# POSITIVE ENERGY DISTRICTS BASED ON NZEB

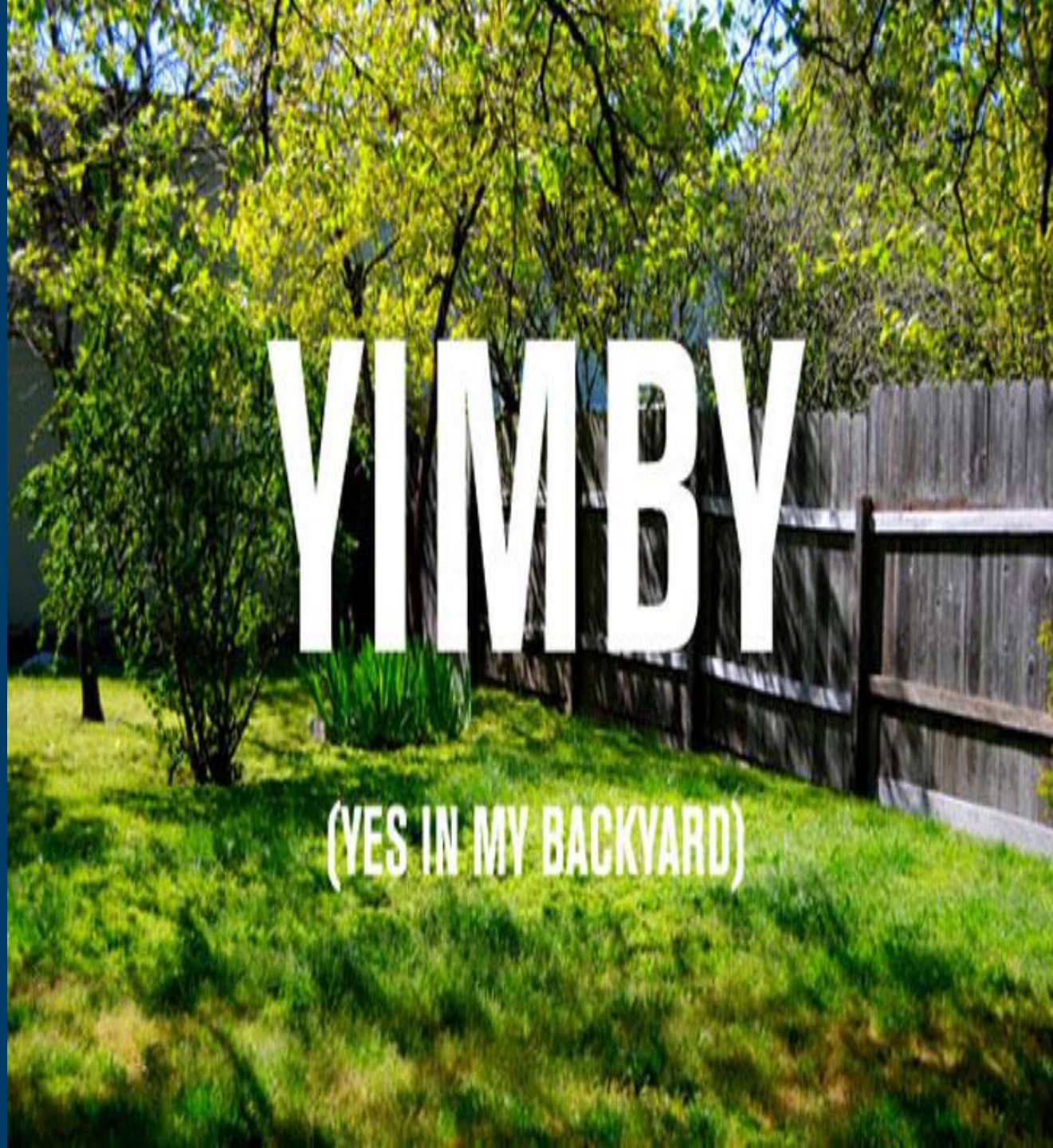
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Senior research scientist

SINTEF Community

# Content

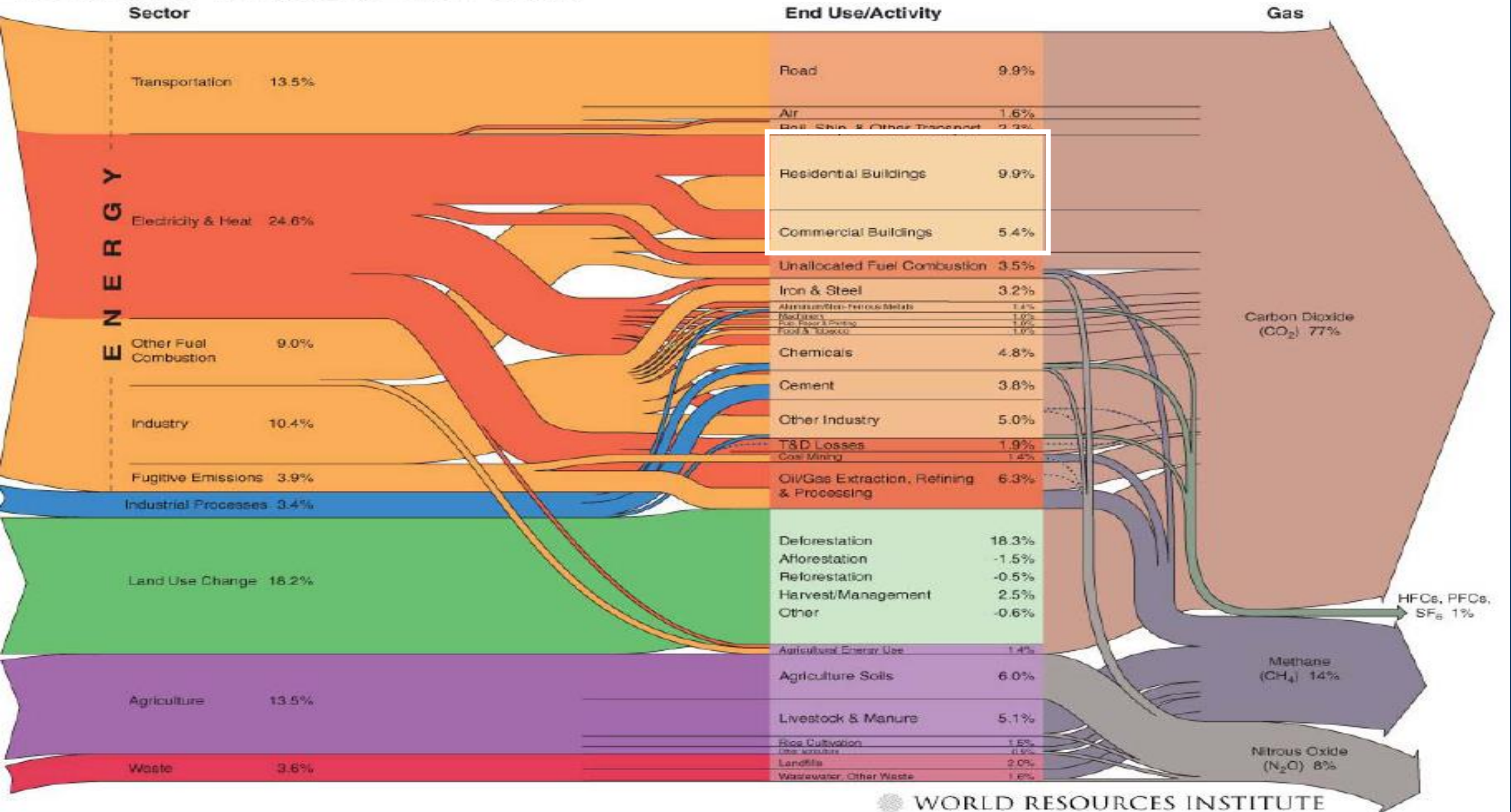
- Introduction
- Background
- Definitions
- Key performance indicators
- Constraints
- Discussion



# Intro

- Increasingly there are discussions about absolute resource limits in our cities.
  - How much can we safe and how much can we consume?
  - Will we have enough energy to continue as before, if we only apply (much) more energy efficiency and shift to renewables?
- A more systemic approaches and solutions are needed.

# World GHG Emissions Flow Chart



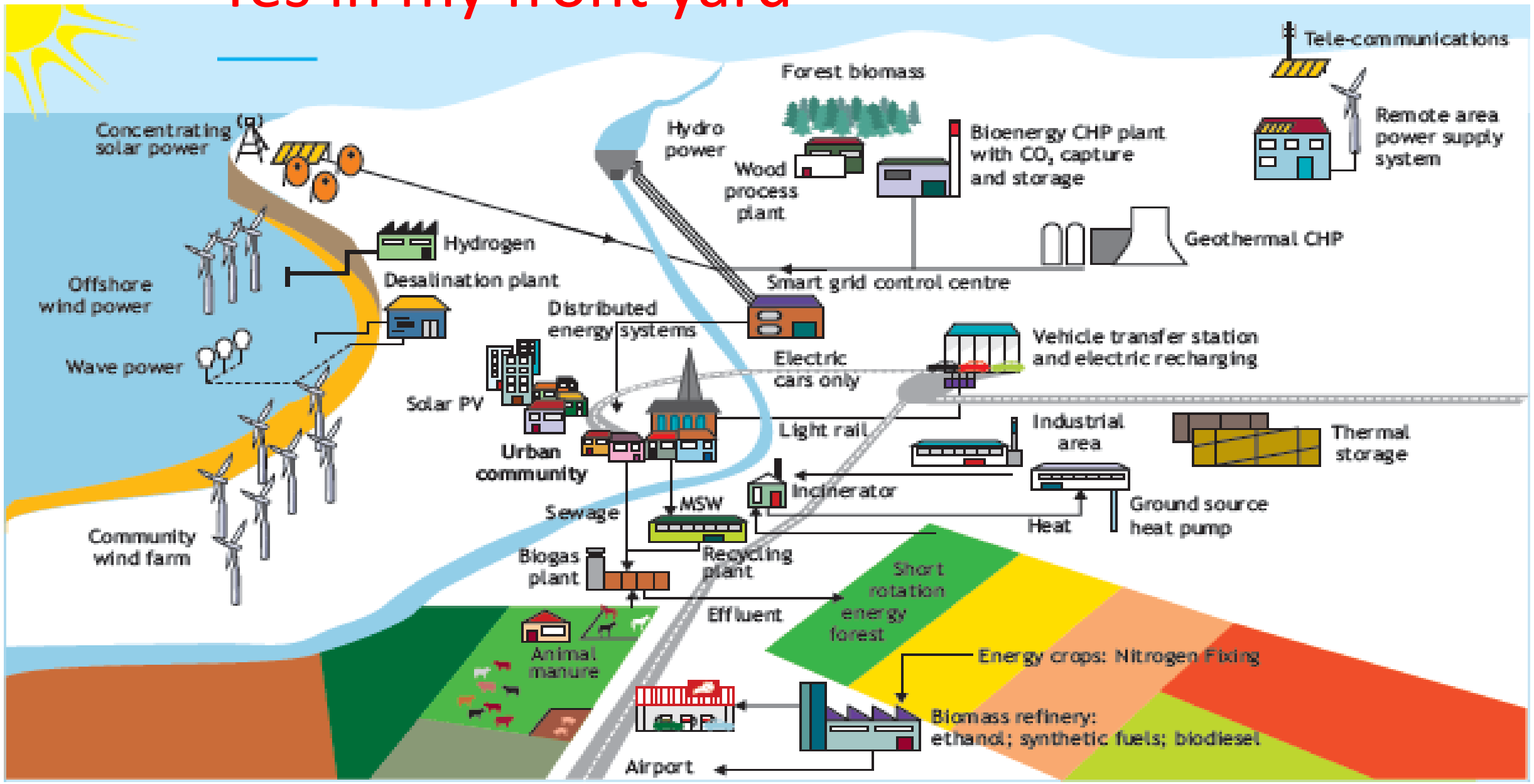

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# Background

- Energy Master planning as a process (IEA EBC Annex 73).
- The Positive Energy Districts were introduced by the SETPlan 3.2 and consist of several buildings (new, retro-fitted or a combination of both) that actively manage their energy consumption and the energy flow between them and the wider energy system.

**Figure 3 • *Producing significant shares of heat, power and biofuels from locally available resources including solar, wind, ocean, geothermal, energy crops and biomass from wastes, could be a future option for a municipality***

# Yes in my front yard




Cities, towns and renewables – yes in my front yard, IEA

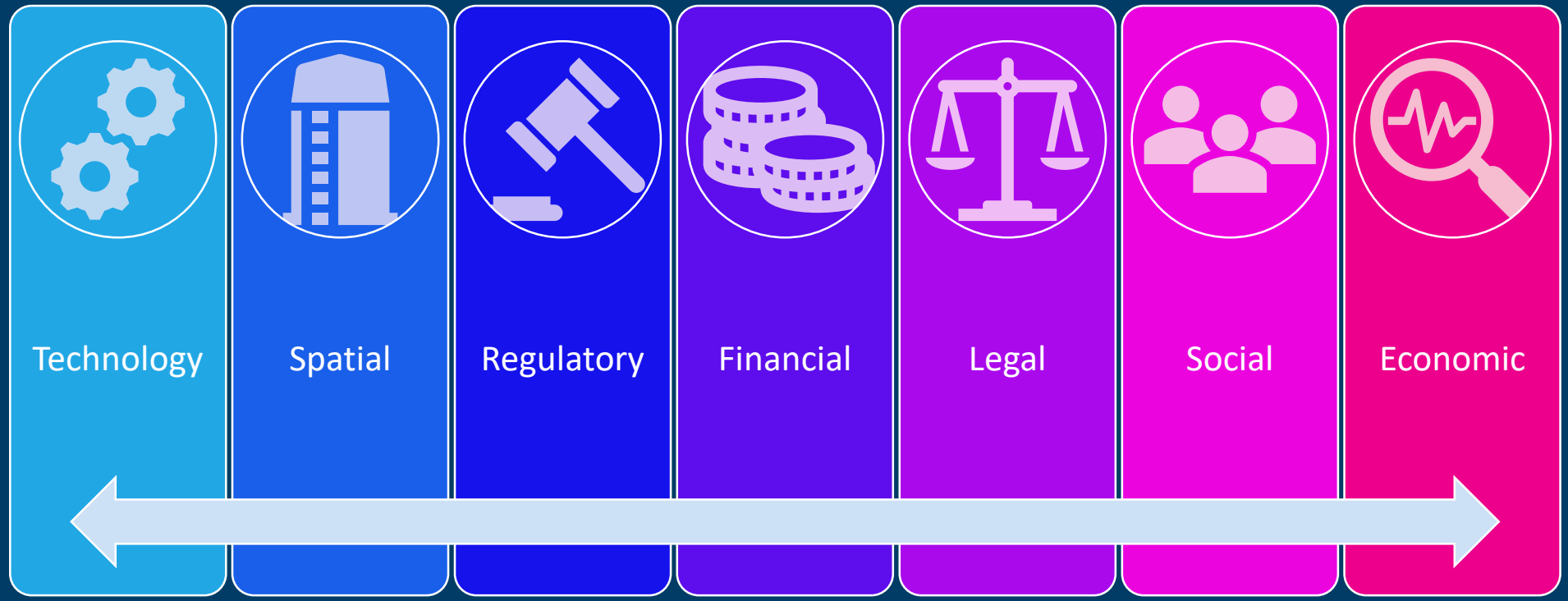
# Definitions






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# Integrative approach including different perspectives

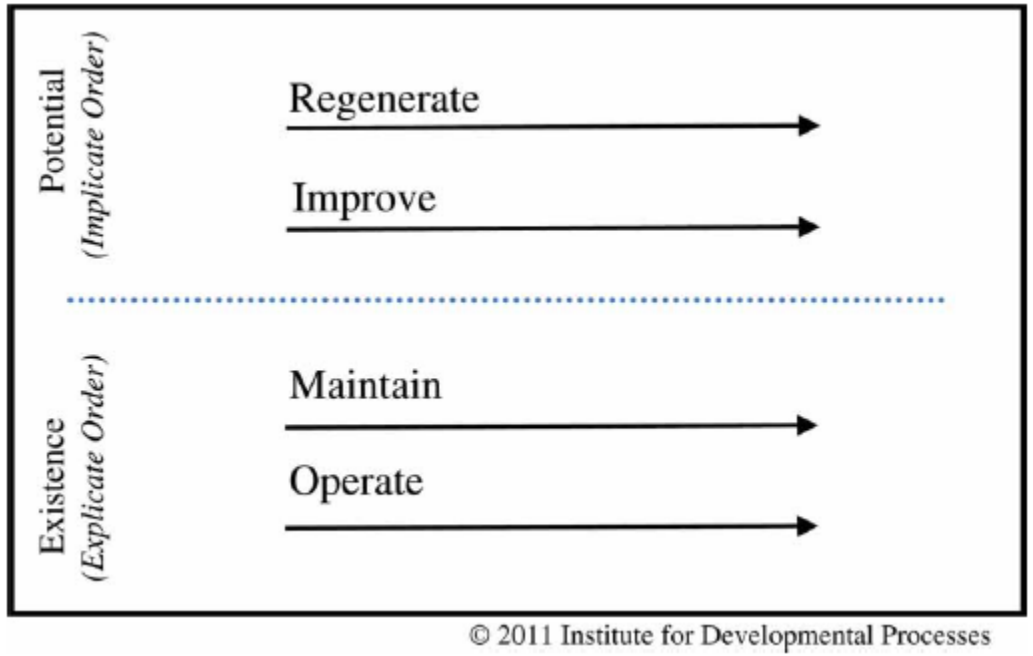





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# Notion of "Positive"

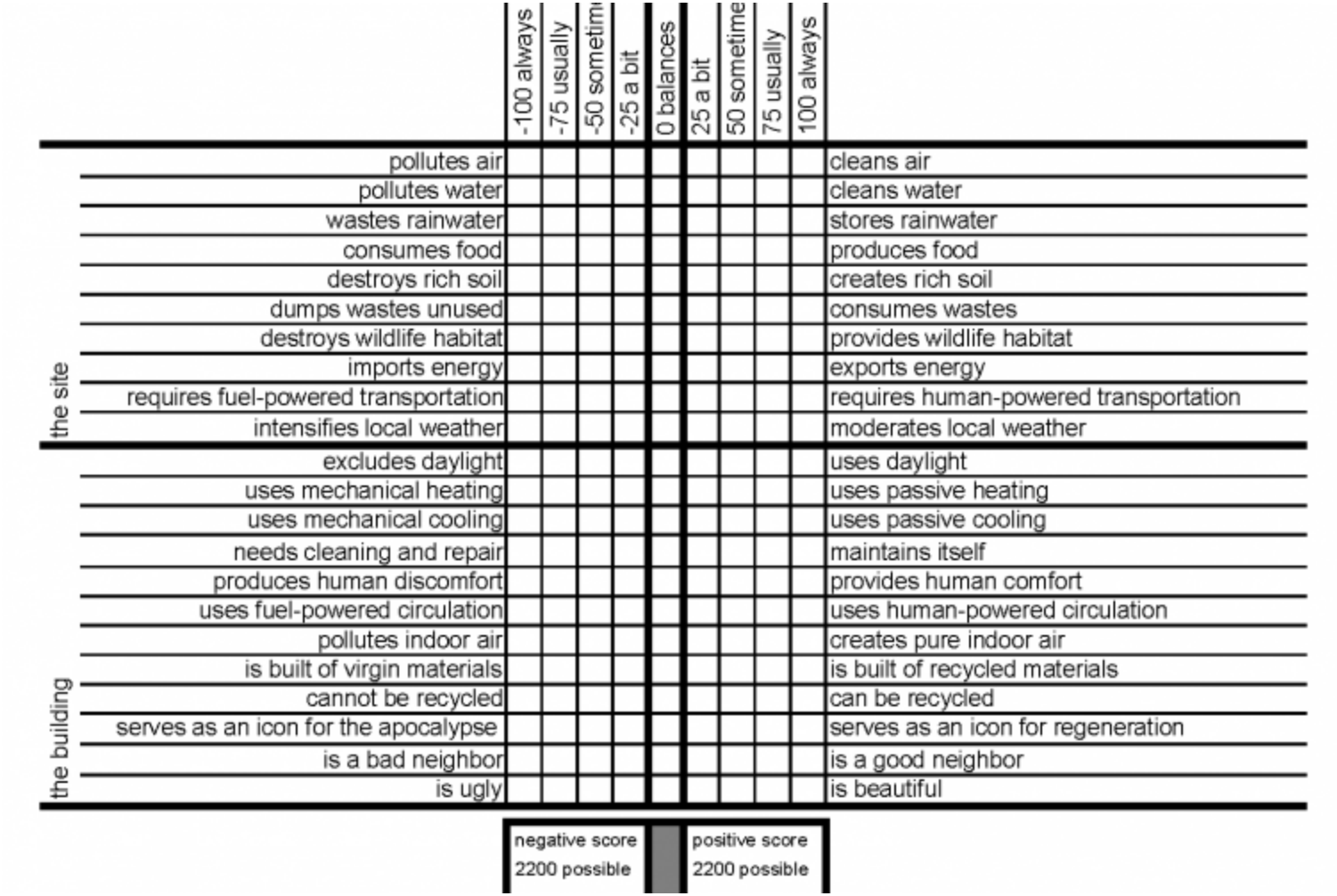
Understanding regeneration as a level of work




Pamela Mang & Bill Reed (2012): Designing from place: a regenerative framework and methodology, Building Research & Information, 40:1, 23-38

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# Well's checklist



| | | -100 always | -75 usually | -50 sometim | -25 a bit | 0 balances | 25 a bit | 50 sometime | 75 usually | 100 always | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| the site | pollutes air | | | | | | | | | | cleans air |
| | pollutes water | | | | | | | | | | cleans water |
| | wastes rainwater | | | | | | | | | | stores rainwater |
| | consumes food | | | | | | | | | | produces food |
| | destroys rich soil | | | | | | | | | | creates rich soil |
| | dumps wastes unused | | | | | | | | | | consumes wastes |
| | destroys wildlife habitat | | | | | | | | | | provides wildlife habitat |
| | imports energy | | | | | | | | | | exports energy |
| | requires fuel-powered transportation | | | | | | | | | | requires human-powered transportation |
| | intensifies local weather | | | | | | | | | | moderates local weather |
| the building | excludes daylight | | | | | | | | | | uses daylight |
| | uses mechanical heating | | | | | | | | | | uses passive heating |
| | uses mechanical cooling | | | | | | | | | | uses passive cooling |
| | needs cleaning and repair | | | | | | | | | | maintains itself |
| | produces human discomfort | | | | | | | | | | provides human comfort |
| | uses fuel-powered circulation | | | | | | | | | | uses human-powered circulation |
| | pollutes indoor air | | | | | | | | | | creates pure indoor air |
| | is built of virgin materials | | | | | | | | | | is built of recycled materials |
| | cannot be recycled | | | | | | | | | | can be recycled |
| | serves as an icon for the apocalypse | | | | | | | | | | serves as an icon for regeneration |
| | is a bad neighbor | | | | | | | | | | is a good neighbor |
| | is ugly | | | | | | | | | | is beautiful |

| negative score | positive score |
|---|---|
| 2200 possible | 2200 possible |

Well's checklist, SBSE
https://www.sbse.org/resources/regeneration-based-checklist-design-and-construction

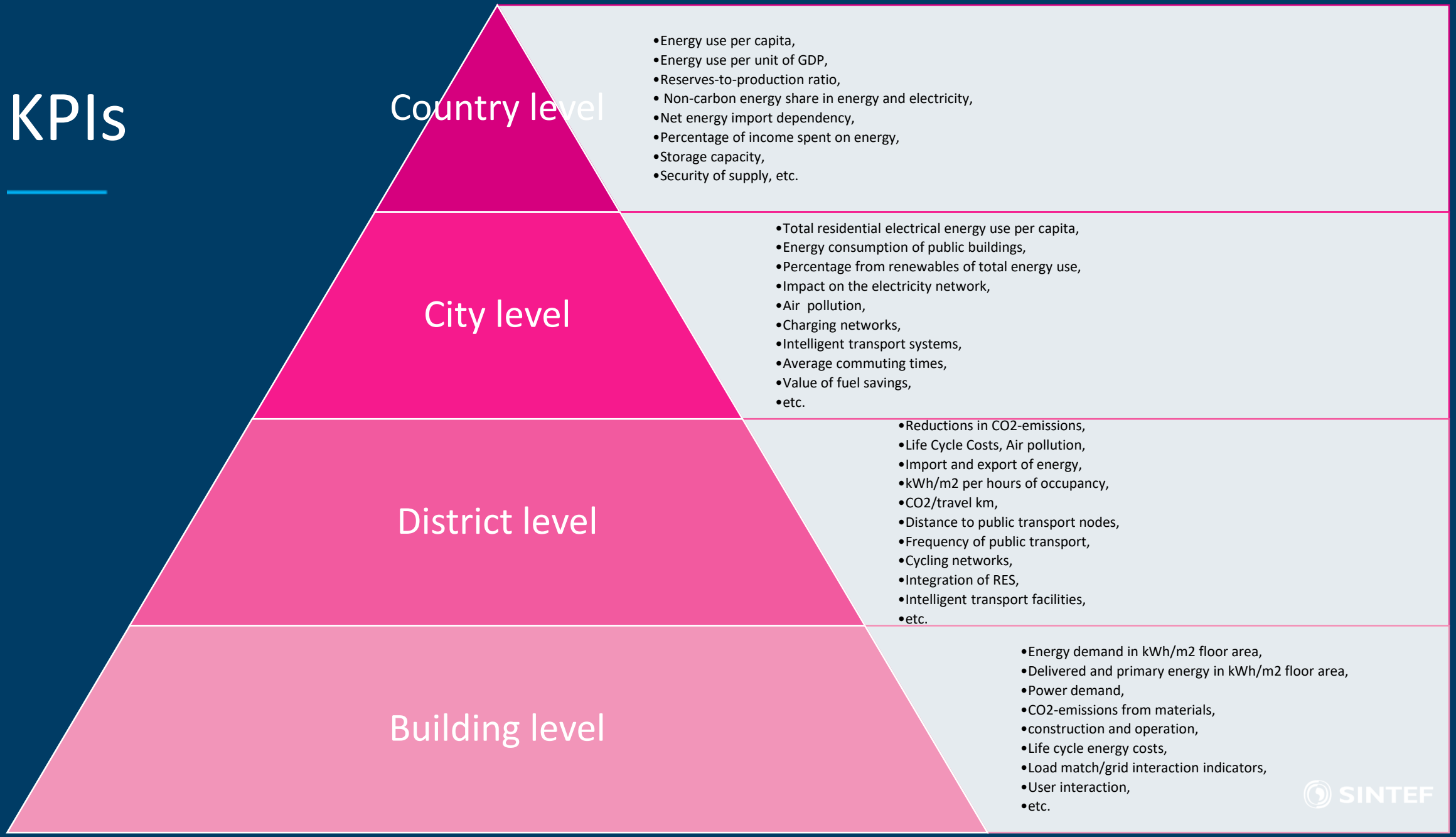


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# Key Performance Indicators

- What is currently lacking is a consistent, robust basis for GHG / carbon metrics associated with the built environment.
- The development and application of life cycle analysis and sustainability assessments have led to numerous initiatives.
- Terms, concepts, guidelines, databases and tools nowadays proliferate in a seemingly endless variety.

# KPIs


Country level
•Energy use per capita,
•Energy use per unit of GDP,
•Reserves-to-production ratio,
• Non-carbon energy share in energy and electricity,
•Net energy import dependency,
•Percentage of income spent on energy,
•Storage capacity,
•Security of supply, etc.
City level
•Total residential electrical energy use per capita,
•Energy consumption of public buildings,
•Percentage from renewables of total energy use,
•Impact on the electricity network,
•Air pollution,
•Charging networks,
•Intelligent transport systems,
•Average commuting times,
•Value of fuel savings,
•etc.
District level
•Reductions in CO2-emissions,
•Life Cycle Costs, Air pollution,
•Import and export of energy,
•kWh/m2 per hours of occupancy,
•CO2/travel km,
•Distance to public transport nodes,
•Frequency of public transport,
•Cycling networks,
•Integration of RES,
•Intelligent transport facilities,
•etc.
Building level
•Energy demand in kWh/m2 floor area,
•Delivered and primary energy in kWh/m2 floor area,
•Power demand,
•CO2-emissions from materials,
•construction and operation,
•Life cycle energy costs,
•Load match/grid interaction indicators,
•User interaction,
•etc.

# Energy master planning

- Identifying constraints and evaluating and applying their limits
- Comprehensive and systematic screening of technologies
- Identify and frame the constraints that bound the options towards an optimized energy master planning solution.
- Framing goals as typically higher-level objectives a country, community, or building designer or owner want to achieve -may be diverse and can be long-term or short-term.

# Constraints in EMP

- Constraints are rigid requirements which shall be met in either the design or actual performance of the building, or both. In this way, framing goals can translate into design constraints and shape the design of local buildings and communities.
- EMP framing constraints were classified into these groupings:
  - Natural Constraints
  - Imposed Constraints

# Constraints in EMP

**Natural Constraints**

- Locational Threats
- Locational Resources

**Imposed Constraints**

- Distribution Systems & Storage
- Building and Facility
- Indoor Environment
- Building Equipment and District System

# Constraints in EMP

- While locational threats usually do not influence technology selections, locational resource limits as well as the limits of existing distribution and energy storage systems can profoundly affect technology selection.
- Building energy efficiency requirements usually do not exist at the whole building or facility level.  They usually exist at the system (attics or windows for example) or equipment (chiller or heating system).
- Some energy codes require a new building to be a specific percentage better that a standard or baseline design.

# Discussion

- Environmental-related, building-level constraints could easily impact technology selection. A renewable energy use requirement would affect technology selection if the renewable energy is generated on-site.
- An emissions-related constraint at the building level is rare but could affect technology selection if they exist. Primarily, it is local air quality threat or building equipment constraints on emissions that affect technology selection.

# Discussion

- Decision making on hard and soft constraints is often required under cost limit constraints.
- EMP process is usually carried out in multiple stages.
- We recommend to gather the most important constraint factors in the different sections (spatial plan, resilience concept, energy concept) on a check list for a set of different usages.

# Conclusions

- Clarity and consistency are needed on boundary definitions and although carbon metrics exist, they deserve further scrutiny and development to create a next generation of metrics.
- In this way, the topic also takes on a new dimension: While carbon metrics have been the subject of scientific discussion in the past, their results should now become a reliable and directional basis for real decisions.
- Appropriate and consistent methods, data and tools are needed to support the collection, assessment, communication and interpretation of relevant information.

# Conclusions

- The introduction of PED can lead to the development of effective business models for
  - sustainable energy services solutions
  - storage solutions (from short-term to seasonal)
  - big data, data management and digitalisation solutions
  - electro-mobility solutions

# Conclusions

- Bringing Energy Master Planning on a district level gives the possibility to untangle the academic discussions on the dynamics of energy.
- Consumers and producers are integral parts of the solution by understanding and influencing energy use/consumption both on individual and societal level.
- Communication issues between consumers and citizens will be eased and their role empowers them in limiting energy use/consumption and thus in creating the necessary communication and or engagement.

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Technology for a better society

Table 2: Energy Master Planning Design Constraints

| Natural Constraints | | Imposed Constraints | | | | | |
|---|---|---|---|---|---|---|---|
| *Constraint Area* | *Constraint (that could limit technology selection)* | *Constraint Area* | | *Constraint (that could limit technology selection)* | *Constraint Area* | *Constraint (that could limit technology selection)* | |
| *Locational Threats* | Regional or local air quality | *Distribution System & Storage* | | Natural Gas | *Indoor Environ-ment* | Indoor temperature | |
| | Low-lying area (flooding) | | | Electricity | | Humidity[1] | |
| | Extreme temperatures | | | Fuel Oil | | Lighting illumination levels | |
| | Extreme/high humidities | | | Chilled water | | Radon | |
| | High winds | | | Hot water/steam | | Ventilation | |
| | Fire | | | Water | | Space heating equipment | |
| | Lightning | | | | | | |
| | Ground threats (volcano, mud slide, sinkhole, earthquake) | *Building and Facility* | *Energy use and effic-iency* | Energy use (site) | *Building Equip-ment and District Systems* | Space cooling equipment | |
| *Locational Resources* | Solar insolation | | | Energy use (primary/source) | | Ventilation equipment | |
| | Wind | | | Energy efficiency | | Humidity control equipment | |
| | Biomass | | *Environ-mental* | Renewables | | Water heating equipment | |
| | Land area | | | Emissions | | Food preparation equipment | |
| | Roof area | | *Opera-tional* | Resilience | | Waste handling equipment | |
| | Natural Gas | | | Financial/Cost | | Control systems | |
| | Electricity | | | Maintenance limitations (e.g., simple, low cost) | | Stationary electric generation systems (combustion-engine-driven) | |
| | Liquid fuels (oil, LPG, etc.) | | | Work force limitations | | District steam and hot water | |
| | Chilled water | | | Critical facility | | District chilled water | |
| | Hot water/steam | | | Other planner or building owner limiting factor | | | |
| | Water | | | | | | |

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| | | Country-Specific Limits (United Kingdom) | | |
|---|---|---|---|---|
| Constraint Category | Constraint (that could limit technology selection) | U.S.A. | Norway | Australia, Denmark, Finland, Germany, UK |
| Natural Constraints: Locational Threats | Regional/local air quality | Assess (USA-NAAQS) | | |
| | Low-lying area (flooding) | Constraint typically impacts the way technologies are installed (bermed, raised, etc.), not technology selection. | | |
| | Extreme temperatures | | | |
| | Extreme/high humidities | | | |
| | High winds, Fire, Lightning | Constraint typically impacts the way technologies are installed (isolated, hardened, etc.), not technology selection. | | |
| | Ground threats (volcano, earthquake, etc.) | | | |
| Natural Constraints: Locational Resources | Solar insolation; Wind; Biomass; Land & Roof area; | Limit is local amount available | | |
| | Electricity; Natural Gas; Liquid fuels (oil, LPG, etc.) | | | |
| | District chilled or hot water; District steam; Water | | | |
| Distribution System & Storage Constraints | Electricity; Natural gas; Fuel oil; District chilled or hot water; District steam | Limits are local distribution and storage capacities | Limits are local distribution and storage capacities. Installation of fossil fuel heating systems not permitted (NO19) | Limits are local distribution and storage capacities |
| | Water | | | |

*References for Table 3 are listed at the end of this paper.



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| Constraint Category | | Constraint (that could limit technology selection) | Country-Specific Limits | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | U.S.A. | Denmark | Finland | Norway | Germany | United Kingdom | Australia |
| Building and Facility Constraints | Energy use and efficiency | Energy use (site) | Military (Army): Maximum annual energy use limits by building type (US1). Commercial: Maximum annual energy use limits by building type if standard adopted (USStd100). Outperform simulated reference building or perscriptive requirements if standard or code adopted (Std90.1,IECC) | | | Natl code has max kWh/m2 values by building type (net demand, i.e. without efficiency of technical systems). NO15, 16, 17, 18.<br><br>BREEAM-Nor,NS3700/NS3701, ZEB | Outperform simulated reference building (DE1-EnEV (Energy Saving Ordinance) | | |
| | | Energy use (primary/source) | Maximum annual energy use limits by building type if adopted by local code (Std100) | Maximum annual kWh/m2 by building type (DK1). | Maximum annual kWh/m2 by building type. (FI??) | BREEAM-Nor,NS3700/NS3701, ZEB | EnEV (Ref DE1) regulates primary energy demand for newly built buildings as well of existent buildings. There are no explicit limits (see cell J4) | | Maximum annual hourly average kJ/m2-hr by building type. (NCC Sec. JP1). Class 6 building, 80 kJ/m2.hr; Class 5, 7b, 8 or 9a building or Class 9b school, 43 kJ/m2.hr; Other classes (with limits): 15 kJ/m2.hr. |
| | | Energy efficiency | Commercial and Military: Minimum thermal requirements of building components (walls, roofs, etc.) Minimum air tightness. (US-Std90.1,US-IECC) | | | Requirements on U-values for the envelope, SFP, Air thightness, and cold bridges (National Building Code) See Ref ? (BREEAM-Nor,NS3700/NS3701, ZEB) | | 1. Building Regulations and Government Buying Standard Minimum<br>2. Defence Related Environmental Assessment Methodology, DREAM (UK2) | National limits (NCC, Sec. J). State limits.<br>(c) solar radiation being utilised for heating; and |
| | Environ mental | Renewables | | Must use renewables. District heating assumed (DK2) | | NO 17, 20. Heating systems using fossil fuels are not allowed. | Fixed quotas for heating and cooling. | No obligation to include renewables. | No obligation to include renewables. |
| | | Emissions | None at building level. | | | BREEAM-Nor,NS3700/NS3701, ZEB | | Must achieve Target CO2 Emissions Rate (Building Regulations) | None at building level. |
| Building and Facility Constraints | Operational | Resilience | Military: 14-day, grid-independent operation for critical facilities. (US5) | | | Buildings heating over 1,000 m2 shall: a) have energy flexible heating systems, b) be adaptable to low-temperature heating solutions. (NO19) | | No set standard, assessed on individual basis to meet resilience requirements. | |
| | | Financial /Cost | | | | NO18 | | Government: DREAM or equivalent (e.g. CEEQUAL6, BREEAM7 etc.) assesement required. New projects require 'excellent' and major refurbishments require 'very good' rating (Regulations/Govt Buying Std) | |
| | | Maintenance (simple,low cost) | | | | | | Different Regulation Documents for home based UK Countries (UK??) | |
| | | Work force | | | | | | | |

| Constraint Category | Constraint (that could limit technology selection) | Country-Specific Limits (United Kingdom) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | U.S.A. | Denmark | Finland | Norway | Germany | United Kingdom | Australia |
| Indoor Environ-ment Constraints | Indoor temperature (DB-dry bulb/WB-wet bulb)[1] | U.S. Army:<br>Occupied: min DB: 70F, max. DB: 75F<br>Unoccupied (short term) min DB: 55F,max DB: 85F<br>Unoccupied (long term) min DB: 40F, max DB:none<br>Critical equipment min DB: Equip min<br>Critical equipment max DB: Equip max<br>Commercial: Comfort zones limits vary by occupant conditions if standard adopted (US-Std55) | Requirements exist (DK?).<br>Occupied min: 20 C<br>Occupied max: 26 C (cooling penalty).<br>Dwellings: Max 100 hrs above 27 C and 25 hrs over 28 C;<br>Offices/buildings with similar usage pattern: Max 100 hrs above 26 C and 25 hrs over 27 C. Recommendations for minimum workplace temperatures. | Requirements exist (FI??).<br>Heating season: 20 - 26 °C<br>Other time: 20 - 32 °C (30 °C old people's house) | see 4 | | As per CIBSE Guide A - Environmental Design (UK?).<br>MOD Estate - Joint Service Publication 315 - Building Performance Standards Estate Wide Standards and Guidance (UK?). | Maximum contaminant limits |
| | Humidity[1] | U.S. Army:<br>Occupied maximun: 50%<br>Unoccupied (short term) max: 50%<br>Unoccupied (long term) max: 50%<br>Critical equipment max: 50% or equipment max<br>Commercial: Limits vary by occupant conditions if standard adopted (US-Std55) | Recommendations exist (see Ref DK?). | | NO8-NO12 | | As per CIBSE Guide A - Environmental Design (UK?).<br>MOD Estate - Joint Service Publication 315 - Building Performance Standards Estate Wide Standards and Guidance (UK?). | refer to NABERS Energy for Offices |
| | Lighting levels | Level requirements if code adopted (US6). | Lighting levels and daylighting requirements. | | NO6 | | Regulated (UK2, UK3) | |
| | Radon | Mitigation in NJ,WA,MI,MN,MD,OR,IL,MA, CT | | | NO5 | | | |
| | Ventilation | Requirements per person and area per space occupancy category when code adopted (US-Std62) | Requirements per person and area by building type (daycares, schools, etc.) (DK?) | Requirements per person and area by building type | Requirements per unit area. | | Regulated (UK2, UK3) | Required per person and area based on occupancy category |
| Building Equipment and District System Constraints | Space heating equipment | Min efficiencies by equipment type (US-Std90.1/US-IECC) | Minimum efficiencies by equipment type. | | | | Equipment energy efficiency requirements (Building Regulations and Government Buying Standard Minimum, UK?) | Minimum efficiencies by equipment type (AU1) per Equipment Energy Efficiency Program (E3)<br>Performance rating of water-chilling and heat pump water-heating packages using vapor compression (AHRI 551/591).<br>Gas fired water heaters for hot water supply and/or central heating (AS 4552) |
| | Space cooling equipment | | | | | | | |
| | Ventilation equipment | Numerous control requirements (US-Std 90.1/US-IECC) | Minimum efficiency and maximum power use | | Energy efficiency requirements (NO1,NO2,NO3) | | | |
| | Humidity control equipment | Equipment requirements (US-Std 90.1) | | | NO 8, 9, 12 | | | |
| | Water heating equipment | Service water heating requirements (US-Std90.1/US-IECC) | Minimum efficiencies by equipment type. (DK?) | Min/max hot water temp. +50 °C, +65 °C | NO 19, 21 | | | |
| | Cooking equipment | | | | | | | |
| | Waste handling equipment | | | | NO45,46,47,48,49 | | | |
| | Control systems | Specific controls requirements (US-Std90.1/US-IECC) | Minimum efficiency | | | | | |
| | Combustion-type electric generation systems | Emission and noise limits (US20, local noise/nuisance ordinaces) | | | | Regulated emissions & noise. | | |
| | District steam/hot water, chilled water | Minimum efficiencies by equipment type.(US-Std 90.1 or US-IECC) | | | | | | |