EPB CENTER
Consultancy Services on the Energy Performance of Buildings

Support, consultancy and services on Energy Performance of Buildings standards calculations and implementation

EPB standards and waste water heat recovery

Laurent Socal – EPB Center expert

The context

- Modern civilization and well-being is based on the massive **availability** and **use** of quite a lot of **cheap energy**
- The growing concern is **sustainability** of the use of large amounts of energy, mainly because of:
  - Environmental impact → "zero emission building" **ZEmB**
  - Depleting resources → "nearly zero energy building" **NZEB**

  … and other concerns like dependency from suppliers…

EU is planning a tough transition for the building sector:
EPBD on-going 2nd recast

The meter and the target

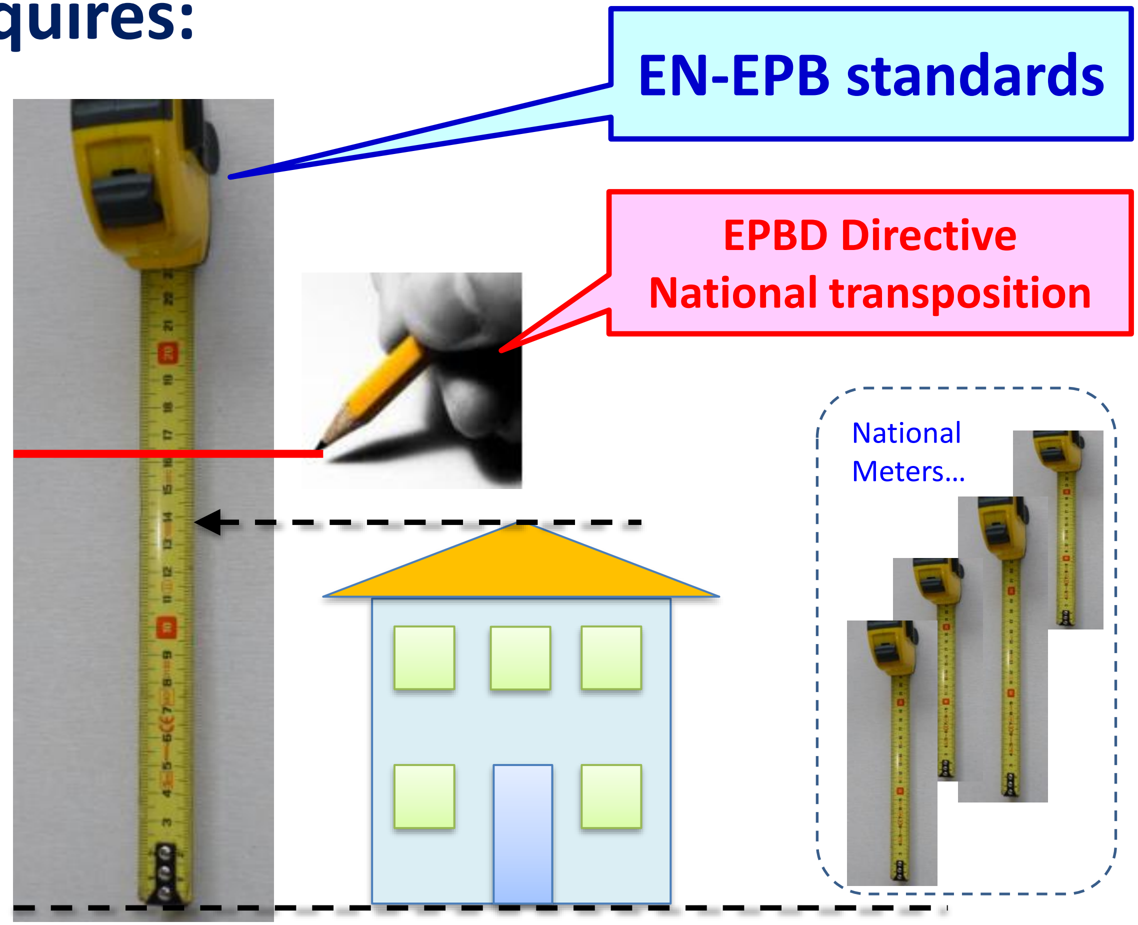
Setting up legal requirements to evaluate and improve buildings and products requires:

A meter

- Calculation methods
- Common definitions

A benchmark

- Legal requirements
- Energy classes definition



> ***You can't improve (nor regulate) it if you can't measure it***
> Lord Kelvin
> … any requirement depends on criteria…

Energy use in a building

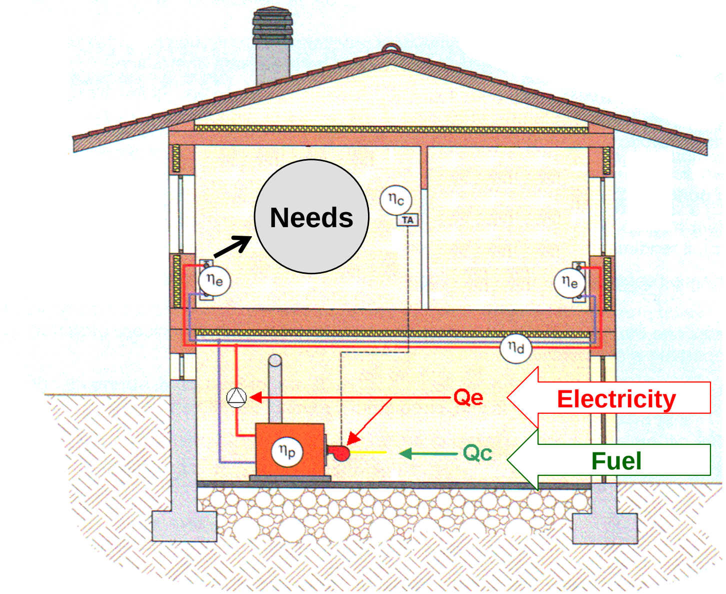
Energy is used in the buildings for two main reasons:

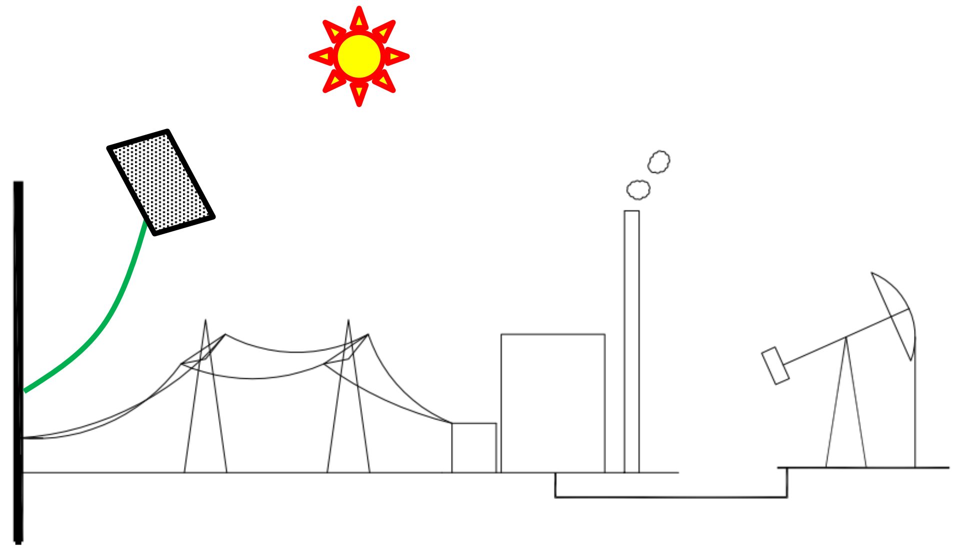
- **comfort services**: providing adequate comfort conditions inside the building
- **process use**: supporting the activities performed inside the building (plug loads, …)

Energy Performance of Buildings Directive and EPB standards are focused on comfort services.

Code	EPB Service name	Definition	Needs kWh/m²y
H	Heating	Keeping indoor temperature above a minimum comfort value.	**10…200** (heat)
C	Cooling	Keeping the indoor temperature below a maximum comfort value	**0…50** (heat removal)
W	**Domestic hot water**	**Providing domestic hot water for personal hygienic needs of people within the building**	**0 - 15…20 – 50 (heat)**
V	Ventilation (only fans)	Providing a minimum flow rate of outdoor air	**0…20** (electricity)
HU/DHU	Humidification and dehumidification	Keeping indoor relative humidity within a defined range	**0…50** (heat & removal)
L	Lighting	Providing a minimum illumination in lux on work planes	**20…50** (electricity, LENI)
T	People transport	Transporting people around the building	0…?

It's not only needs...





ENERGY NEEDS
for comfort "services"

Building envelope & activities

Losses
Auxiliary
Efficiency

Technical systems

Delivered energy

Exported energy

ASSESSMENT BOUNDARY

Weighted energy

Primary, non renewable
Primary, renewable
Primary, total
CO_2 emission
Costs
...

Energy terminology

Level	Type of energy involved
Needs	Various definitions. The native need may not be an energy amount. Reference conditions are needed to define needs (e.g. desired indoor temperature, domestic hot water temperature at the tap, etc.)
Usable energy	Heat, heat extraction, electricity (auxiliary energy), air flow, light flux… This is what is produced by the “generation” sub-systems using delivered energy
Delivered energy	**Any energy carrier** (gas, electricity, heat from district heating, etc.) which is crossing the assessment boundary.
Weighted energy	**A common property of all energy carriers**, such as primary energy contents, CO_2 emission, cost, etc. **The weighted energy provides the actual impact of providing EPB services**

How to obtain sustainable buildings

Reduce needs

Per service…

- **All**: user behavior (moderation)
- **H**: insulate building envelope, optimize gains …
- **L** Optimize daylight
- **C**: Provide shadings …
- **W**: ??

Reduce delivered energy

(build efficient systems)

- Control service "*emission*": how much, when, where.
- Reduce "losses"
- Use less auxiliary energy
- Change technology:
  - combustion → hp
  - incandescence → LED
- Optimize operating conditions
- Commission systems
- **Allow use of energy carriers from sustainable resources**

Use sustainable resources

- Use renewable energy
  - Photovoltaic
  - Thermal solar
  - Hydropower
  - …
- Use low carbon emission sources *(often similar but not equal to renewable)*
- **Recover / recycle energy (regeneration)**

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The meter : EPB standards

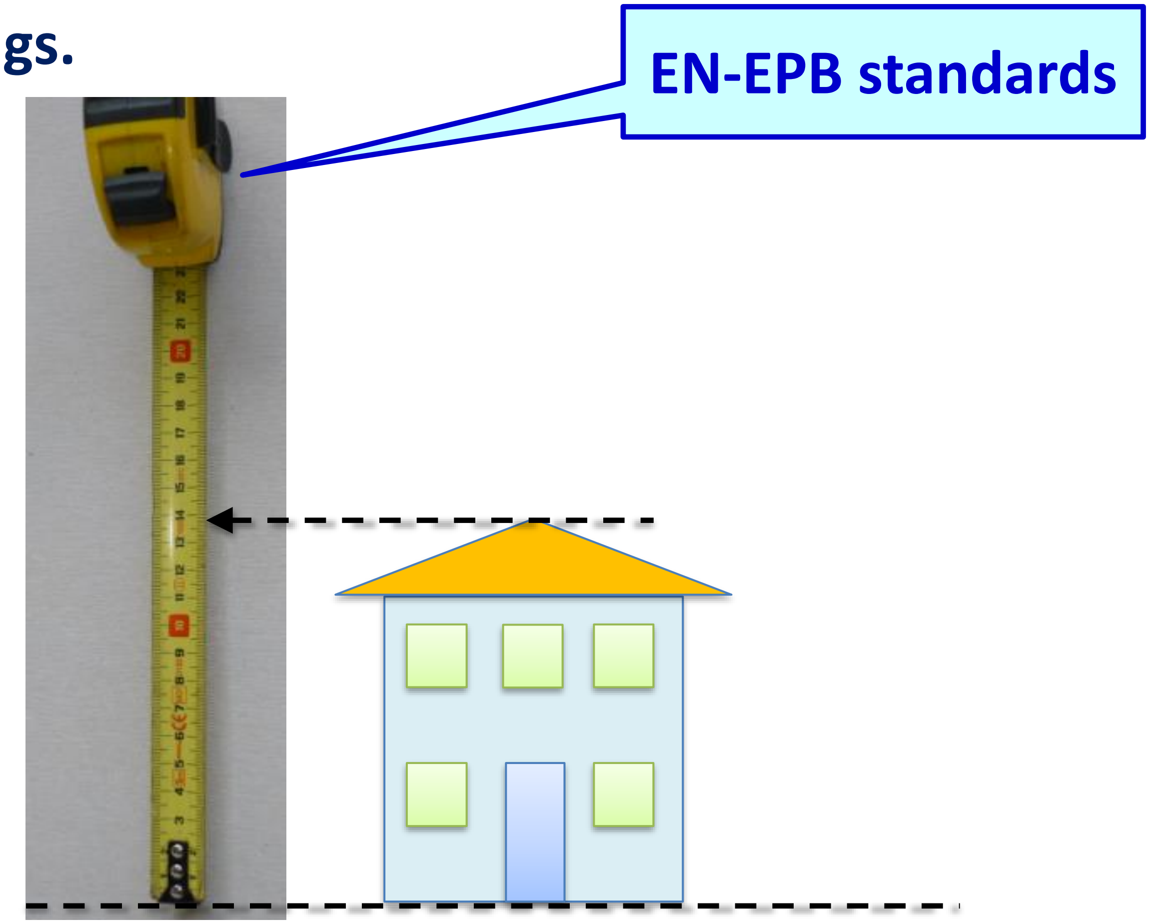
EN-EPB standards are the European meter of the energy performance of buildings.

First drafting under mandate M324
→ 2007 release

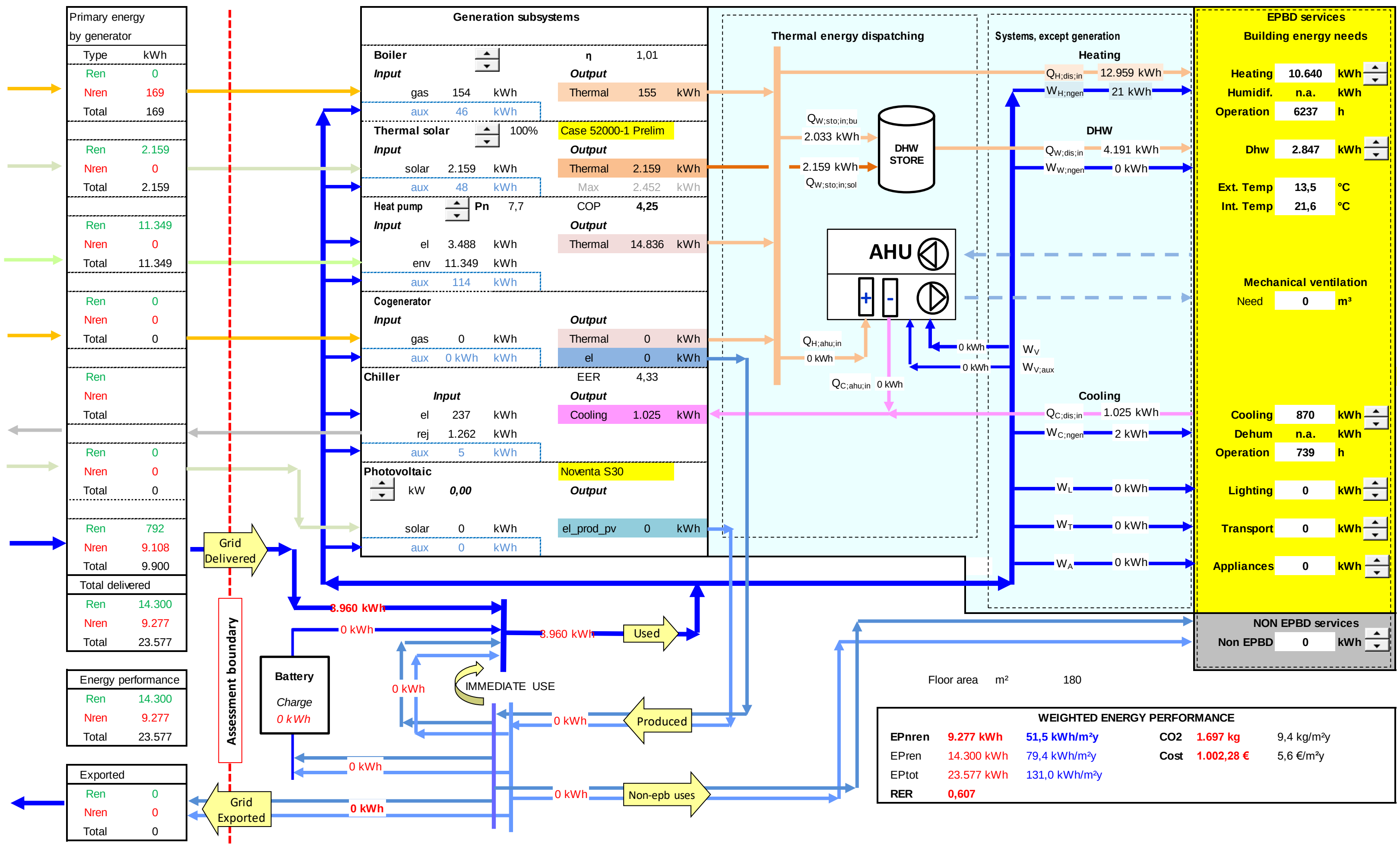
First revision under mandate M380
→ 2017 release

Starting: 5 years periodic review

If the Directive sets target values as absolute values, the meter of energy performance shall be unique throughout Europe



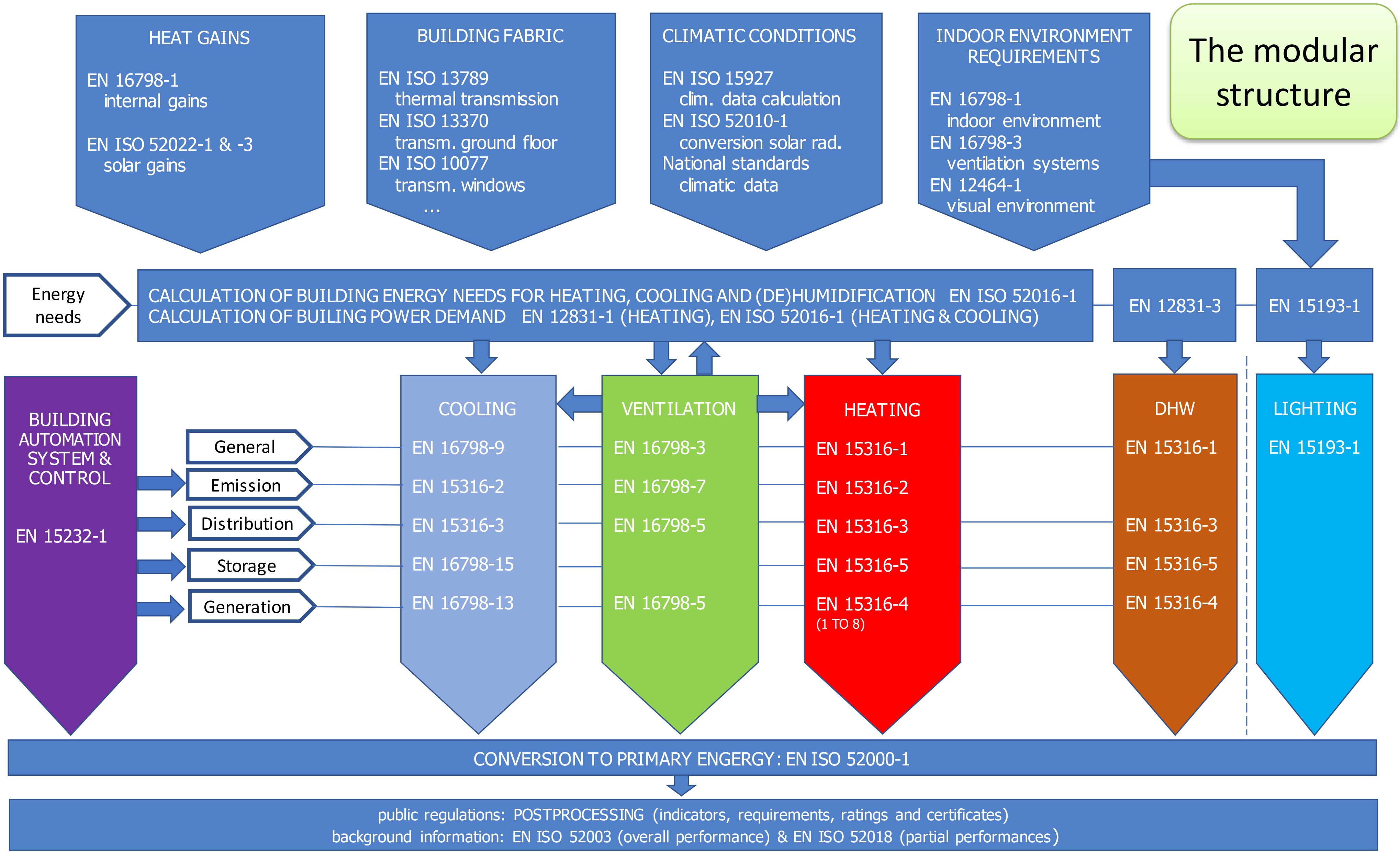
EPB calculation scheme…



Calculating the energy performance of a building is a «complicated» task

… maybe because modern buildings are complicated…

Do it by modules.



HEAT GAINS
EN 16798-1
internal gains
EN ISO 52022-1 & -3
solar gains
BUILDING FABRIC
EN ISO 13789
thermal transmission
EN ISO 13370
transm. ground floor
EN ISO 10077
transm. windows
...
CLIMATIC CONDITIONS
EN ISO 15927
clim. data calculation
EN ISO 52010-1
conversion solar rad.
National standards
climatic data
INDOOR ENVIRONMENT REQUIREMENTS
EN 16798-1
indoor environment
EN 16798-3
ventilation systems
EN 12464-1
visual environment
The modular structure
Energy needs
CALCULATION OF BUILDING ENERGY NEEDS FOR HEATING, COOLING AND (DE)HUMIDIFICATION EN ISO 52016-1
CALCULATION OF BUILING POWER DEMAND EN 12831-1 (HEATING), EN ISO 52016-1 (HEATING & COOLING)
EN 12831-3
EN 15193-1
BUILDING AUTOMATION SYSTEM & CONTROL
EN 15232-1
General
Emission
Distribution
Storage
Generation
COOLING
EN 16798-9
EN 15316-2
EN 15316-3
EN 16798-15
EN 16798-13
VENTILATION
EN 16798-3
EN 16798-7
EN 16798-5
EN 16798-5
HEATING
EN 15316-1
EN 15316-2
EN 15316-3
EN 15316-5
EN 15316-4
(1 TO 8)
DHW
EN 15316-1
EN 15316-3
EN 15316-5
EN 15316-4
LIGHTING
EN 15193-1
CONVERSION TO PRIMARY ENGERGY: EN ISO 52000-1
public regulations: POSTPROCESSING (indicators, requirements, ratings and certificates)
background information: EN ISO 52003 (overall performance) & EN ISO 52018 (partial performances)

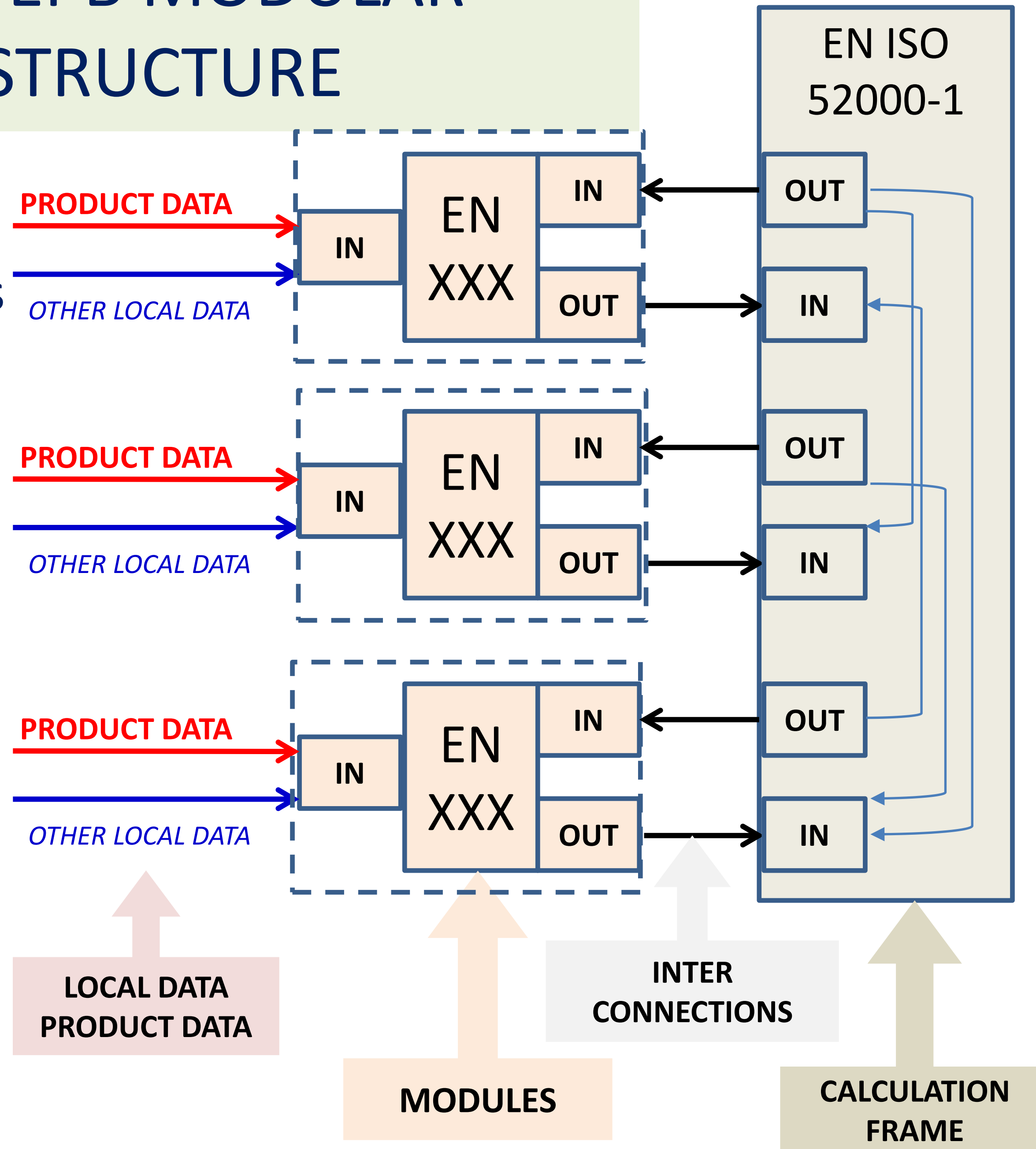
What is a module?

Each «module» is a package covering a specific topic consisting of:

- **EN standard**: normative calculation procedure and I/O data
  - Drafted according to the module template
  - Annex A: template for default data and parameters (normative)
  - Annex B: default data and parameters (informative)
- **CEN Technical report**: informative explanation of the procedure
- **Accompanying XLS**: demonstration of the calculation procedure
  Sheets: input data → calculation procedure → output data
- **Quality checklist**: to document that the module complies with EPB standards specifications:
  - EN ISO 52000-1 annexes
  - CEN TS 16629, detailed technical rules

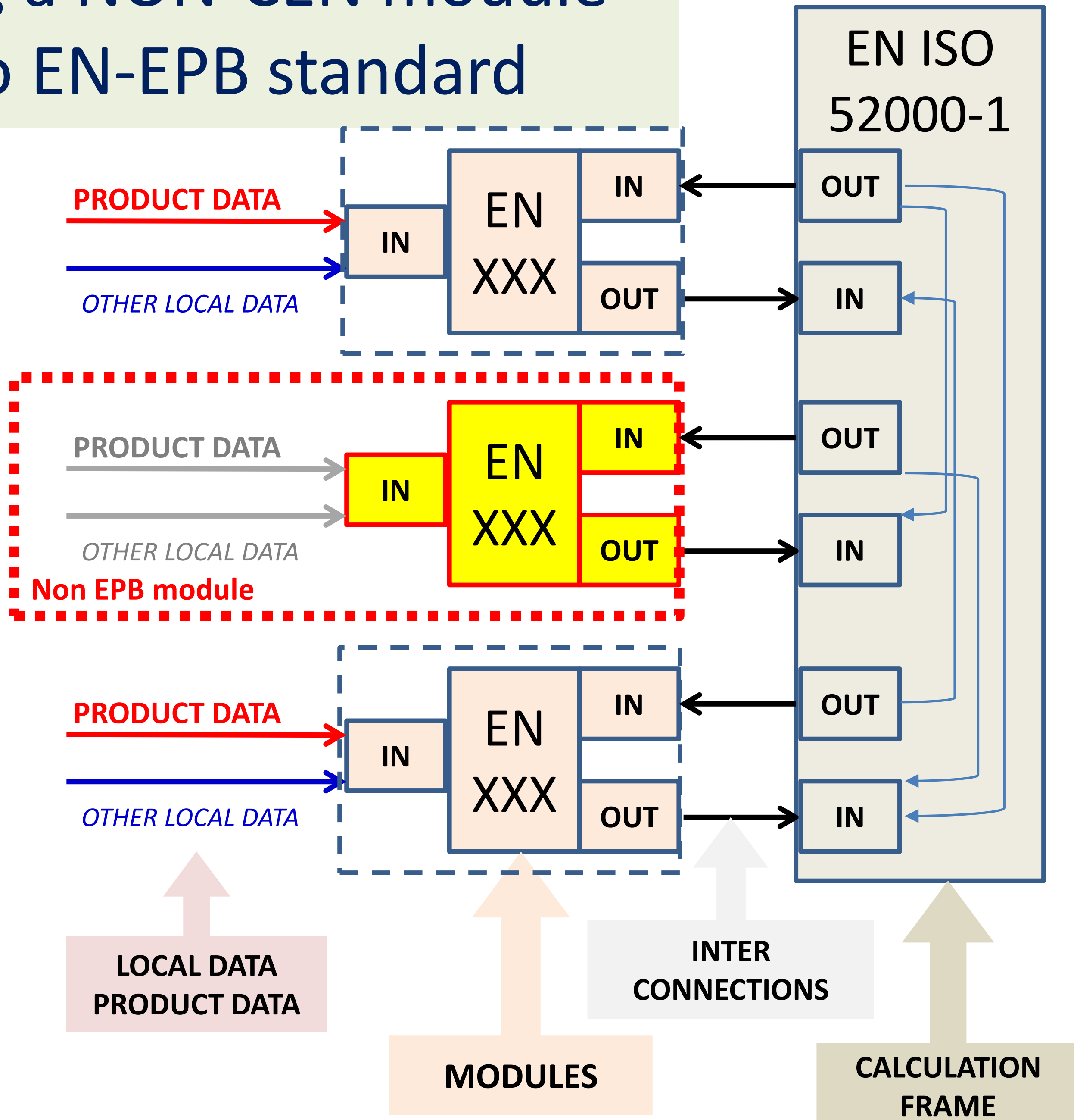
CEN-EPB MODULAR STRUCTURE

- CALCULATION STRUCTURE
  EN ISO 52000-1 + general parts
- CALCULATION MODULES
  FOR EACH STEP
  1 XLS per module
- EACH CALCULATION
  MODULE REQUIRES
  - INTERCONNECTION VALUES
    (I/O TO THE STRUCTURE)
  - PRODUCT DATA (LOCAL DATA)
  - OTHER LOCAL DATA ABOUT
    SPECIFIC APPLICATION
    (LIKE LOCALISATION , INDOOR/
    OUTDOOR INSTALLATION INFO)



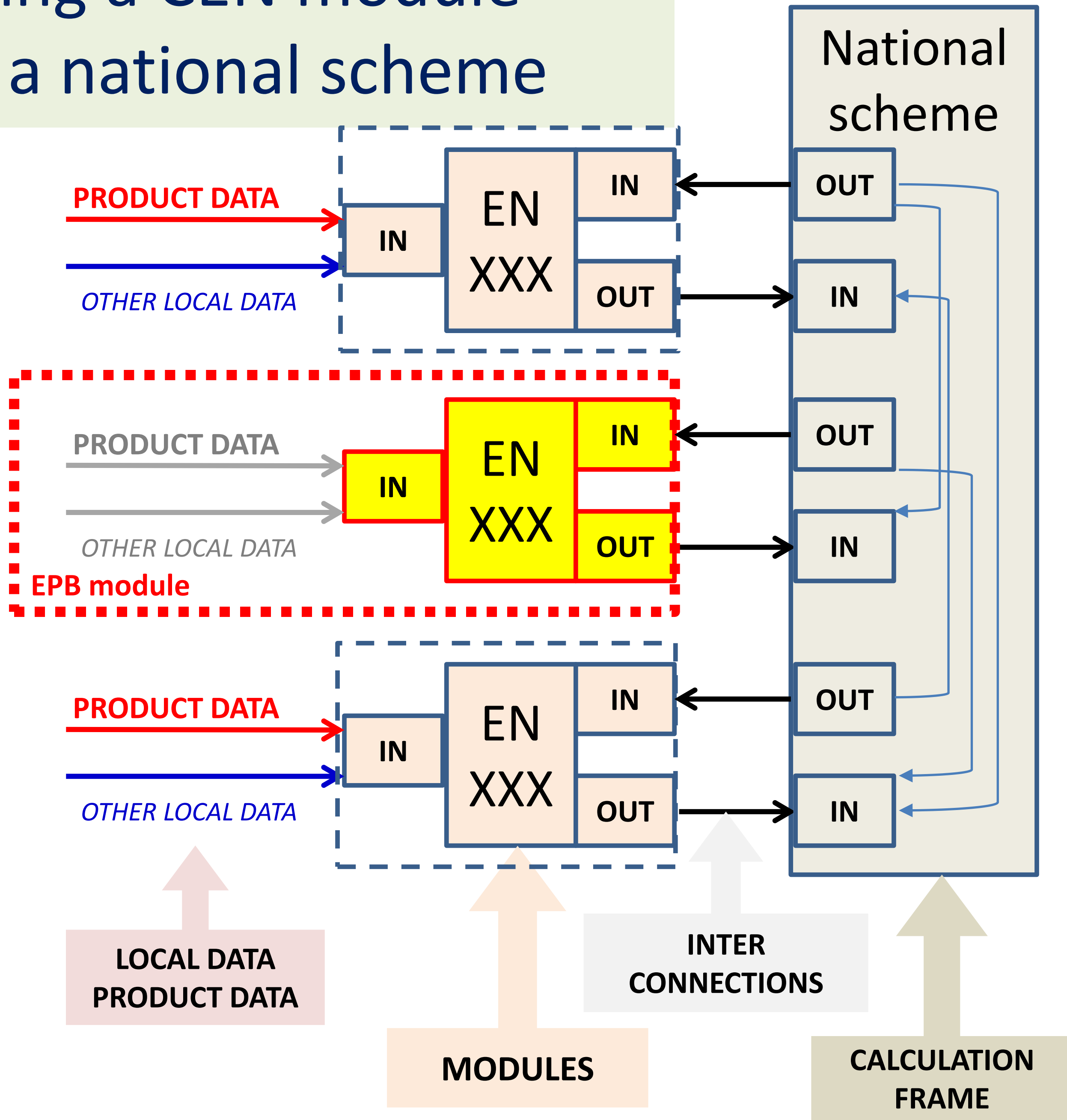
Fitting a NON-CEN module into EN-EPB standard

- Possible **thanks to the modular structure**
- … but the I/O structure has to be respected
- Needed info can be found both in the accompanying XLS and in the specific I/O clauses in the EN standard



Fitting a CEN module into a national scheme

- Possible **thanks to the modular structure**
- … but the I/O structure has to be respected
- Needed info can be found both in the accompanying XLS and in the specific I/O clauses in the EN standard



For more information…

EPC-center website: https://epb.center/

Short videos (≅ 10…15 minutes each) https://epb.center/support/short-videos/	**Basic**: quick explanation of the EN EPB standards package and of the fundamentals about primary energy, weighted energy, exported energy …
Webinars (≅ 1 hour each) https://epb.center/support/webinars/	**Intermediate**: Detailed overview and analysis of specific aspects.
Case studies including supporting XLSs https://epb.center/support/case-studies/	**Basic:** Simplified EN ISO 52000-1 case study **Advanced**: Detailed analysis of overarching standards (EN ISO 52000-1, EN ISO 52016-1, …) and other relevant standards with hourly calculation examples using individual or multiple spreadsheets
Documents https://epb.center/support/documents/	**Link to available supporting documents for download**: short videos, webinars, case studies **but also** additional supporting documents and demonstration spreadsheets of EN-EPB standards,

Why interest in WWHR

Domestic hot water needs for residential buildings: 12…20 kWh/m²yr:

- Not so relevant when compared to 150…250 kWh/m²yr H needs for old building
- Significant when in a context of 60…90 kWh m²yr primary energy for all services

Domestic hot water needs cannot be reduced acting on thee building: they are determined by use (**volume at draw-off temperature**) and **cold water temperature**.

What is left:

a) System **efficiency**

b) Using **renewable** energy (thermal solar or PV)

c) **Regenerating energy** (WWHR when showering)

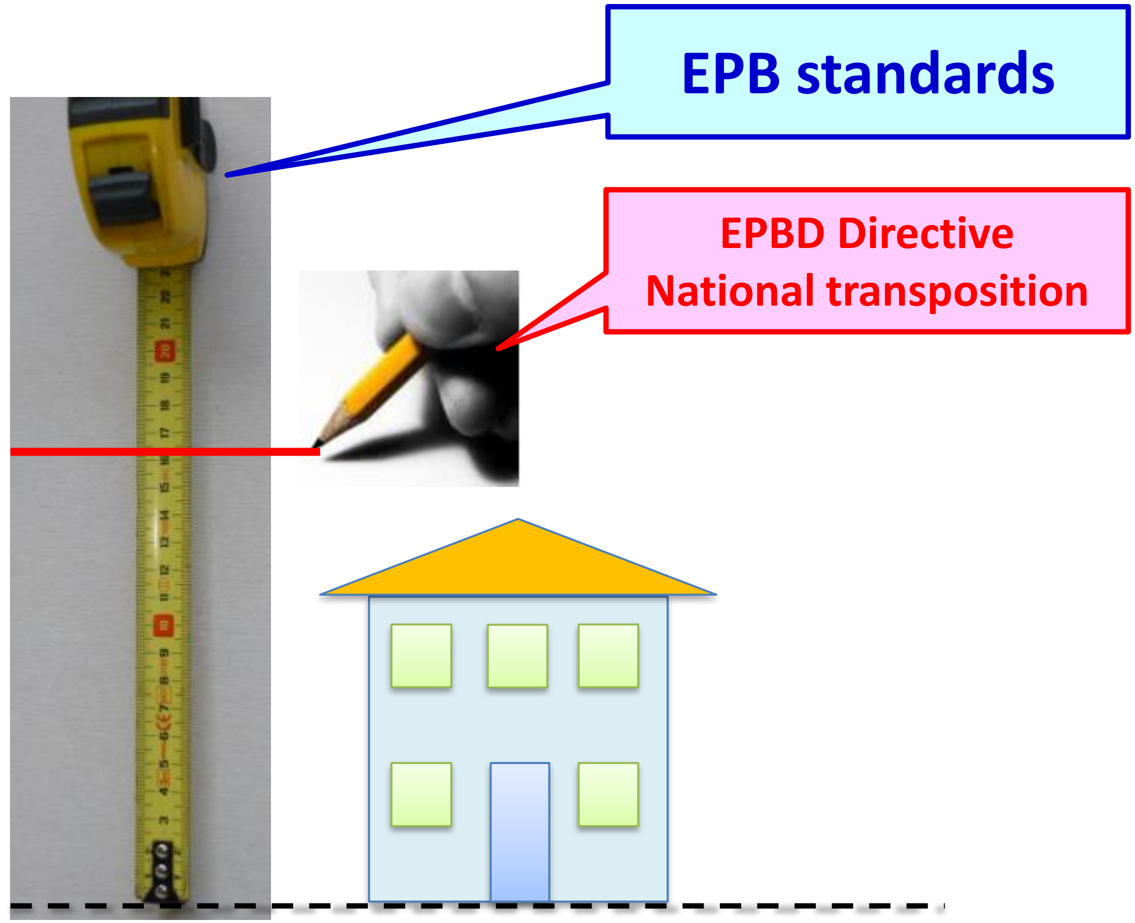
a) and b) are well known and covered in EN and national standards

c) is still not well known in several EU markets despite it may provide a similar contribution to domestic hot water needs as thermal solar.

«Level playing field?»

A technology can contribute to the energy performance when:

- **it is available**
- **it is known by professionals and users**
- **It is mentioned in the regulation**
  → EPBD Directive
- **It is taken into account in the calculation procedure**
  - **Are there national calculation modules?**
  - **Is there an EN-EPB standard module for WWHR?**



Current WWHR calculation

A literature review showed a huge diversity of «national meters»

Item \ Country	UK	ES	PT	NL	F	IT
Calculation method for WWHR is defined	Yes	No	Yes *(10% savings)*	Yes	Yes	Yes
Fraction of needs for shower	Calc.	n.a.	No	80%	80%	Calc.
Connection type taken into account	Yes	n.a.	No	Yes	Yes	No
Transient operation (utilisation factor)	Yes	n.a.	No	Yes	Yes	No
Calculation interval (Hourly / Monthly)	M	M	M	M	H	M
Source of product data	Various	?	Not needed	NTA 8800	CSTB Recado	?
Official product data base	Yes	No	No	Yes	Yes	No
Contributes to RER targets	Yes	No	No	No	Not required	No

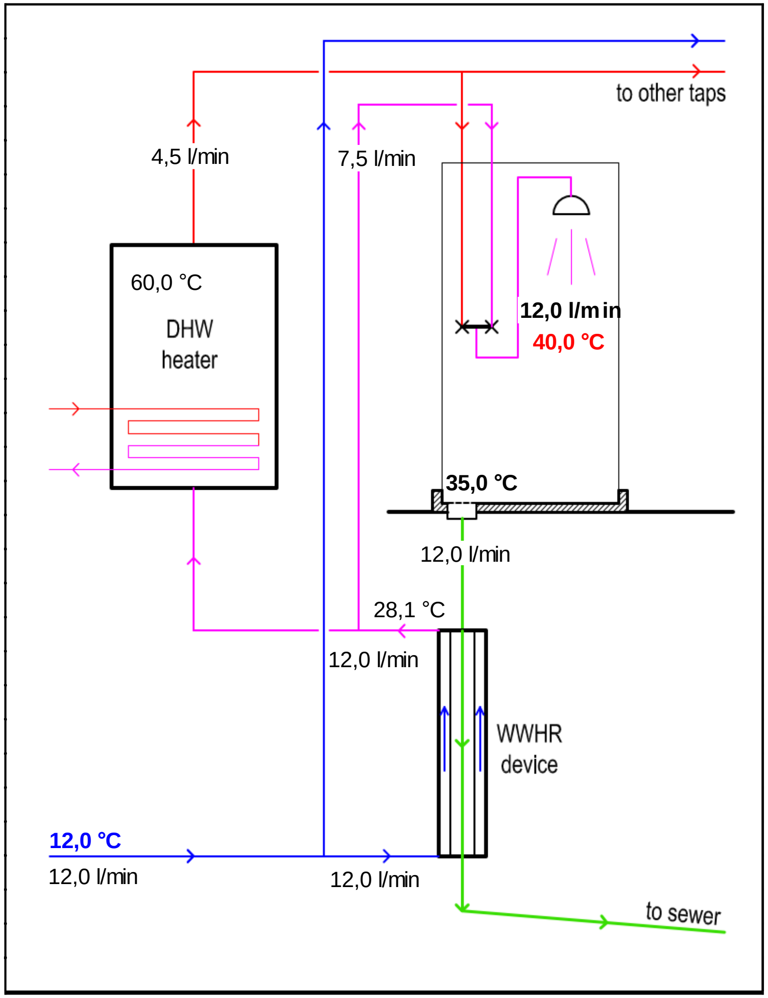
A new calculation module for WWHR

Informative impact

- A new **EN-EPB calculation** module is being prepared
- **Basic calculation steps** of the recovered fraction:
  - **Share of needs** for showering — x 0,80
  - **Unavoidable losses** because water cools down ≅ from 40 °C to 37…35°C in the **shower basin** — x 0,85…0,80
  - **Maximum recoverable heat** due to **connection** and **operating conditions** — x 1,0…0,0
  - **Recovered fraction** of recoverable heat due to **heat exchanger efficiency** — x 0,85…0,20
  - **Transient** operation — x 0,95…0,85
  - Details (heat losses, mass losses) → negligible — x 0,99…0,98

The new module will be available on EPB-Center website

Type A connection



Domestic hot water needs = 23,4 kW
(40°C-12°C) x 12 l/min x 60 min/h x 1,16 Wh/°C l

Recoverable power = 19,2 kW = 82% of needs
(35°C-12°C) x 12 l/min x 60 min/h x 1,16 Wh/°C l

The recoverable fraction of needs only depends on the cold water temperature.

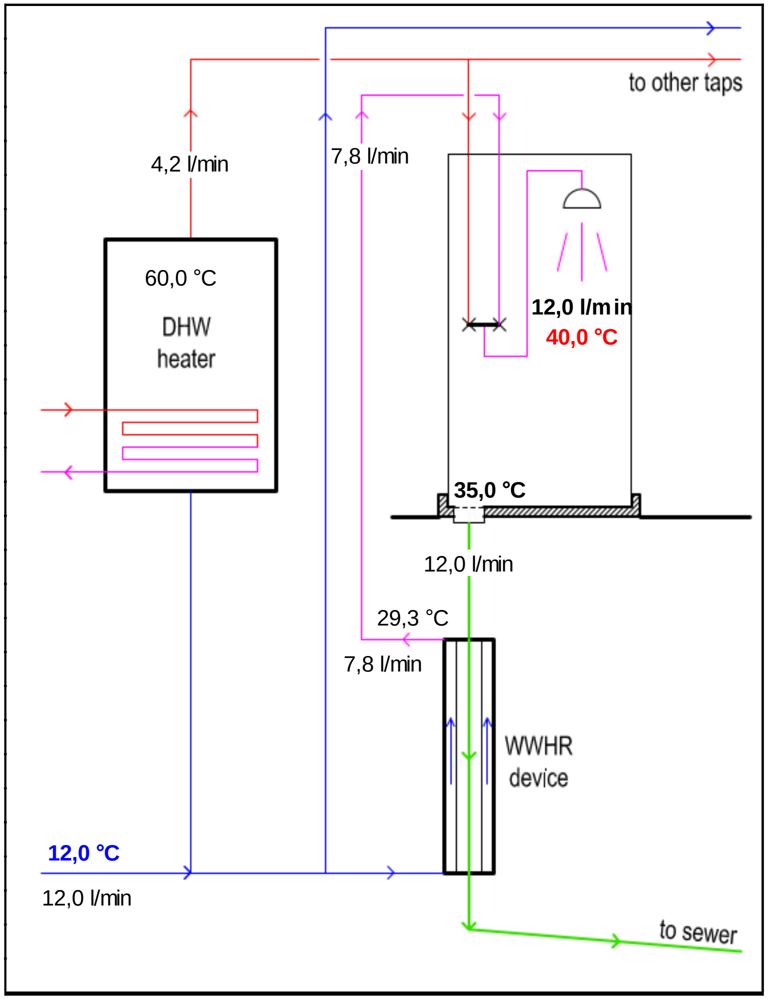
The recoverable fraction of needs does not depend on domestic hot water heater setting

The flow rate in the wwhr device is the same as in the drain, which is the same as the need (shower tap)

$$\dot{V}_{wwhr} = \dot{V}_{W;nd}$$

Balanced operation

Type B connection



Domestic hot water needs = 23,4 kW
(40°C-12°C) x 12 l/min x 60 min/h x 1,16 Wh/°C l

Recoverable power = 12,5 kW = 53% of needs
(35°C-12°C) x 7,8 l/min x 60 min/h x 1,16 Wh/°C l

The recoverable fraction of needs depends on:

- the domestic hot water heater setting,
  the higher the domestic hot water heater setting, the higher the recoverable fraction
- the cold water temperature;
- the efficiency of the waste water heat recovery device.

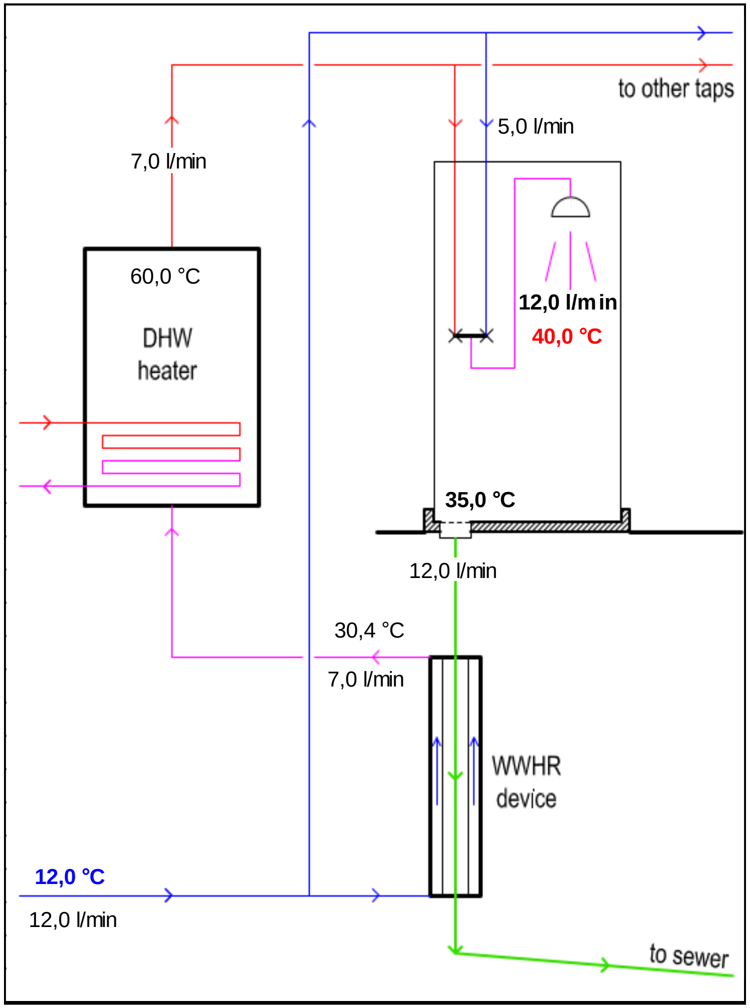
The flow rate in the wwhr device V'_{wwhr} is given by:

$$\dot{V}_{wwhr} = \dot{V}_{W;nd} \frac{\theta_{W;dis} - \theta_{W;draw}}{\theta_{W;dis} - \eta_{wwhr} \cdot (\theta_{W;drain} - \theta_{W;cold})}$$

WWHR device efficiency is higher than in type A connection
Outlet temperature raises from 28,1 °C to 29,3 °C .

However it applies to a lower recoverable heat.

Type C connection



Domestic hot water needs = 23,4 kW
(40°C-12°C) x 12 l/min x 60 min/h x 1,16 Wh/°C l

Recoverable power = 11,2 kW = 48% of needs
(35°C-12°C) x 7,0 l/min x 60 min/h x 1,16 Wh/°C l

The recoverable fraction of needs depends on :

- the domestic hot water heater setting,
  the higher the domestic hot water heater setting, the lower the recoverable fraction
- the cold water temperature.

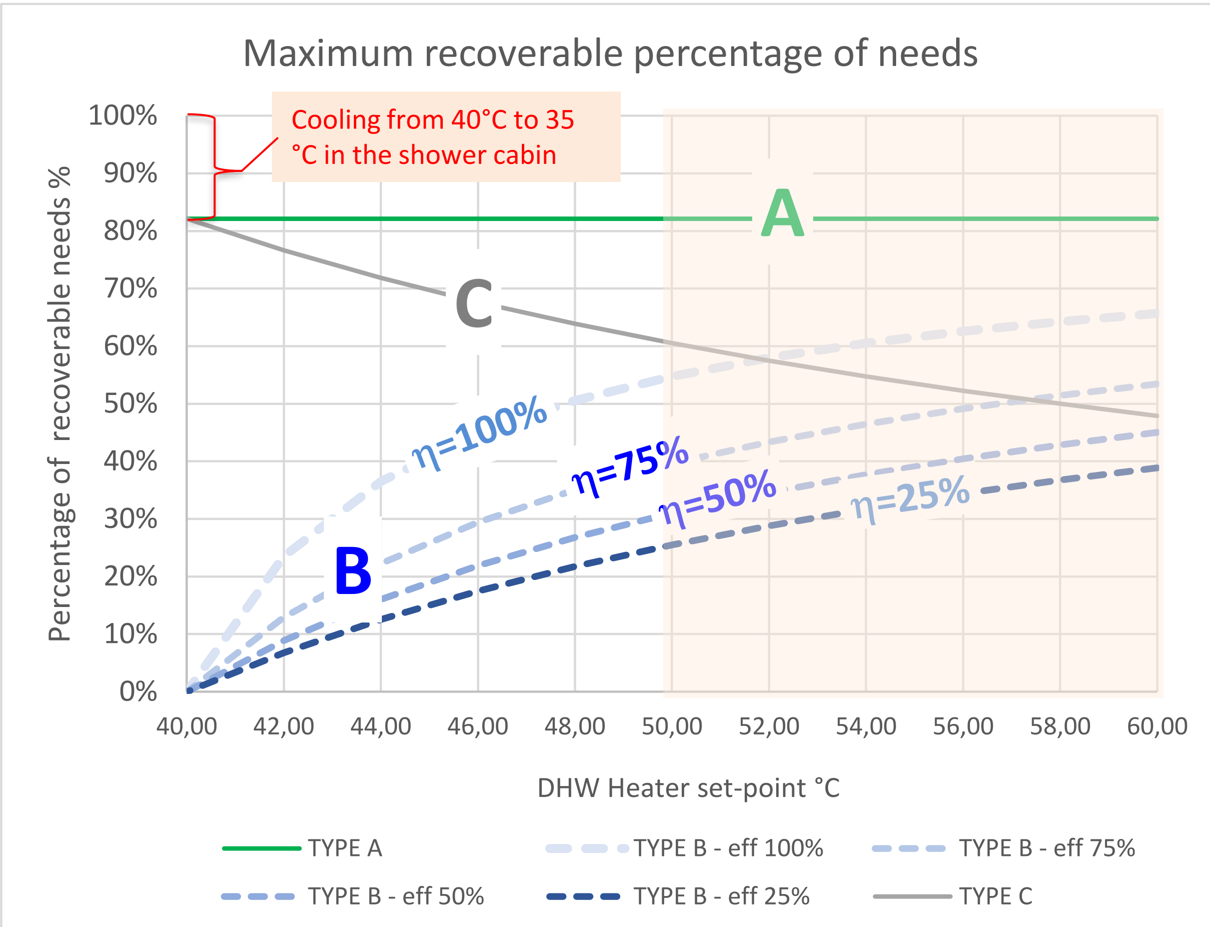
The flow rate in the wwhr device V'_{wwhr} is given by:

$$\dot{V}_{wwhr} = \dot{V}_{W;nd} \frac{\theta_{W;draw} - \theta_{W;cold}}{\theta_{W;dis} - \theta_{W;cold}}$$

WWHR device efficiency is higher than in type A connection.
Outlet temperature raises from 28,1 °C to 30,4 °C .

However it applies to a lower recoverable heat.

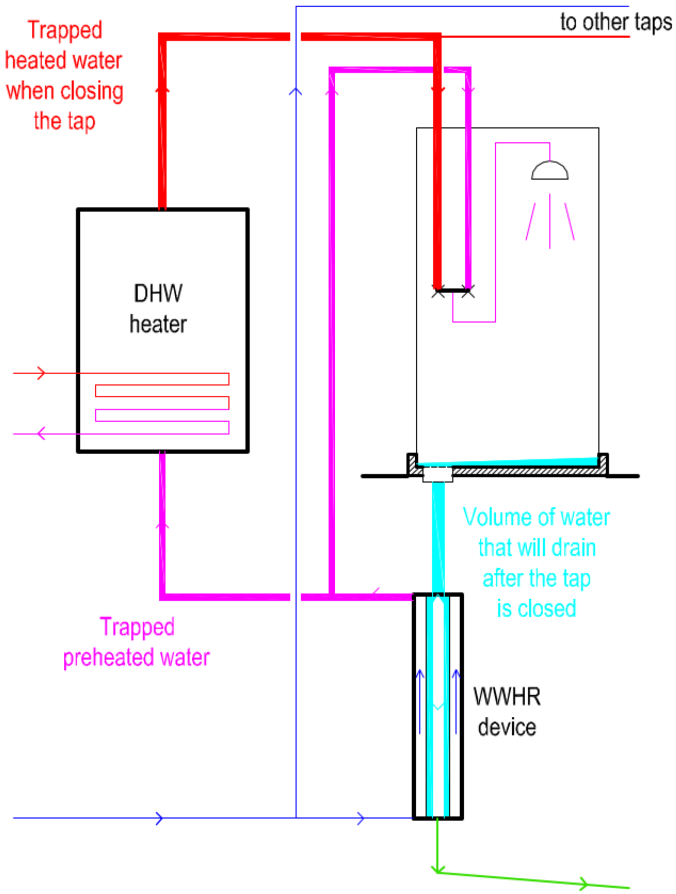
Why calculating the recoverable part



The **recoverable** part of needs strongly depends on connection type A –B – C but also on dhw heater set-point (operational choice)

Explicit calculation requires ≅ 5 simple equations and no special data

Transient operation



When closing the shower tap, the heat trapped in the system that has been accounted as recovered heat will not be actually recovered. This includes heat:

- in the warm water still in the shower basin, drain connection and primary side that will flush
- in the preheated water connections and in the secondary side of the heat exchanger
- in the heat exchangers materials

The lost fraction of the recovered heat on a shower event is equal to the above equivalent volume of water (a few litres) to the total volume of water used during the shower event (≅12 l/min x 5 min = 60 litres).
Utilization factor is 90% or more.
Easy to calculate based on simple data.

Renewable, recoverable, …

- **WWHR** has clear and obvious effects on
  - Weighted energy performance indicators: E_{Pnren}, E_{Ptot}, CO_2, etc → they are reduced
  - Domestic hot water system efficiency → it is increased
- Hidden technological barrier to WWHR: **RER legal requirements** in EU countries
  - WWHR doesn't provide renewable energy but recovered energy (actually, regenerated energy, see next slides)
  - There are often RER requirements on domestic hot water only → unfair discrimination (but exception, in some countries recovered energy is summed to renewable energy)
  - Sometimes, addition of a WWHR device may increase the RER but only 2nd order effect
  - If a heat pump is used, the current RER targets are always fulfilled
- WWHR does not "*reduce energy needs*": it contributes to covering energy needs with "**regenerated**" energy

Do not mix…

Concept	Remarks
Efficient	Obtains a higher useful effect using less resources «get more, pay less» **Qualifies a technical system**
Renewable	Doesn't exhaust resources at the given rate of exploitation «it will always be available» → eternal **Qualifies a resource**
Sustainable	It is possible to continue to use/perform it indefinitely at the foreseen rate without any issue, including environment, social and economic aspects **Qualifies an entire process** (e.g. of providing comfort services in a building)

Do not mix…

Concept	Remarks
Heat loss reduction	Reducing losses from a technical system e.g. insulating heating system pipes **Cannot make the required energy lower than needs** **Qualifies a technical system energy flow (deviates from intended destination)**
Heat loss recovery	Heat lost that can be still used for the same or for another service e.g. heating system losses within the heated space, losses of the domestic hot water system that contribute to heating … but in summer they add to cooling needs… **Qualifies a technical system lost energy flow (still useful despite deviation)**
Heat regeneration	**Transferring heat** from one side to another of a cyclic process, thus increasing the efficiency of the process (reducing entropy generation). Examples: • feed water preheat with steam extraction from a turbine • heating incoming domestic water with outflowing drain water • heating / cooling incoming outdoor air with expelled exhaust air **For an ideal heating process** regeneration could supply the entire needs

Do not mix

Heat loss reduction

- Insulating pipes or having all the pipes of the space heating system inside the heated space will not cover the needs

Heat regeneration

(currently identified as waste water heat recovery and ventilation heat recovery)

- Neglecting the cooling in the shower box, you could keep showering as long as you like with zero input using an ideal heat exchanger
- You could keep ventilating your building as long as you like without any thermal input having and ideal heat exchanger and cancel ventilation heat losses

Be careful with definitions

- Definitions should focus on principles only.
  Using specific cases or providing details can limit emerging technologies
- Don't mix concepts:
  "***Zero emission*** *building is a building with a very high* ***energy performance****…*"
- Keep in mind the hierarchy: don't mix the goal and the means:
  - "Sustainability" is the overall goal
  - "Efficiency", "renewability", "regeneration", "moderation" *(in using the services)* are all means to achieve sustainability, they are not intrinsic goals, they should be on the same level

Energy regeneration (waste water heat recovery and ventilation heat recovery) should be on the same level as using renewable energy: potentially it may provide the entire needs with an ideal system.

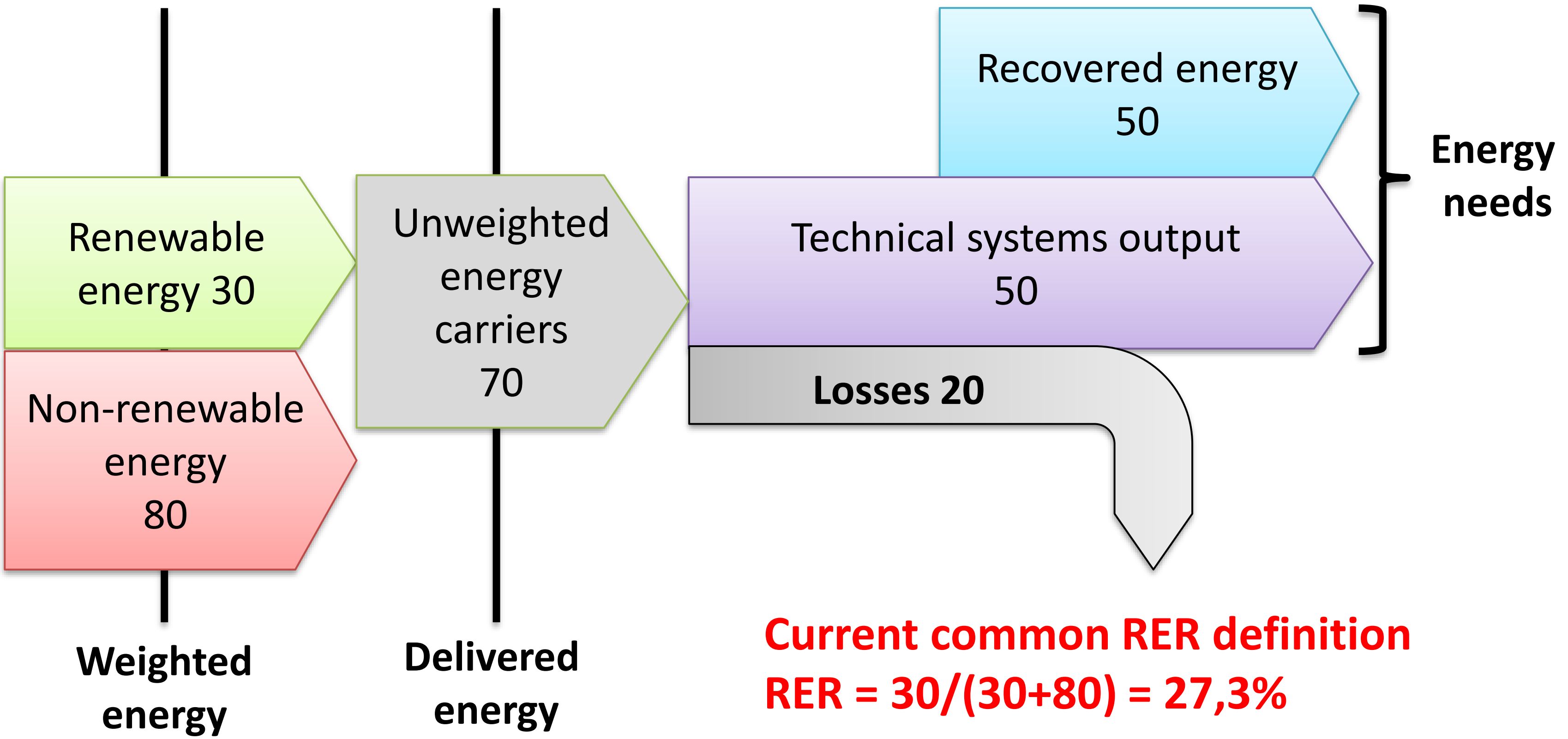
Calculation methods required

Concepts shall be correctly accommodated in the calculation methods.

Some «**nearly hidden**» parameters may have a tremendous impact: in EN ISO 52000-1, k_{exp} qualifies exported energy and actually decides about «coverage» or «compensation» of energy use with on site renewable energy → see short videos on EPB-Center website.

Dealing with **renewable** and **regeneration**, how to consider both if you ask for an indicator of the share of "**sustainable energy**"?
The next slides shows how simple options may change the result

Sustainable energy 1

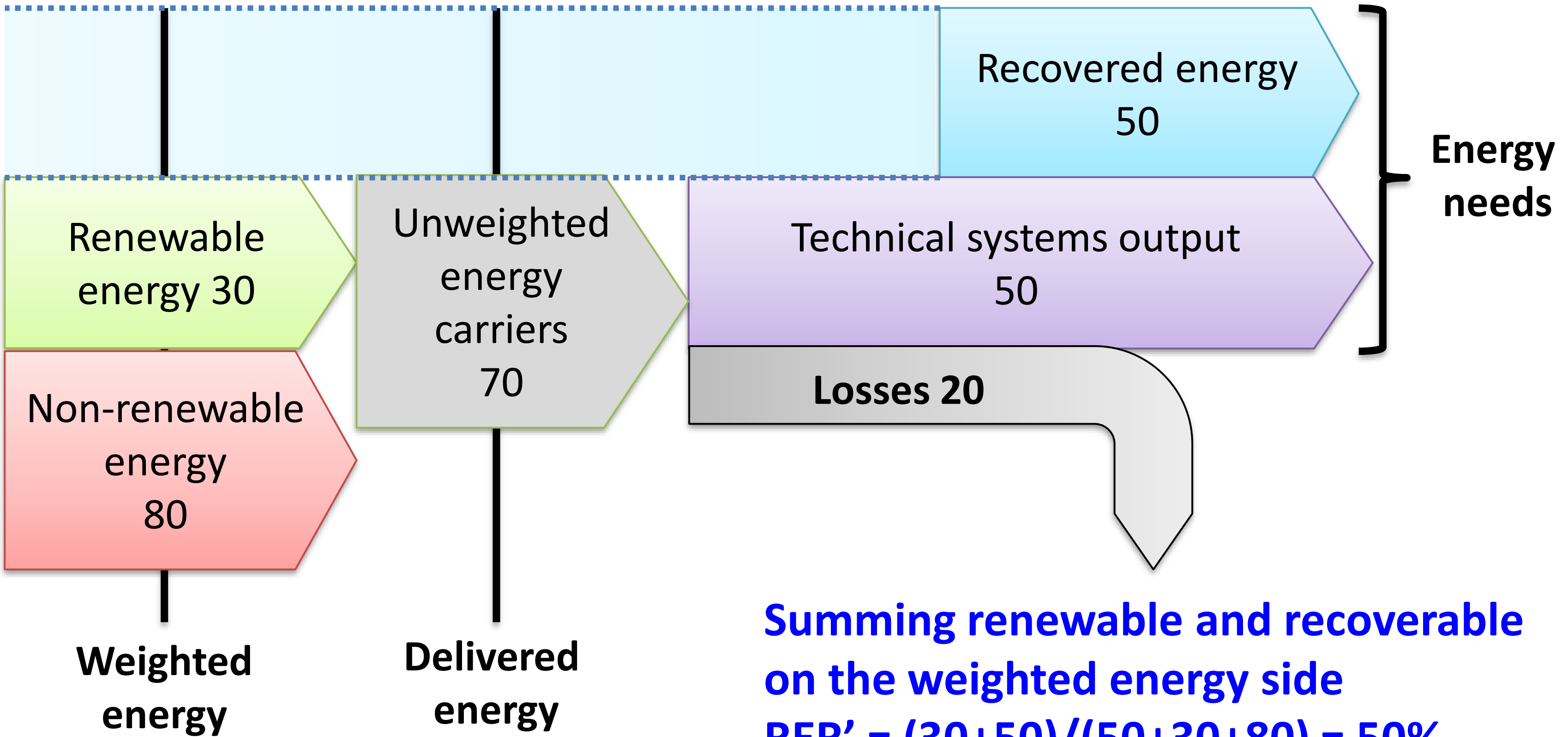


Current common RER definition

RER = 30/(30+80) = 27,3%

This is saying "**less than half** of the energy provided for that service is sustainable"

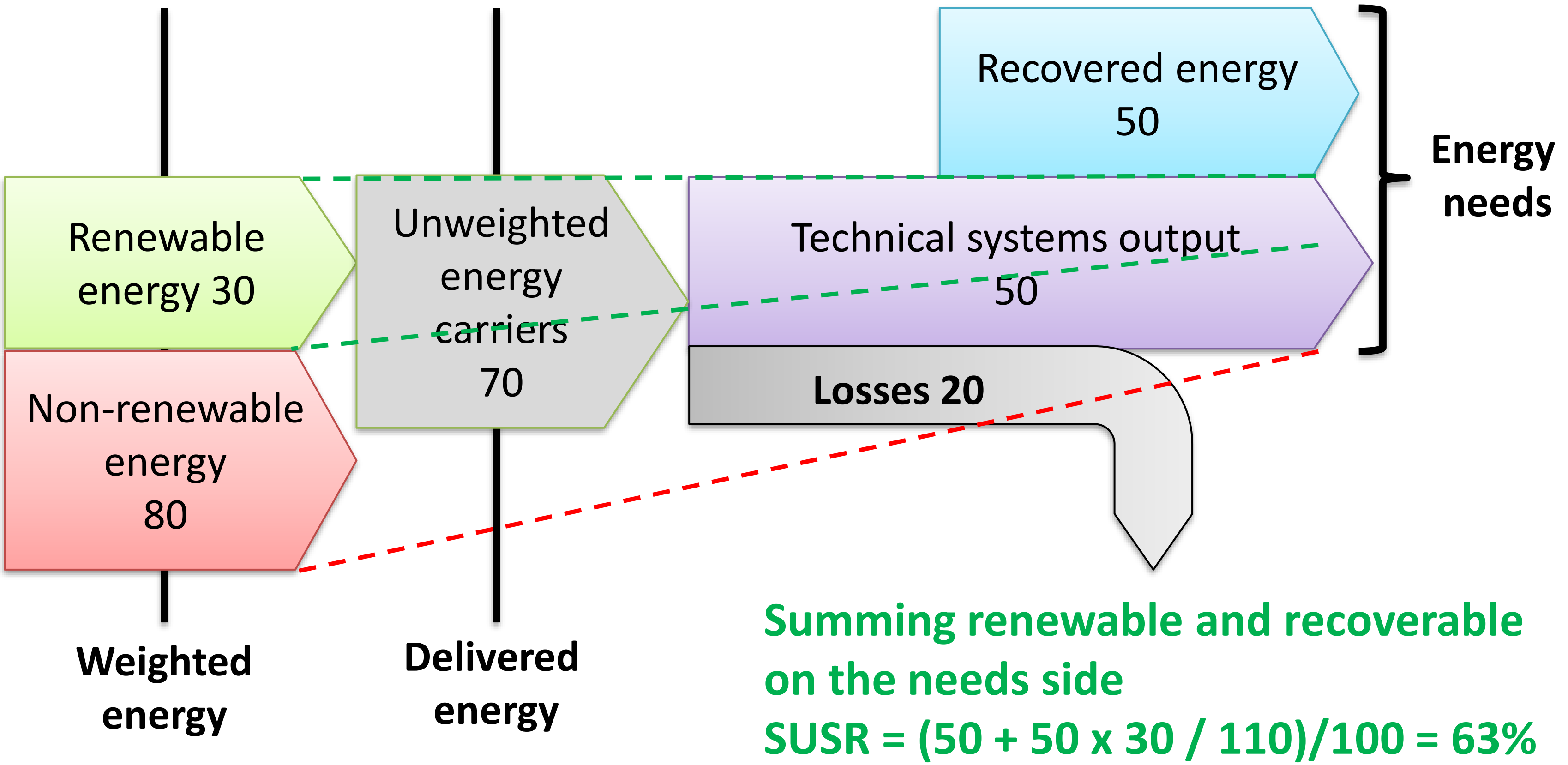
Sustainable energy 2



Summing renewable and recoverable on the weighted energy side
RER' = (30+50)/(50+30+80) = 50%

This is saying "**half** of the energy provided for that service is sustainable"

Sustainable energy 3



This is saying “**more than half** of the energy provided for that service is sustainable”

Which indicator

- The example shown demonstrates how ambiguous the RER indicator (or any similar ratio) can be.
- The actual concern is not “how much renewable energy we use”
  or “how much sustainable energy we use” but
  “how much non-renewable energy we use”, “how much CO_2 we emit” and
  “how much is our use of energy un-sustainable”.
- **Renewable and regenerated energy are not a goal but a means**
- Rational solution to have a fair evaluation, whichever the mix of renewable and regenerated energy : just check “how much CO_2 is emitted”
  and “how much non-renewable energy is used” .
- LCA is the correct complement if you fear un-efficient renewable and/or regenerated energy use.
  … and installation costs are indeed a good warning about that.

Thank you for your attention !

More information on
the set of EPB standards:

www.epb.center

Contact: info@epb.center