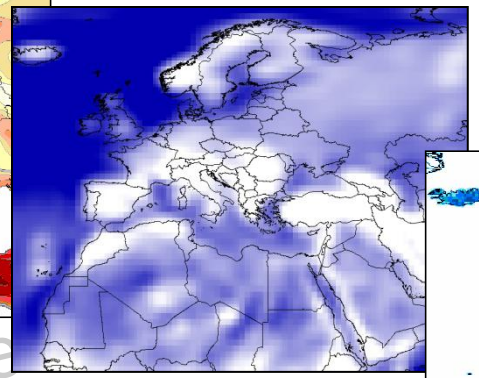
Hydropower



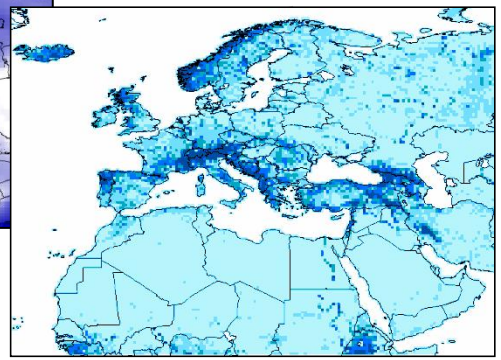
402



414



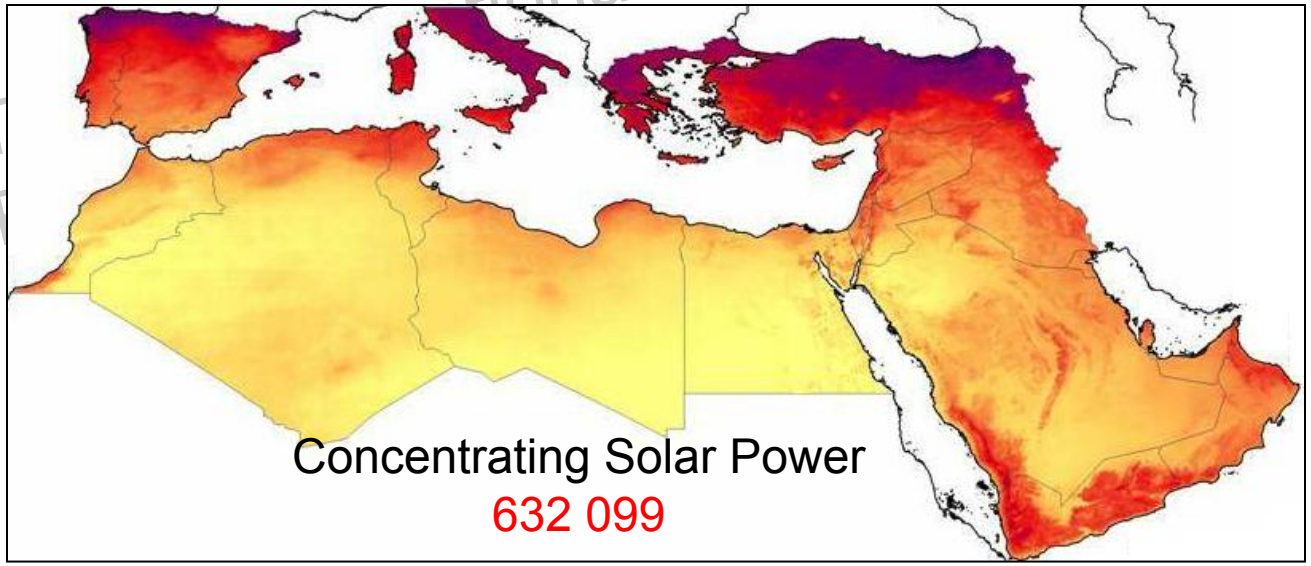
447



432

Economic Potential TWh/y

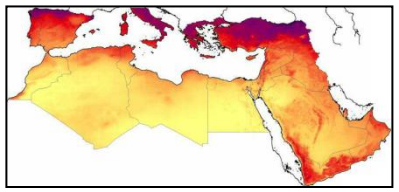
(Demand 2050 ≈ 4000 TWh/y)



Concentrating Solar Power

632 099

PV



218



# *What next*

# Energy, Buildings and the Environment

# Energy Flows To and From Buildings

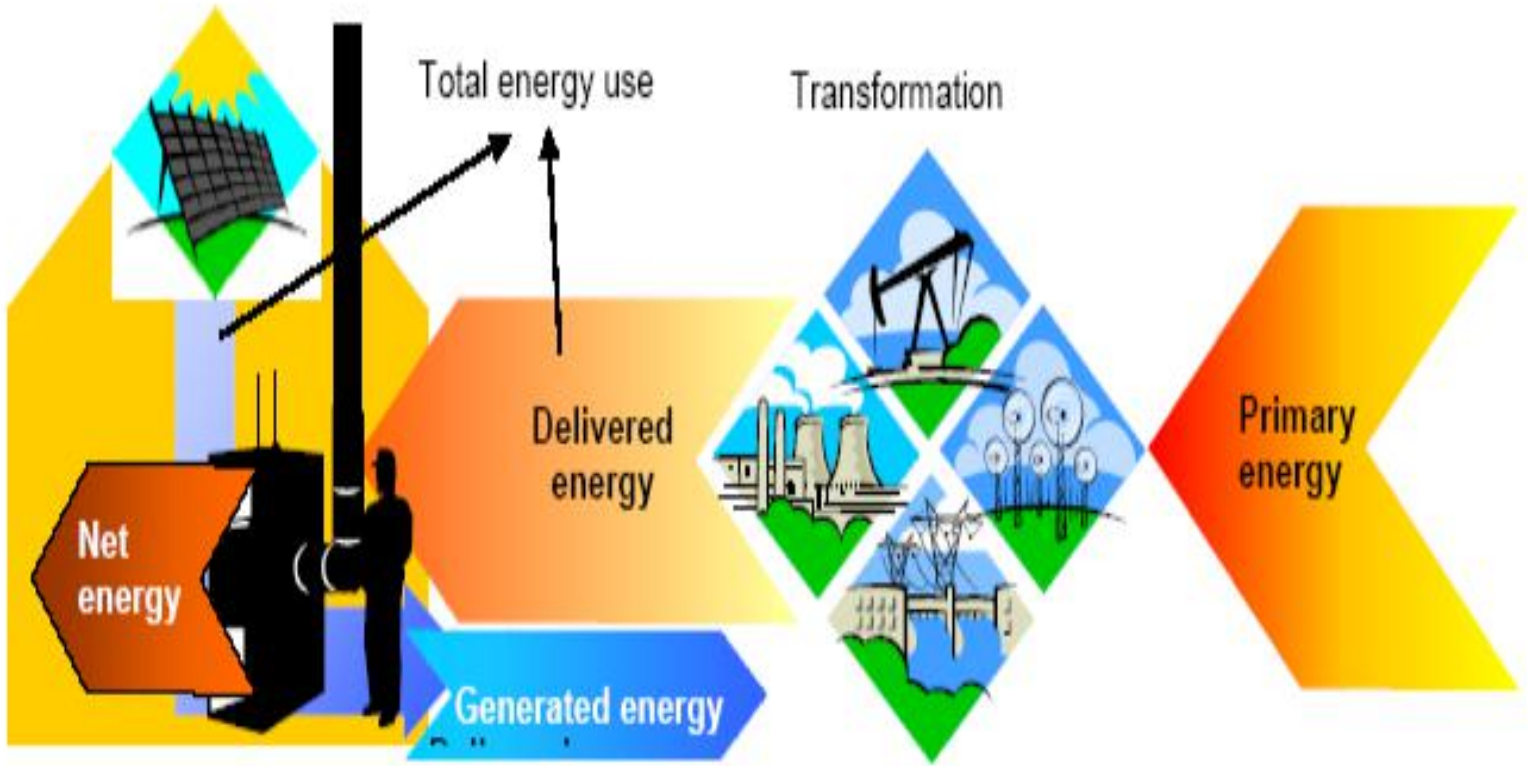
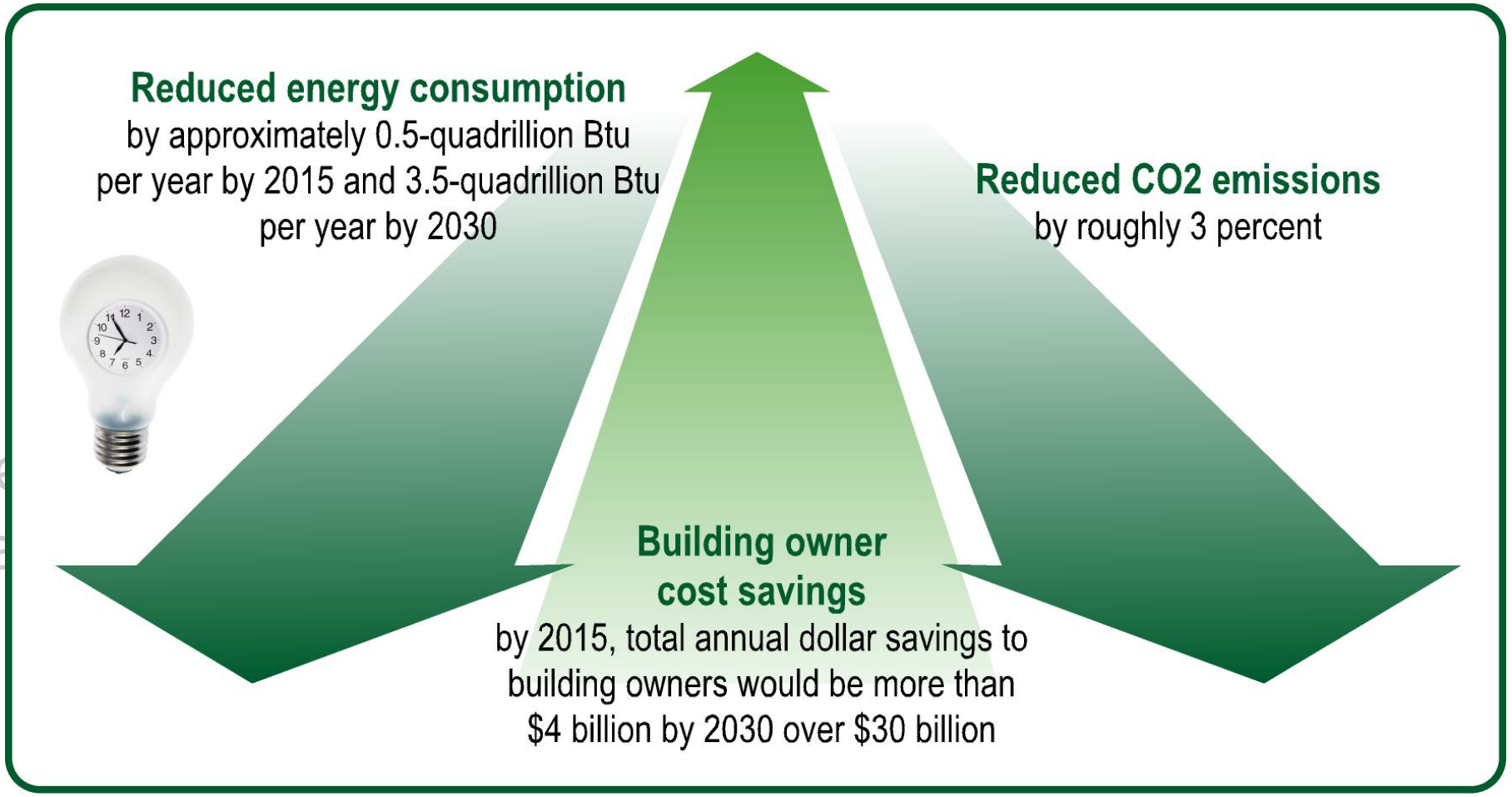



Figure 1 — Energy flows to and from buildings

# Code benefits and challenges



**Building envelope**

Local climate plays a role in the energy code requirements for the material selection and techniques used to construct the building envelope. Code requirements specify the insulation levels in the floor, ceiling, and walls and are intended to seal the building against air leakage and moisture migration. The defined energy-efficiency levels of doors and windows take into consideration heat loss and gain, depending on whether heating or cooling of the building is the predominant concern, and daylighting. Designers and contractors must make sure that the building materials and installation are completed as specified for the building to comply with the code.

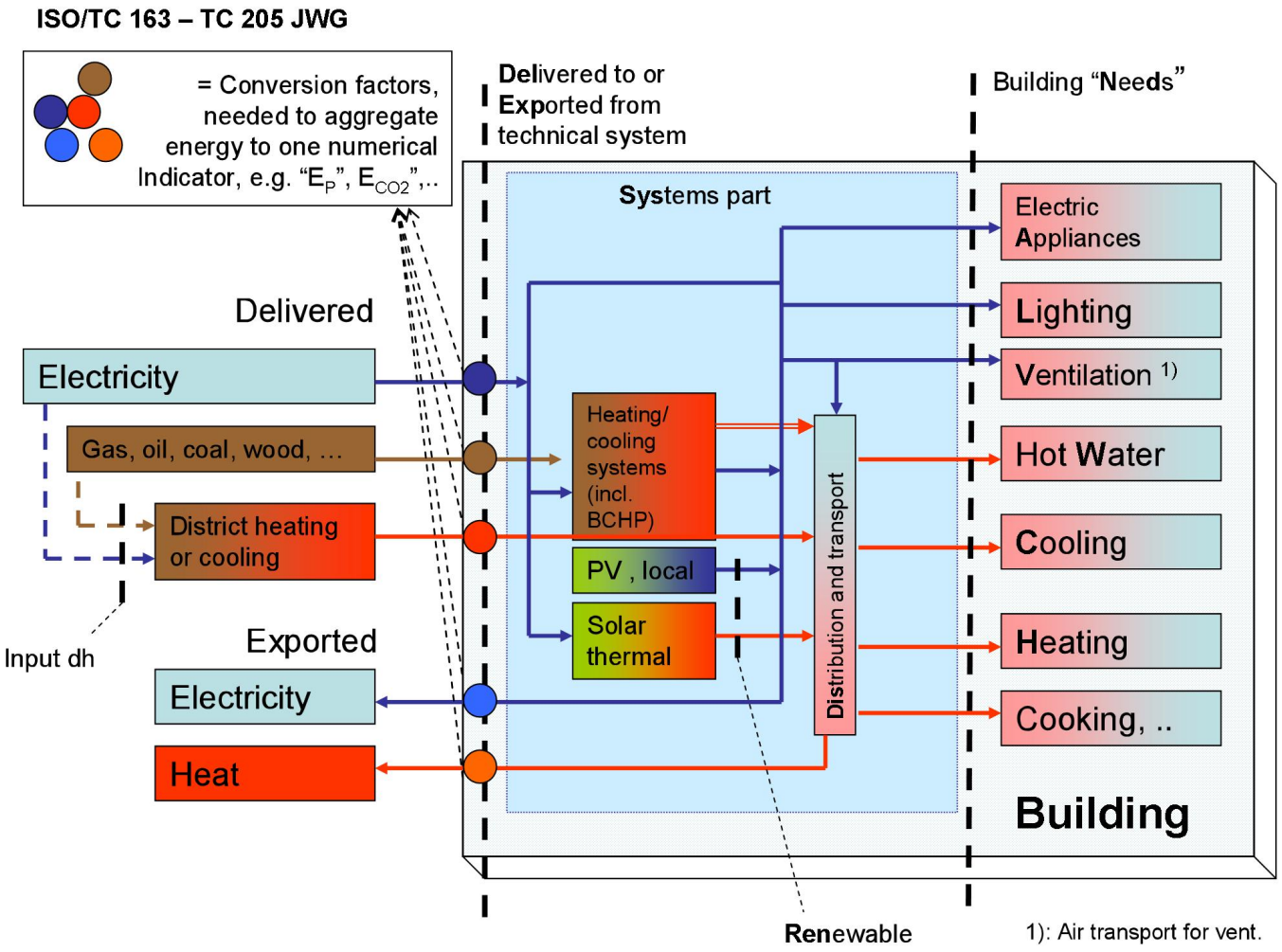
## Heating, ventilating, and cooling

HVAC systems are composed of equipment that creates conditioned air or tempered liquid, conveys air or liquid through passageways (ducts and plenums) or pipes, and automatically regulates the amount to be conveyed via recirculation or exhausting. HVAC system efficiency can be improved by adding equipment that can convert delivered gas or electric power efficiently or by using economizers, which allow the automatic use of outside air or allow users to regulate space conditions. Energy codes provide minimum criteria for the size of HVAC systems and equipment, taking into consideration the energy demands of the building space.


## Lighting and electrical

Energy efficiency for lighting is gained by using efficient sources of illumination, considering the number and location of lights throughout the space, and considering the control systems for appropriate operation. The energy codes provide minimum criteria to provide effective lighting control.

Motor and transformer efficiency is also covered in this area



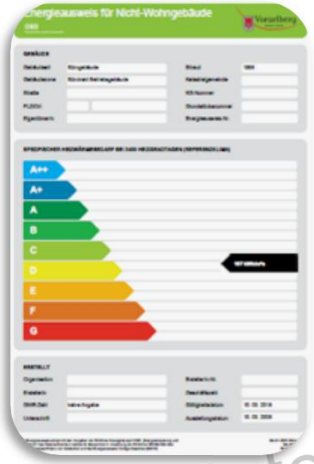



# Needed Energy Satandards

# What's Your Building EQ

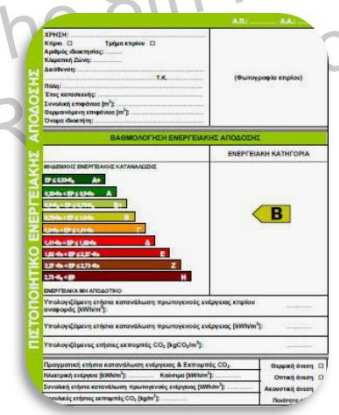
Building Energy Quotient
ASHRAE's Building Energy Labeling Program

AUSTRIA

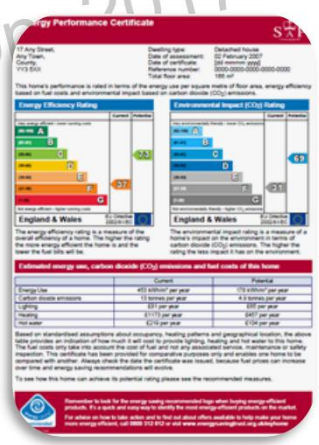


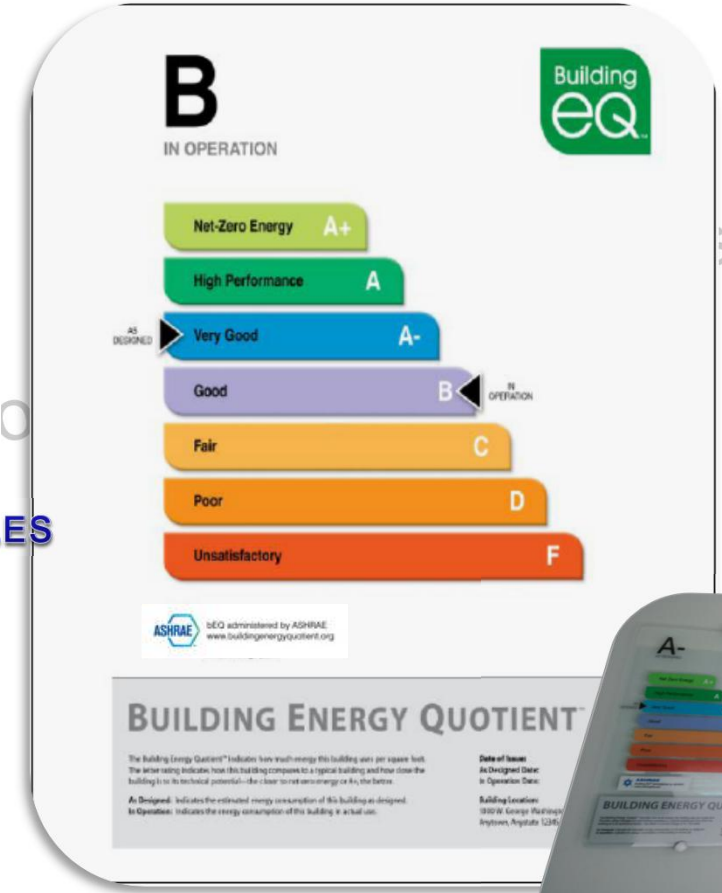
ITALY

GREECE

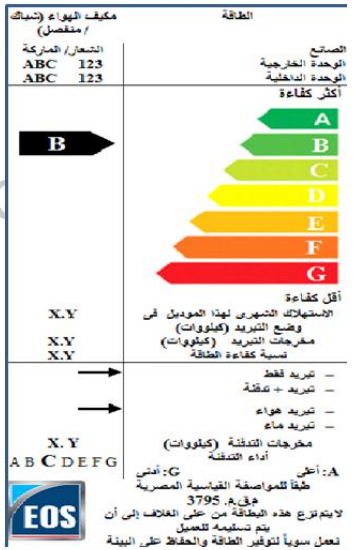


ENGLAND & WALES

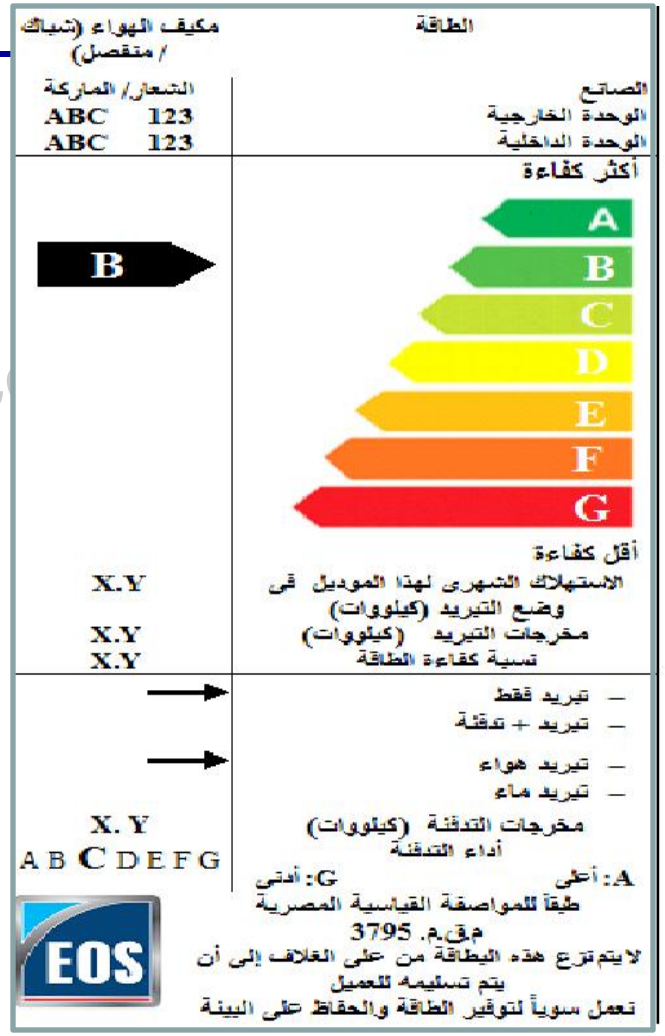





EGYPT




| نسبة كفاءة الطاقة لمكيف هواء الغرفة (للمنفصل) | مستويات نسب هبك هاءف الطاقة |
|---|---|
| 12 وأعلى من أو تساوى | A |
| 12 وأقل من أو تساوى 11.5 | B |
| 11.5 وأقل من أو تساوى 11 | C |
| 11 وأقل من أو تساوى 10.5 | D |
| 10.5 وأقل من أو تساوى 10 | E |
| 10 وأقل من أو تساوى 9.5 | F |
| 9.5 وأقل من أو تساوى 9 | G |




# Egypt -2014

نموذج لمكيف هواء الغرفة (تبريد فقط)2014

# Problems with hydroelectric

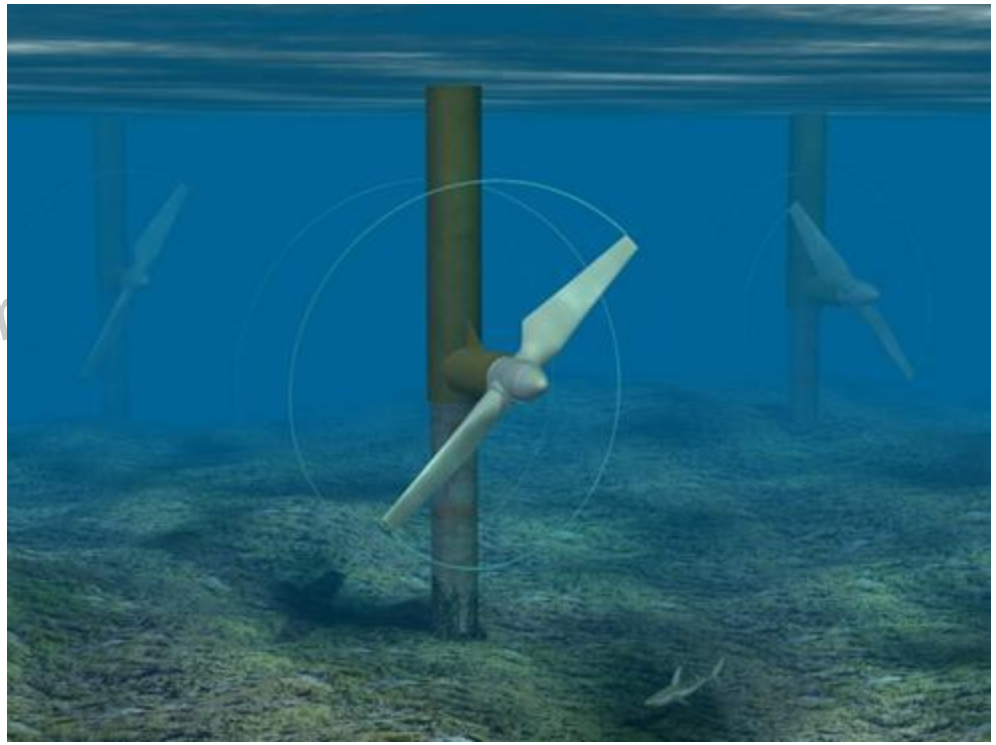
- Location = unused rivers are in extreme north or low population areas
- Competition with recreational uses and environmental concerns
- Hard to build dams in populated river valleys
- Siltation of dams – limited life.

Tidal power anywhere

1. No dam – but a turbine.

Problems:

1. Corrosion
2. Navigation
3. Appearance
4. Amount of energy available is low
5. Best tides are near poles – away from people.

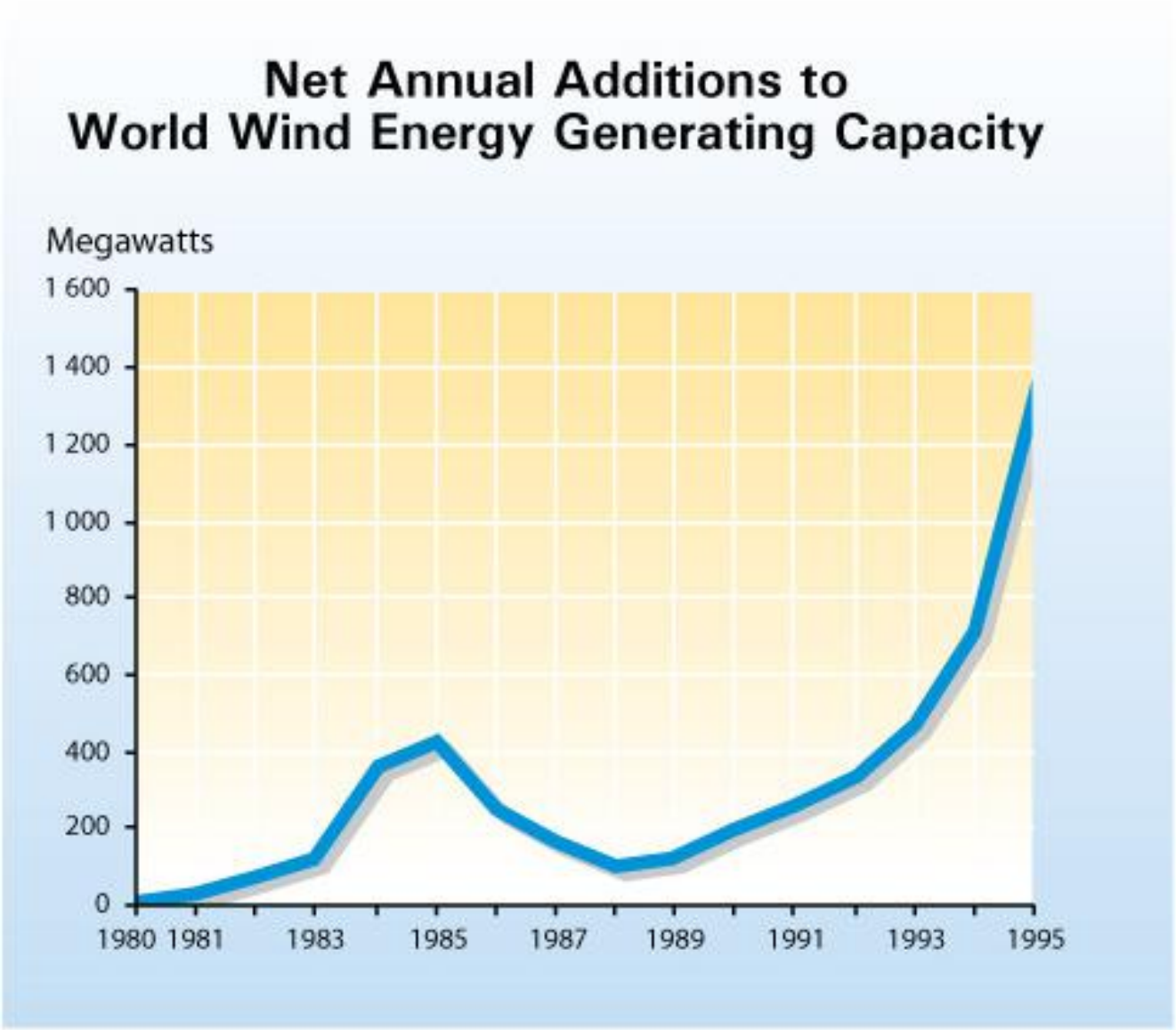


Wind Power = wind farms

Banning Pass

Netherlands = coastal development

England = off shore



# Wind energy problems

- Location – near population center
- Bird migration –
- Visual
- Must be coupled with other sources of electricity. (intermittent supply)

Solar farm = big solar plants

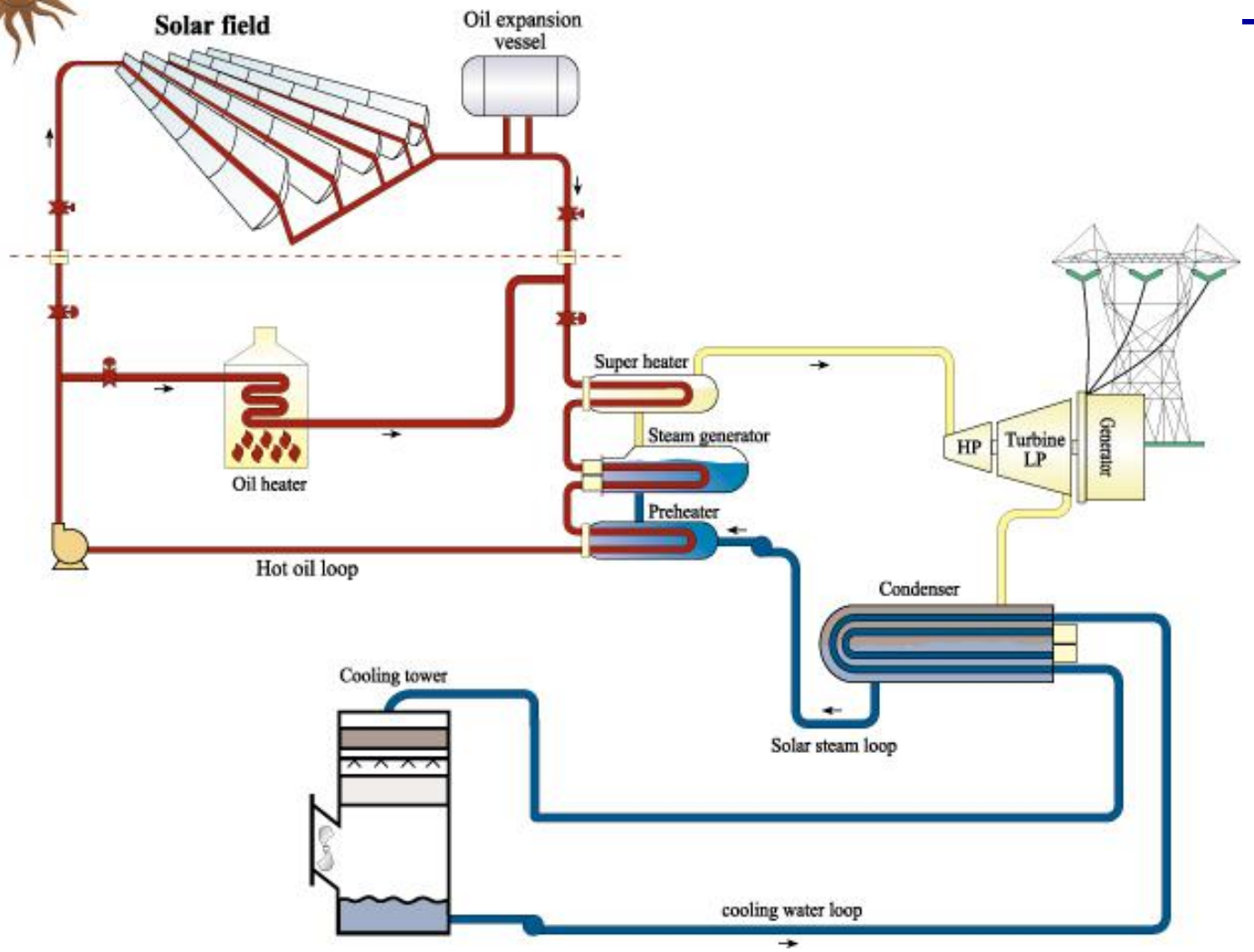
# Egypt plan 100 MW Solar

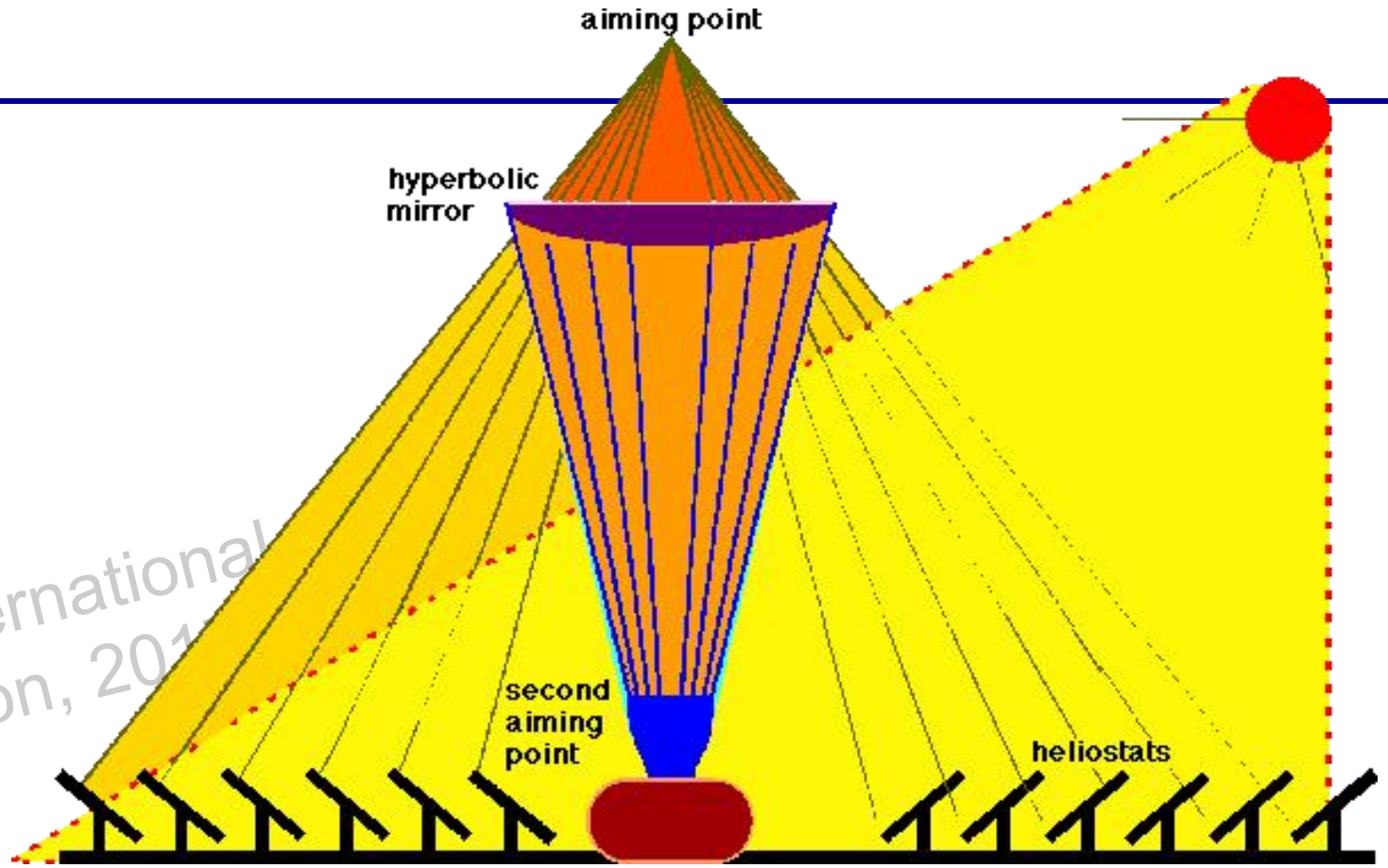


A parabolic trough solar thermal power plant in eastern Spain; Egypt is planning to generate 100MW of electricity from a solar power plant .The first solar plant at El-Koraymat, south of Cairo, which is expected to be finished later this year and will produce 20MW of solar power alongside 120MW of conventional natural gas power. The Egyptian Electricity Ministry has unveiled plans to build a new $700m 100MW solar power plant at Kom Ombo between 2012 and 2017 that should further establish the country as one of the leading developers of utility-scale solar plants.

# The Solel Solar Field

## Application to Power Plant








At focal point = heat liquid – steam to turn turbine

# ‘hard’ vs ‘soft’ energy paths

Hard =

1. Big plants
2. Centralized production

Soft =

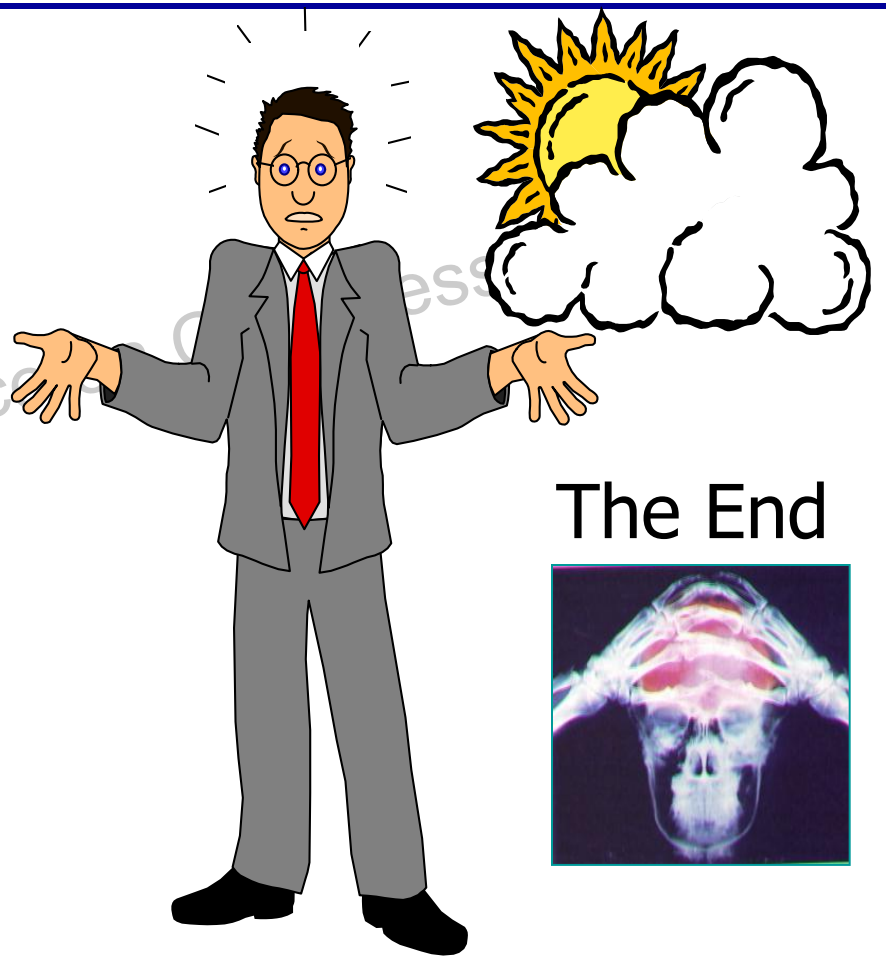
1. Decentralized
2. units per household

Energy efficient house; wind power on roof. Solar panels for heat and electricity.

Solar electricity generation

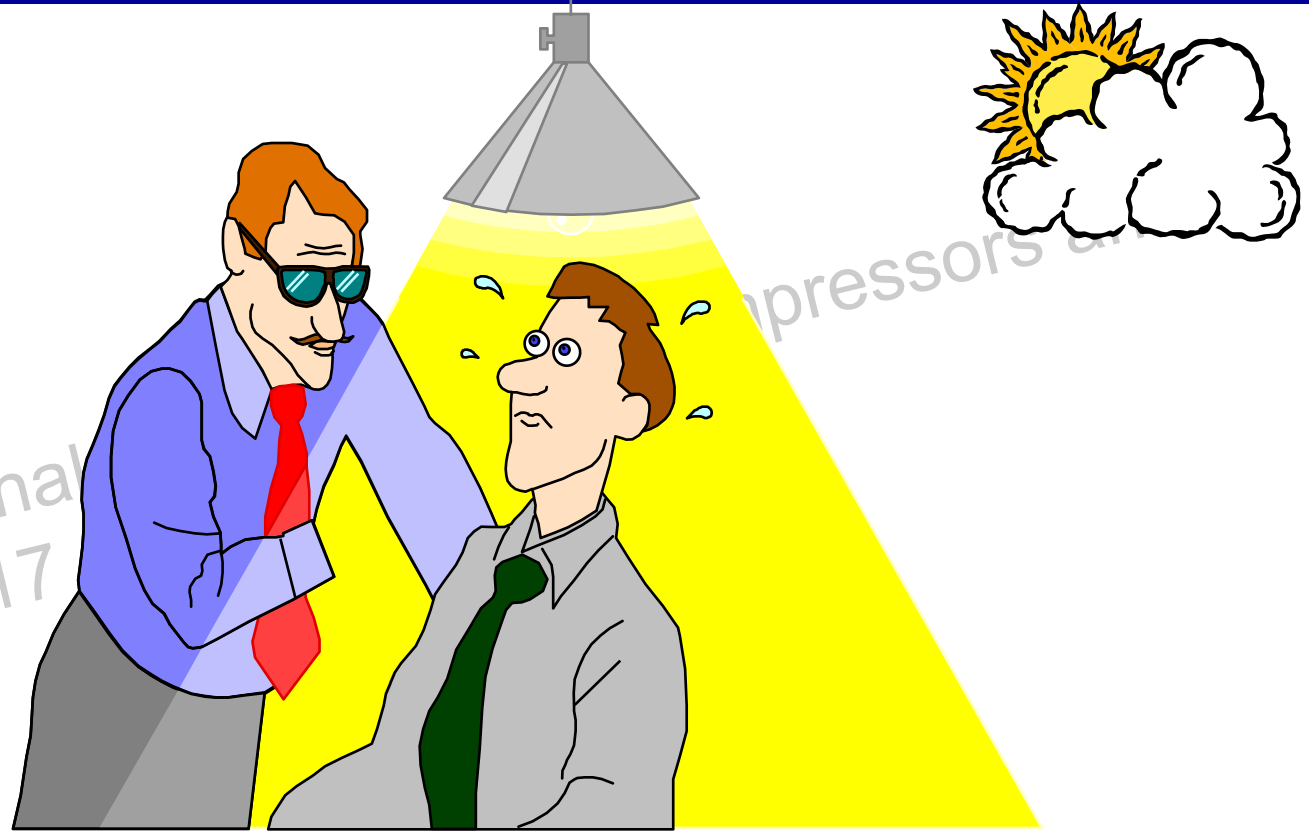
# It is very gratifying to find some one that silently appreciates your efforts

# I REST MY CASE YOUR HONOURS



Thank You

The End



# QUESTIONS !!

# Yes ……. I have two hands