Building the Future of Energy

The Key Role of Energy Efficiency in Abating Climate Change

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Therm

Joule

BTU

Negajoule

GigaJoule

Kill-a-Watt

kWh

MegaJoule

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- Buildings are the dominant user of energy worldwide.
- Buildings use 25-40% of energy worldwide (more than automotive and air transport combined).
- Buildings are responsible for 30-40% of carbon dioxide emissions worldwide.
- A new building will use energy for the next 50 years (probably much longer) - it is important to design them right the first time!

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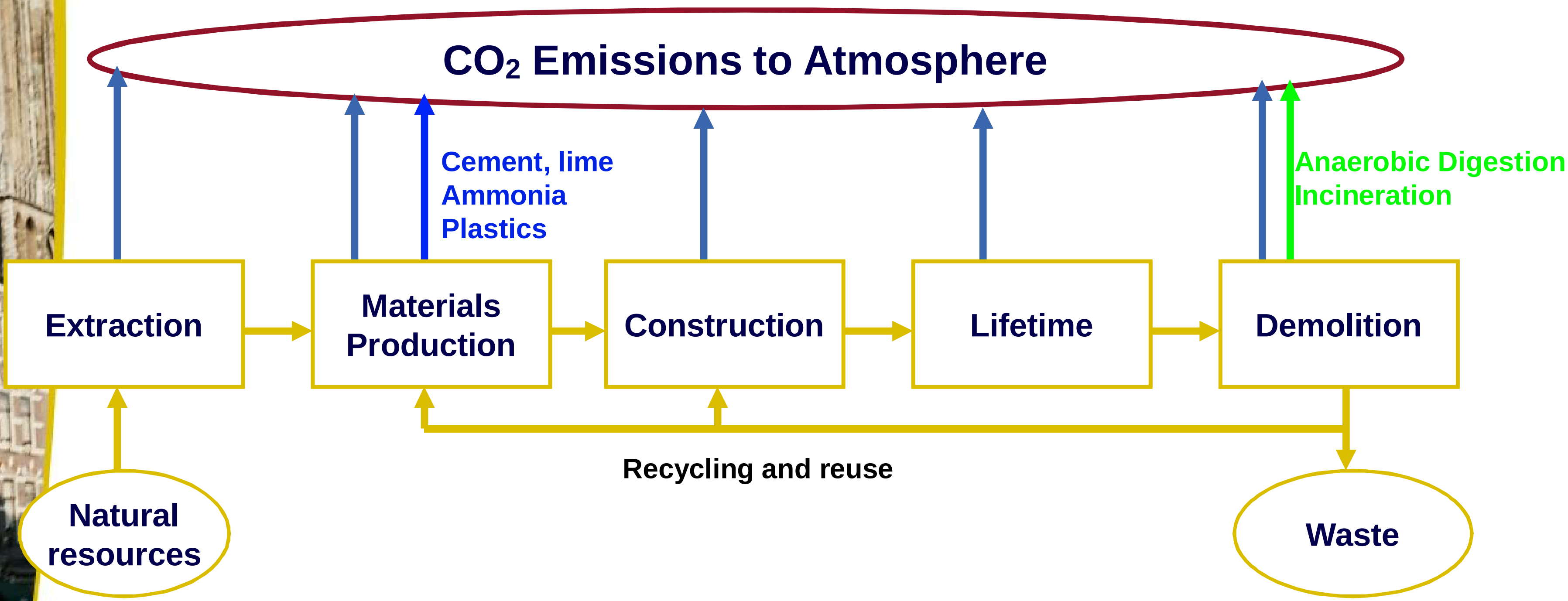
Buildings & GHG Emissions

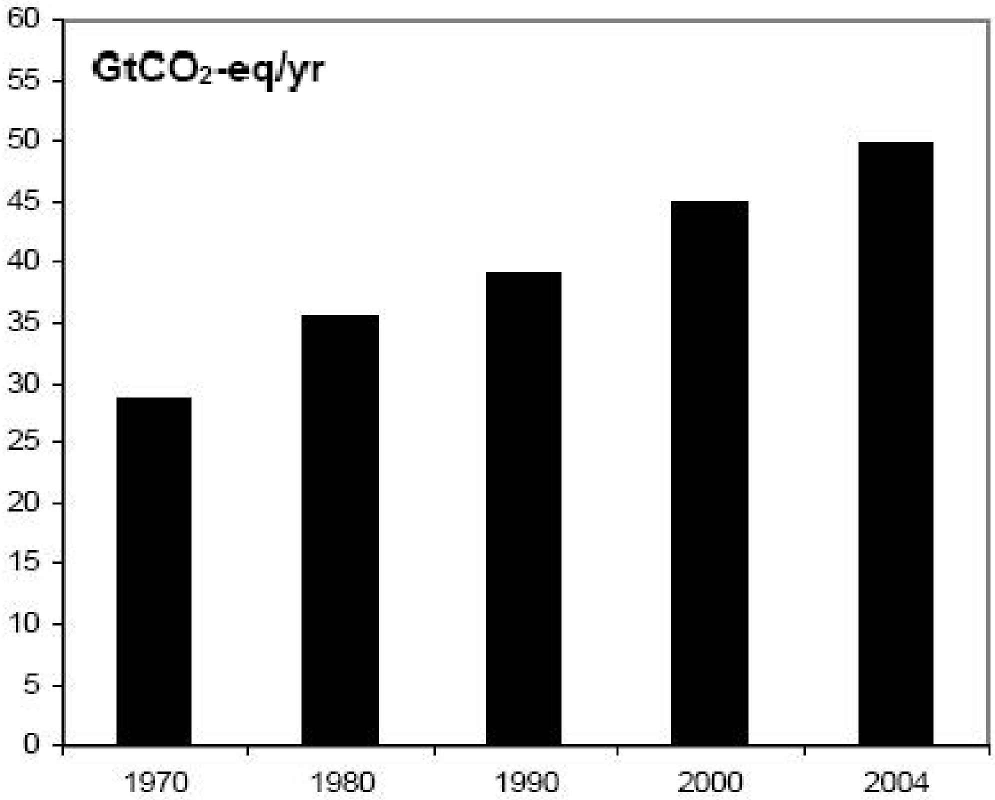


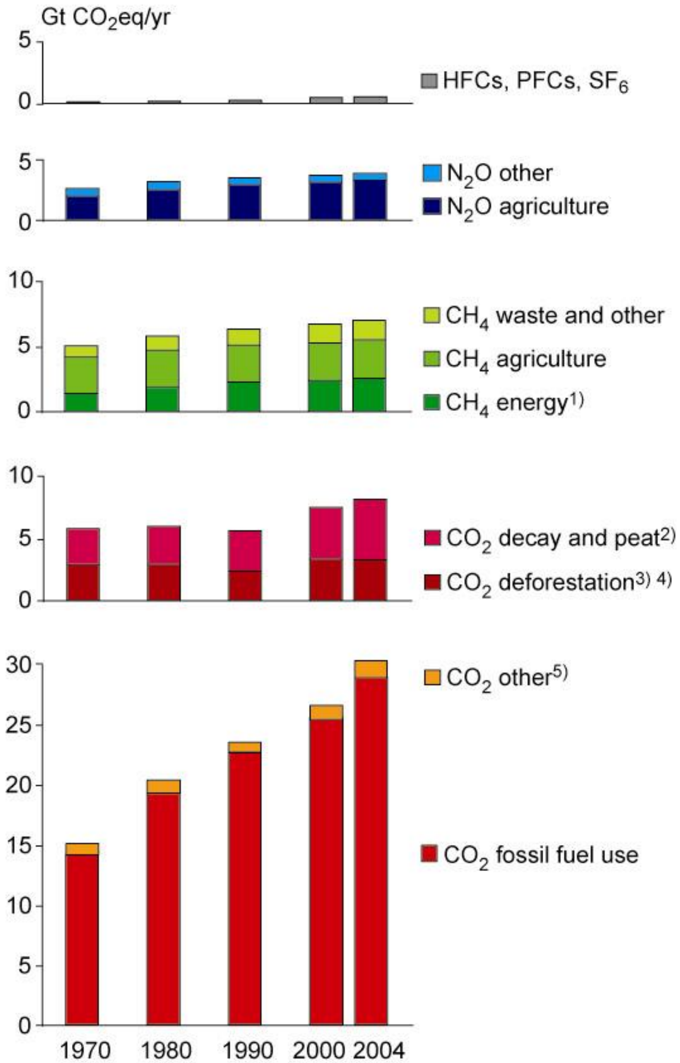
CO_2 from energy

CO_2 from feedstock (fossil fuels, limestone)

CO_2 from waste treatment (fossil and biomass)

Between 1970 and 2004 Global Greenhouse Gas Emissions Increased by 70 %





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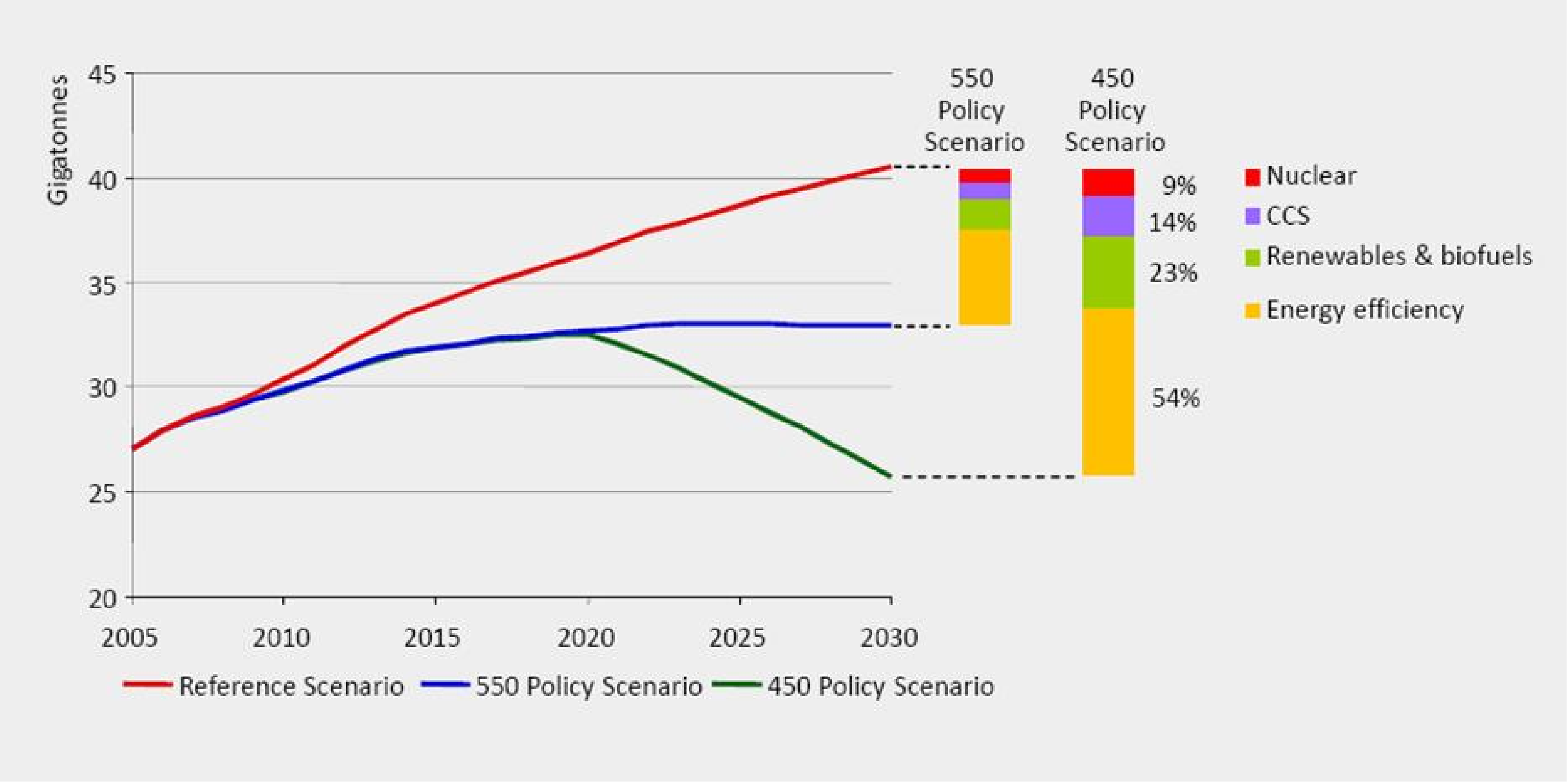
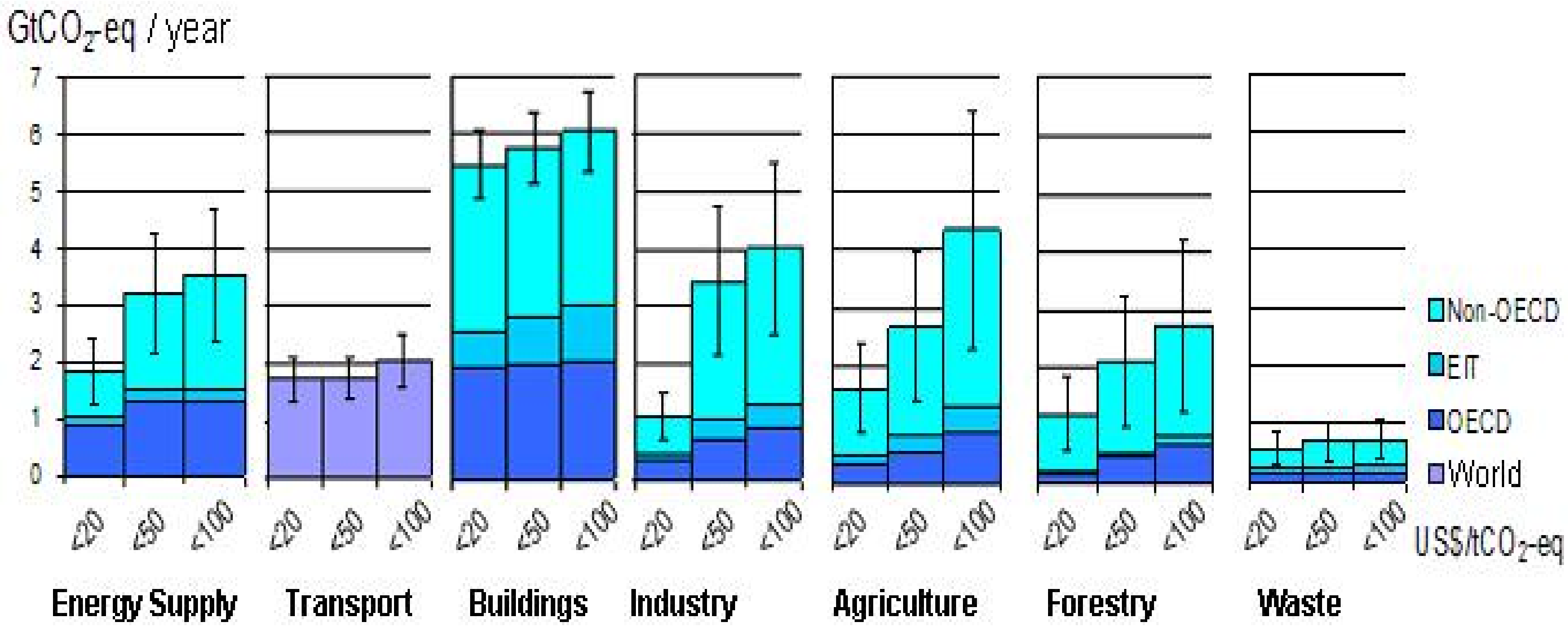
Emission Reduction Pathways



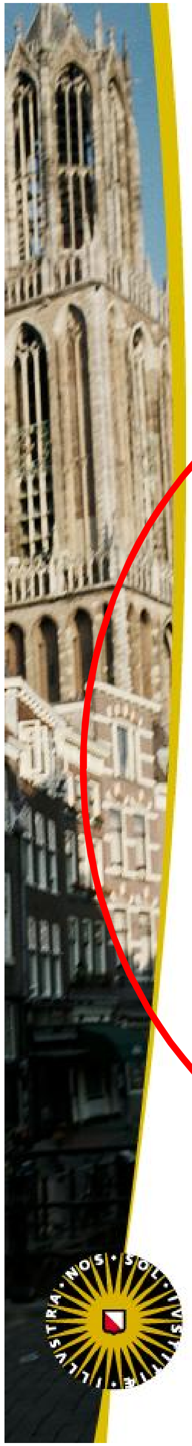
IEA, World Energy Outlook 2008

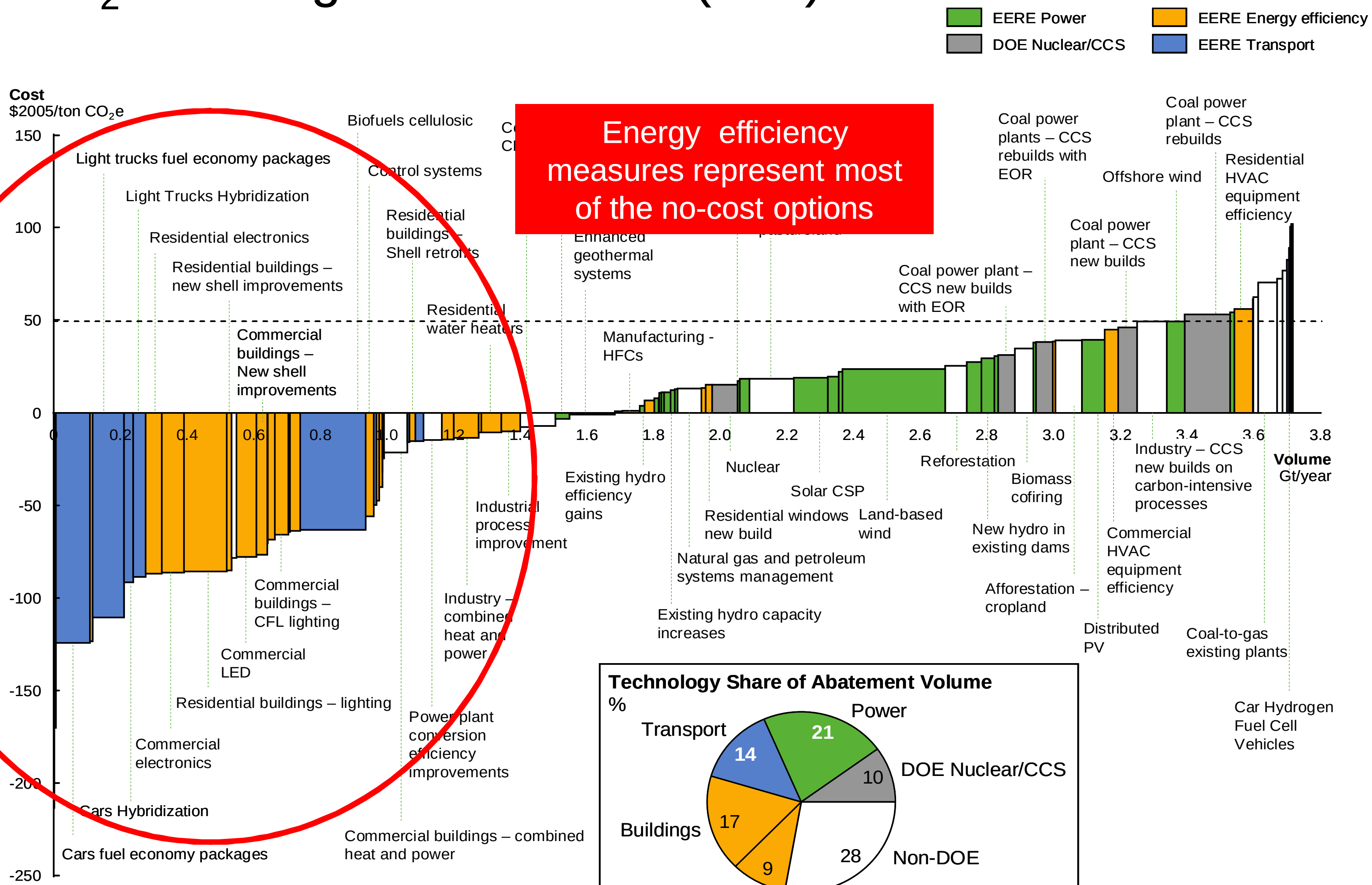
Buildings have the largest mitigation potential



IPCC, 4th Assessment Report – WG-III (2007)

Buildings Energy Efficiency: Large share of CO_2 Savings Potential (US)





Source: December 2008 analysis conducted by EERE with McKinsey using 2008 DOE technology performance projections; mid-range case

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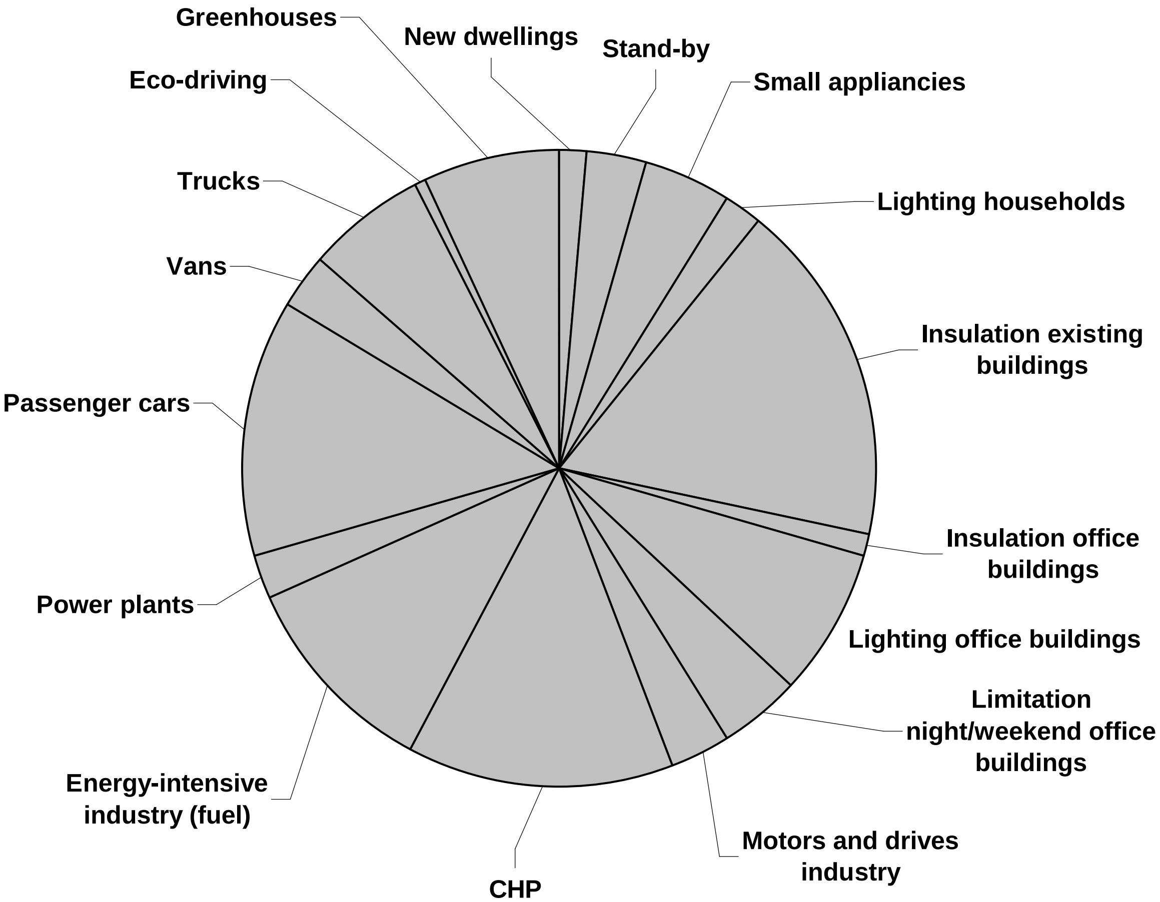
Breakdown of the potential for energy efficiency improvement in the Netherlands



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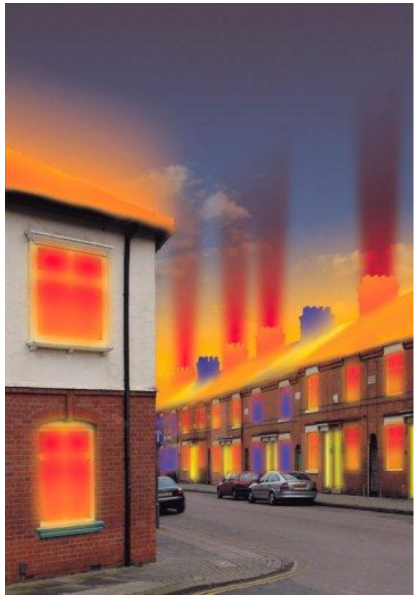
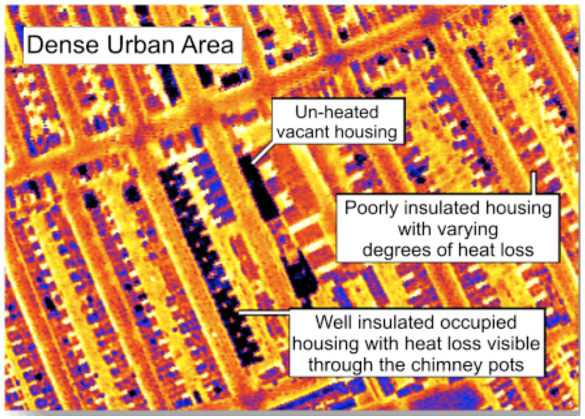
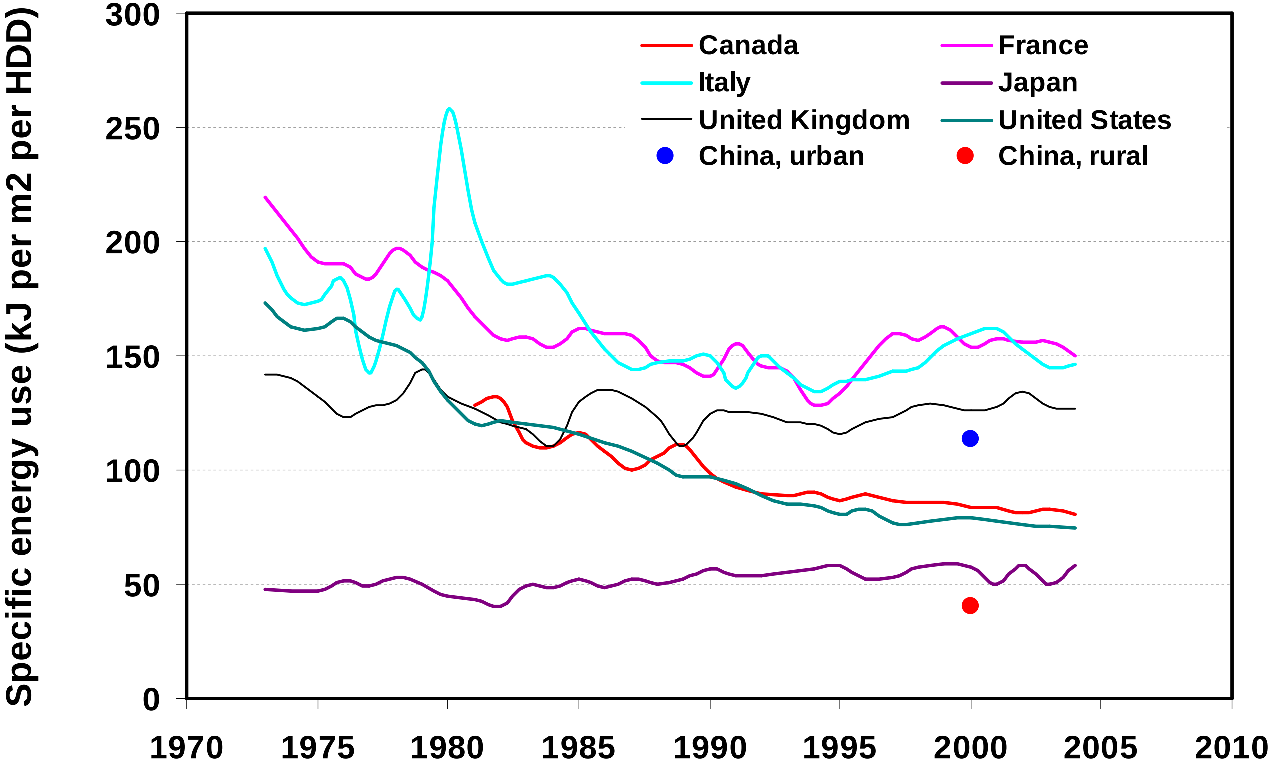
Energy Efficiency - Buildings

- Buildings responsible for 10.6 $GtCO_2$-eq. of GHG emissions, of which 80% from energy use
- Between 20 and 40% of energy used to maintain building environment
  - Building envelope
    - Walls
    - Windows
  - Passive and active use of solar energy
  - Efficient appliances
- Lighting and appliances other key areas





Space heating demand varies widely: Room for Improvement



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Heat losses houses/buildings transmission & ventilation

Space heating is extremely inefficient

Exergy efficiency of space heating
(2nd law thermodynamics)

$E_{fuel}=Q$ at 100% energetic efficiency and $B_{fuel} \approx E_{fuel}$

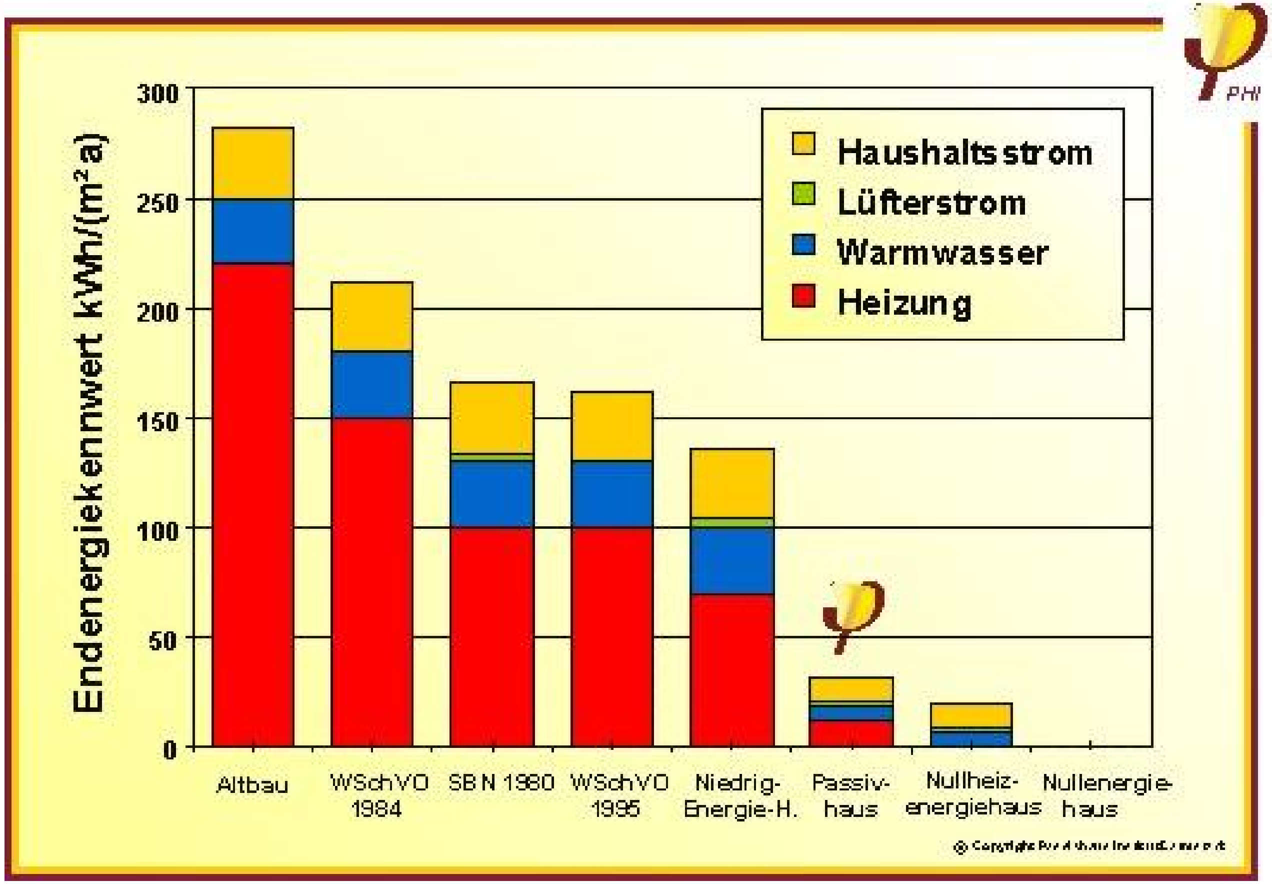
$$\eta_{ex} = \frac{B_{th}\,(\text{heat at room temperature})}{B_{fuel}}$$

$$\eta_{ex} = \frac{\left(1-\frac{T_{ref}}{T_{room}}\right)\cancel{Q}}{\cancel{Q}} = 1-\frac{283}{294} = 0.037 \quad (3.7\,\%) \quad !!!$$

Technologies for Increased Building Efficiency

- Building design as a system
- Insulation materials and glazing
  - Standard insulation materials
  - Vacuum insulation
  - Triple glazing (inert gases, vacuum)
- Heat storage in phase change materials
- Optimum combination of passive and active solar energy
- Low-temperature space heating
- New construction methods and integrated building design
- Building (re-)commissioning

Insulation and Building Standards Key to Realize Building Efficiency



Germany: Passivhaus Targets www.passiv.de

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Housing: PassivHaus

- The PassivHaus standard is gaining popularity around Europe as a benchmark for energy efficient buildings
- The requirements for a Northern European PassivHaus are:
  - very high levels of insulation (wall U-values less than 0.15 W/m2K);
  - high-quality building construction (thermal bridge free, air-tightness of construction better than 0.6 air changes per hour [ACH] measured at 50 Pa with ventilation openings closed, equivalent to 0.03 ACH under normal conditions);
  - high-performance glazing (U-value less than 0.85 W/m2K including installation, frame and glazing edge losses, solar transmittance greater than 50%);
  - a high efficiency ventilation system with heat recovery (MVHR);
  - construction mass, ventilation openings, thermal capacity and shading designed for comfortable summer temperatures; high efficiency appliances and lighting.

Energy Efficient Buildings Expensive?

- In many cases, new buildings using less energy are built with no cost premium.
- A single case study from lower Manhattan estimated a first cost increase between 8% and 15% compared to a typical building.
- A study of 33 sustainable buildings in California found a negligible first cost difference - estimated at less than 2%.
- A US nationwide study of over 600 projects found no statistically significant difference between the two groups.

In summary: Increasing Building Efficiency

No Rocket Science

- Technology here today
  - building is a system
  - low-temperature heating (e.g. heat pumps)
  - optimum combination of passive and active solar energy
  - construction methods and integrated building design
  - efficient ligthing
  - appliances
- Advanced technology under development
  - insulation materials (e.g. vacuum) and smart glazing
  - heat recovery and storage
  - high efficiency LED lighting
- Integration is key to success

Directions

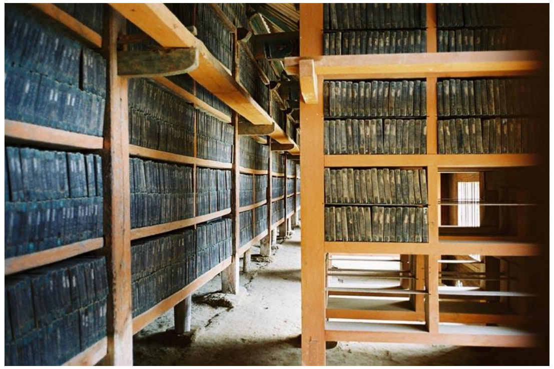
- Strict efficiency standards
- Passive Housing / Buildings
  - housing / offices
  - demonstrations in all community
  - standards
- Appliance labeling and standards
- Procurement by government and public organizations
- Innovation
  - technology RD&D
  - building commissioning
  - training, training, training....

Buildings as a system: 1000 year old architects beat modern technology

Hae-In Temple, Korea

- 1000 years old monastery in South-Korean Mountains
- UNESCO World Heritage Site
- Depository of wooden Tripitaka

- In 1960's new air-conditioned building to store Tripitaka
- Within weeks mold formed on wooden blocks
- Returned to 1000 year old building
- Well integrated design:
    - Natural ventilation through siting
    - Passive temperature control
    - Temperature variation small
    - Insect control through use of lime floors



Thank you for your attention

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