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Sustainable Energy and Housing Approaches in Europe -

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Illinois – Renewable Energy and Sustainable Lifestyle Fair

August 2006

Sustainability

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- "Do not cut more wood than you grow again! …"
- Rio 1992 social, economic, ecological dimensions -> Agenda 21st Century
- Global Challenge
  - Reached and transgressed natural limits during last decades
  - Continued population growth and inequalities built up additional pressure
    - 20% of population use about 80% of the global resources
    - 450 Mill. people in Europe "EU-25" high end consumers … (Germany 80 Mill. largest country)
    - 300 Mill. people in the US … highest load
    - Developing countries (China, India 2400 Mill.) … asking their share
- Factor Energy most critical
  - Resources limited … in unstable countries
  - Sinks limited … climate problem
  - Production & usage … not sustainable

Sustainability Limit

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for Energy Related CO_2-Emissions

Global limit:

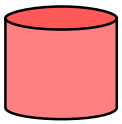
10 billion tons p.a.

Population 2050:

10 billion people

means

max. 1 ton



p.a. per capita

The Situation

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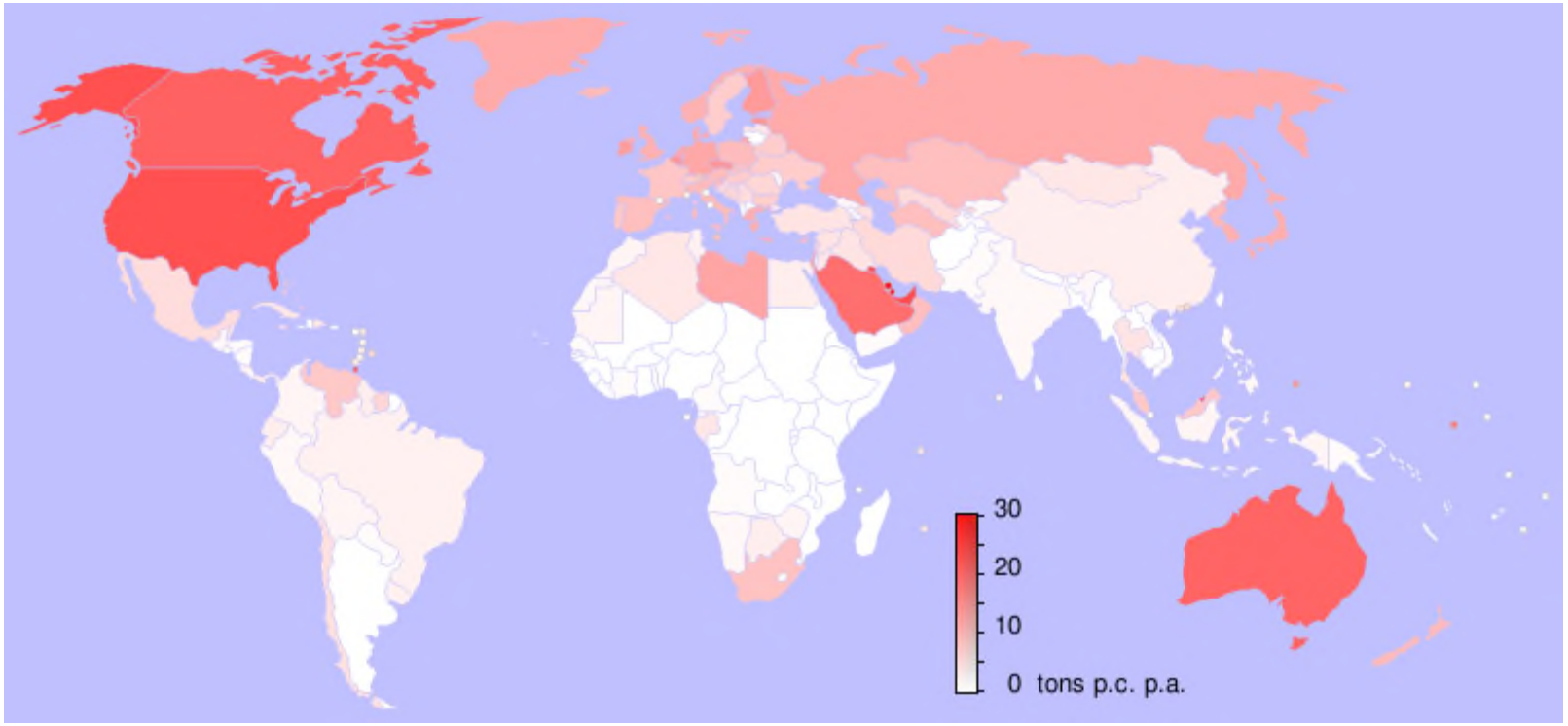
CO_2-Emissions in tons p.c. p.a. across the world



The Implication

Energy-related CO_2-emissions have to be reduced

by at least a factor of 10 in the western world!

This holds for all sectors

in particular for Housing

- Consumption more than 1/3 of energy in most western countries
  - 40% energy share in US and Europe
    - Where heating accounts for more than 50% in US, 80% in Europe
    - Remaining part: electricity for household appliances and cooling
  - Besides housing is responsible for ~ 50% of all material flows

- Offers enormous “no-regret” potentials
  - Energy savings, reduction of CO_2-emissions
  - Ecological improvements
  - Comfort, health
  - Overall cost reductions
  - Sustainability as a whole

Renewable Energies

Global Primary Energy Consumption

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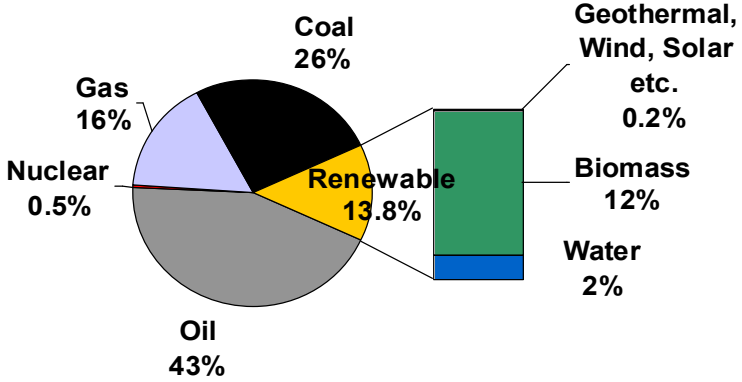
doubled since 1971... share renewables constant < 15%

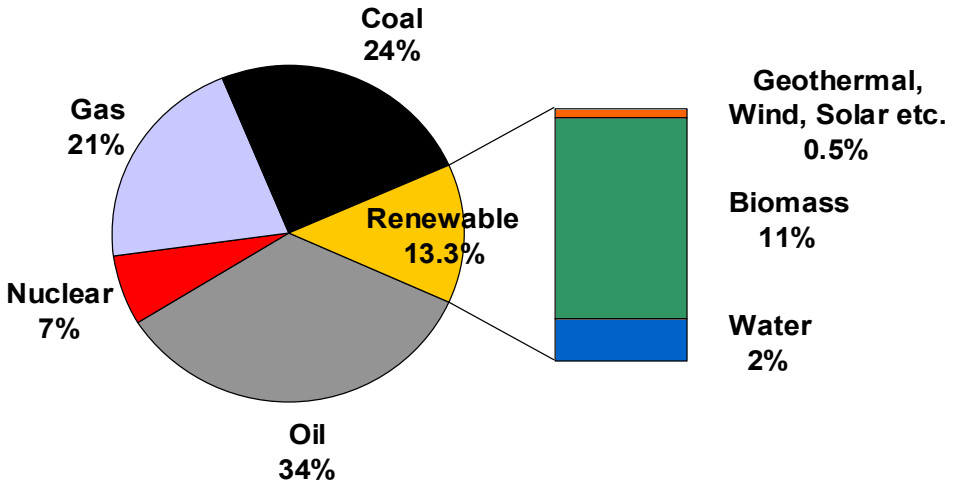
1971:

Total: 234 000 PJ (220 btu 10^{15})



2003:

Total: 443 000 PJ (420 btu 10^{15})



Source: BMU

European Union “EU-25”

- Background
  - 25 countries with heterogeneous conditions
  - Main responsibilities remain with individual nations
  - EU supplies political framework
- Energy Challenge
  - High energy dependency (trend 50 to 70% by 2030), economic dangers
  - Lack of environmental sustainability
- Status Energy and Emissions
  - Renewable energy share 6%
  - CO_2-Emissions 8 t p.a. p.c.
- Short Term Goals
  - Renewable energy share 12% (2010)
  - CO_2-Reduction 8% (Kyoto 2012)

EU Strategy & Political Cornerstones – Renewables & Efficiency

- EU supplies framework to be filled in by national and cooperative actions
- EU Green Papers … outline goals and strategies
  - Security Energy Supply 2000
  - Energy Efficiency 2005
  - Sustainable Energy 2006
- EU-Directives … define legal framework to be implemented nationally
  - Renewable Electricity: Overall target: 21% (2010) + country targets + review mechanisms
  - Renewable Fuels: General target 5,75% (2010)
  - Renewable Heat: in preparation
  - Efficiency for Energy Using Products: performance & labeling standards … in force
  - Efficient Buildings: calculation, performance, labeling standards/energy pass by 2006
- EU- Programs & Projects (Selection) … stimulate research, innovation, education
  - 1984 – 2001 5 Framework Programs and Joule-Thermie Program for Buildings
  - 2002 – 2006 6th Framework Program with 70 mill. € on efficiency , 80 Mill. Renewable
  - 2007 - 2013 7th Framework Program in preparation

Overview Results

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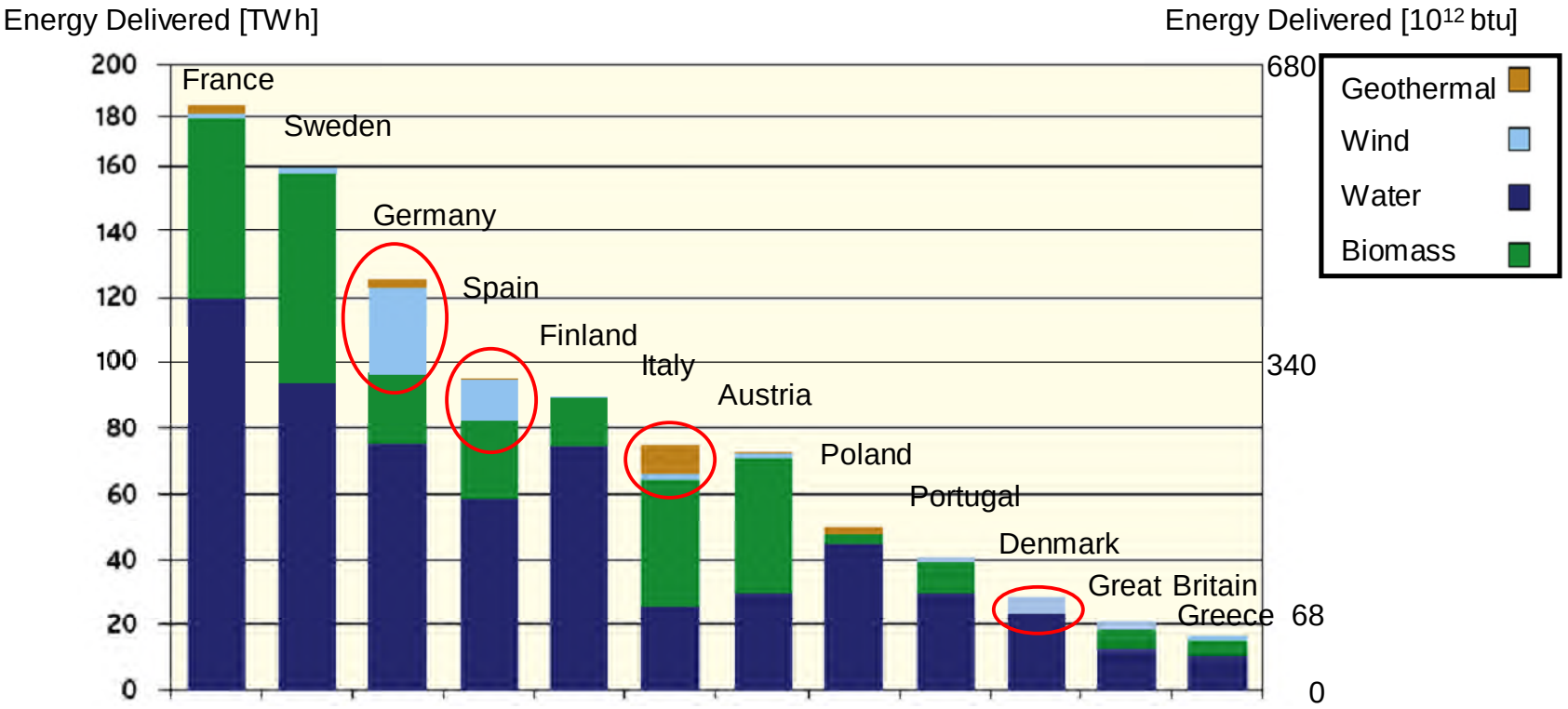
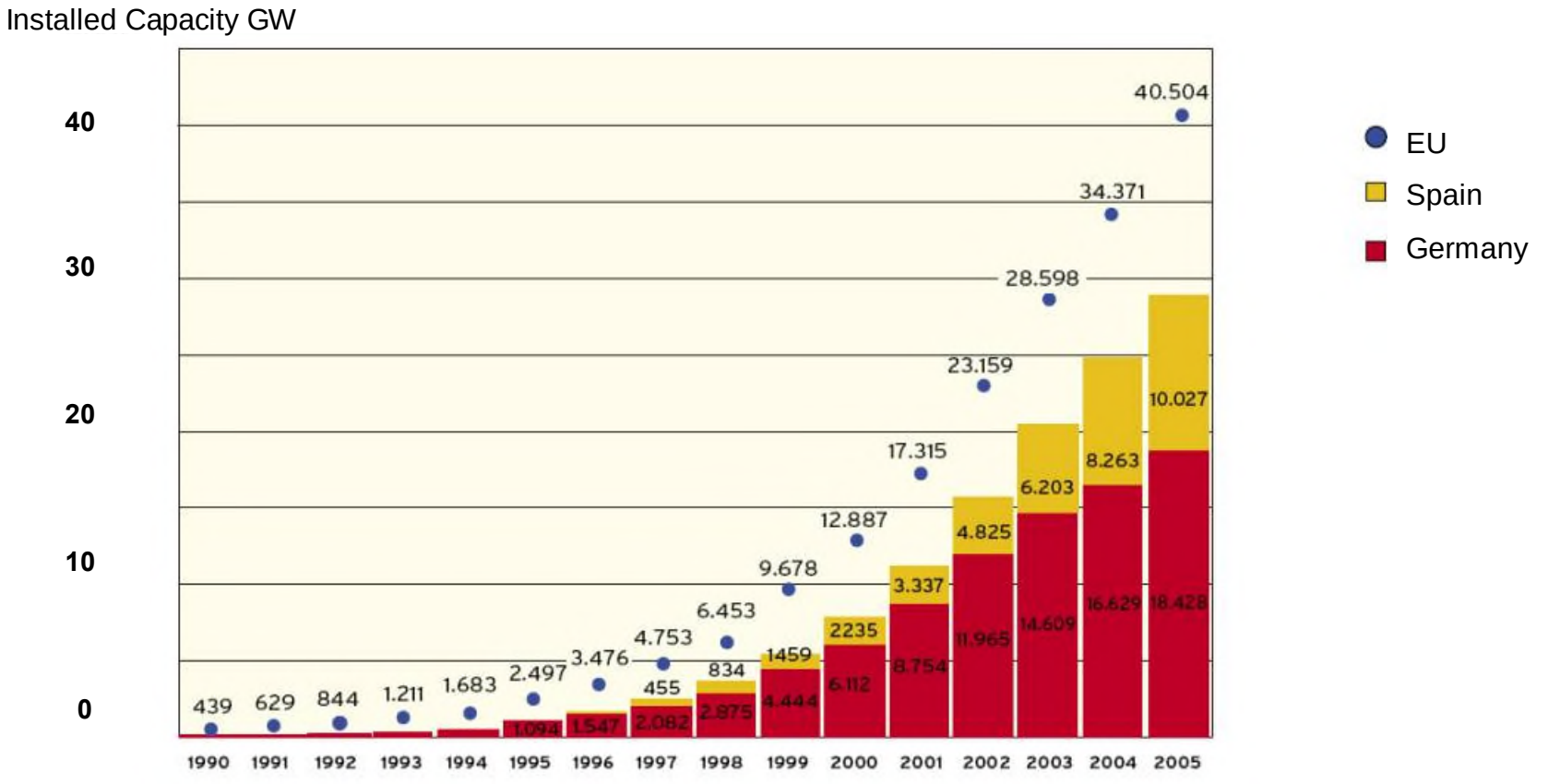
Renewable Energies in EU-Countries 2004 have a 6% Share… "New Renewables" triggered in Germany, Spain …



Source: BMU

The Development of Wind Energy – German Success Story



Source: BMU

Political Cornerstones for Renewables in Germany

- Renewable Energy Act (EEG) ... ~ 2.5 Bill. € p.a.
  - Forces grid operators to buy renewable energy from third parties
  - Guaranteed minimum prices, decreasing over time
  - End customers pay.... ~ 30 €/a p.c., 3% price increase
  - CO_2-Efficiency: Cost 40 €/t versus Benefit 70 €/t → positive balance
- Energy Taxes and Fees
  - Play a prominent role in Germany (and Europe)
  - Order of magnitude 40% (heating oil), 65% (household eletricity), 200% (gasoline)
  - Including VAT, concessions, cogeneration, ecological tax
  - Ecological Tax: up to 2 Cent/kWh (5 ... 25%) → 18 Bill. €/a (220 €/a p.c.)
- Market Stimulation Program ... > 100 Mill. € p.a.
  - Financed by ecological tax reform
  - Subsidies (small plants) and special loans (large plants)
- Continued Research ... 2005: 100 new projects 100 Mill. €

Effects on Renewables in Germany


Wind Electricity

Energy Act

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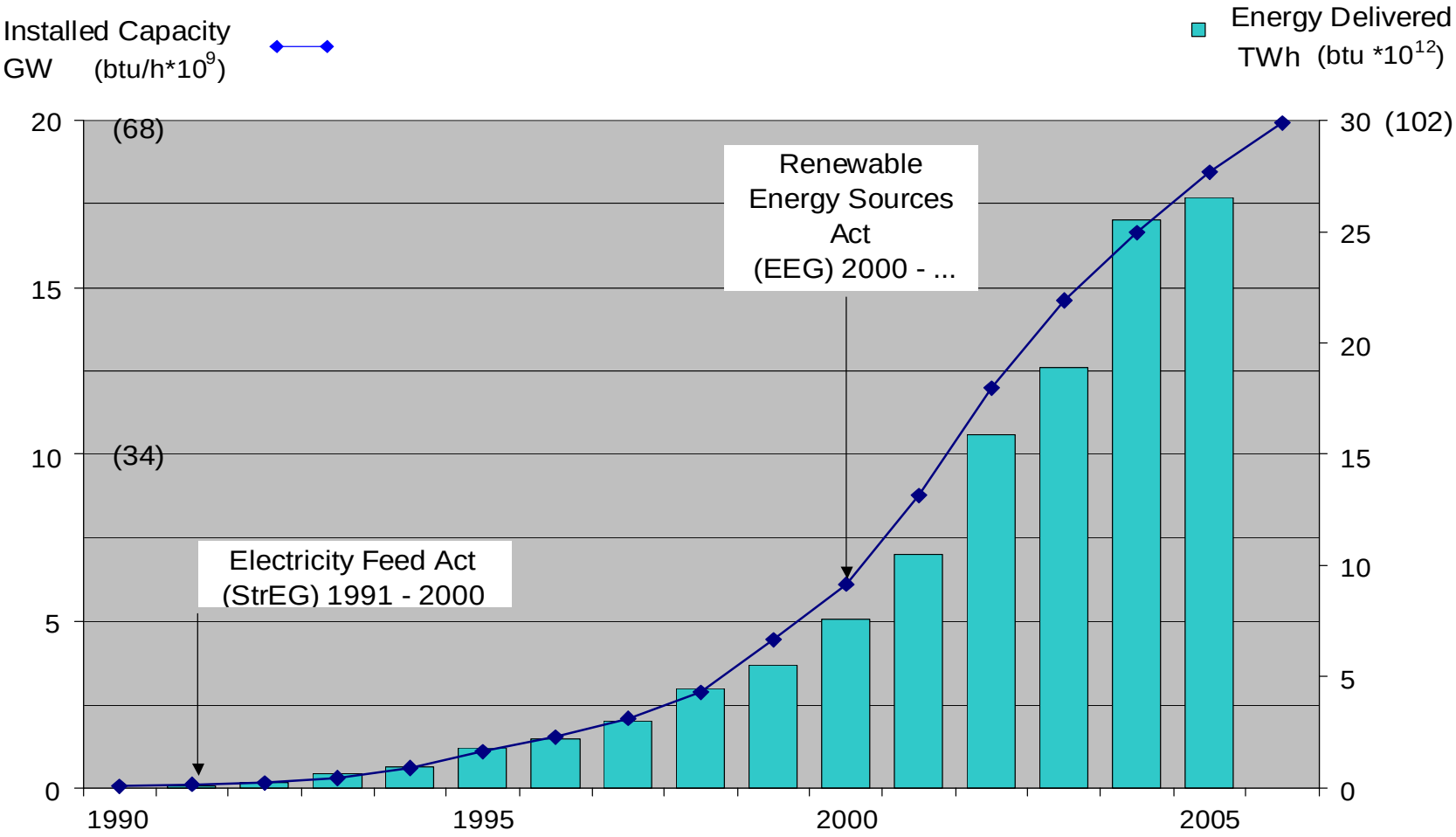
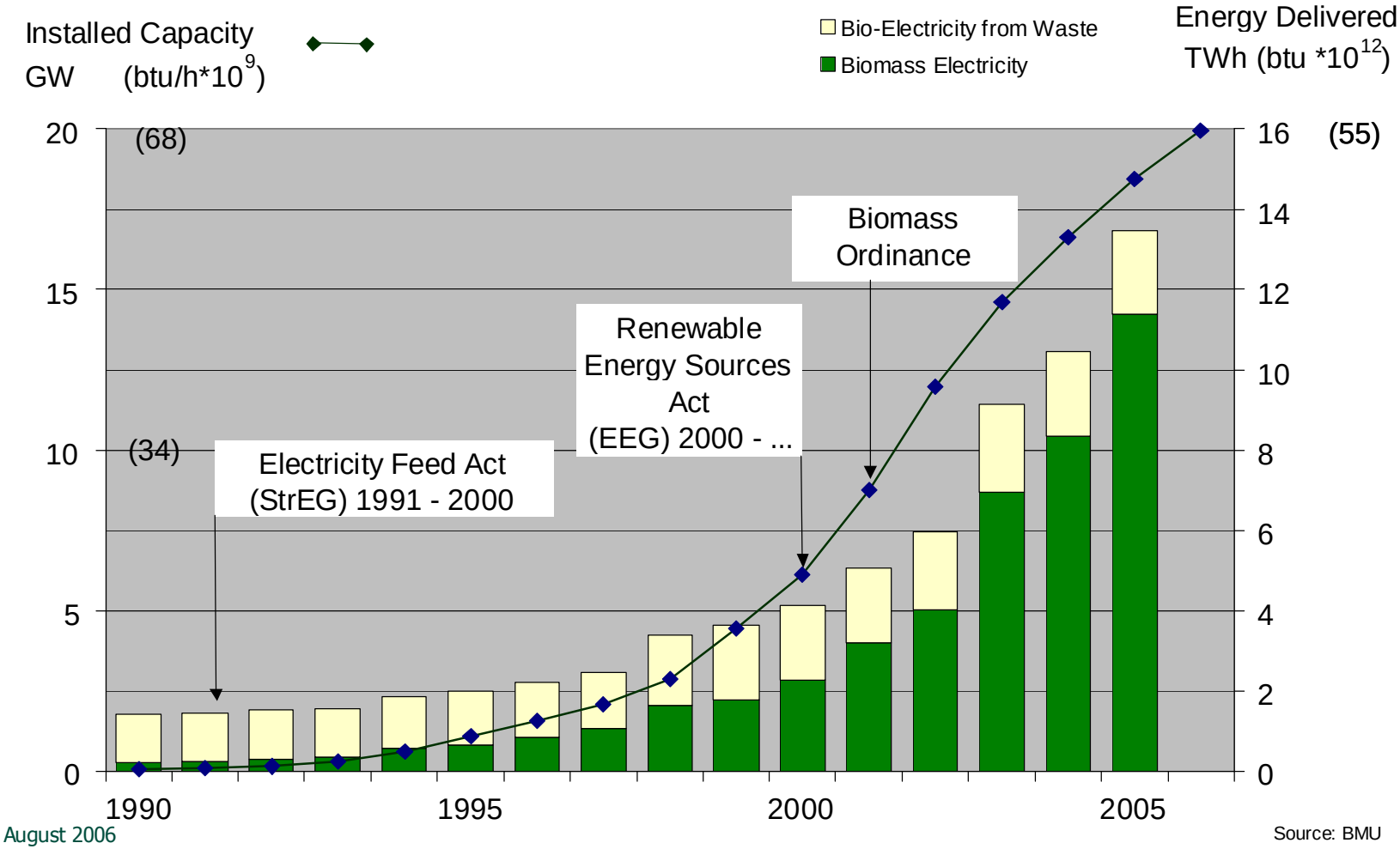
stimulates exponential grow of wind energy



Source: BMU


Biomass Electricity

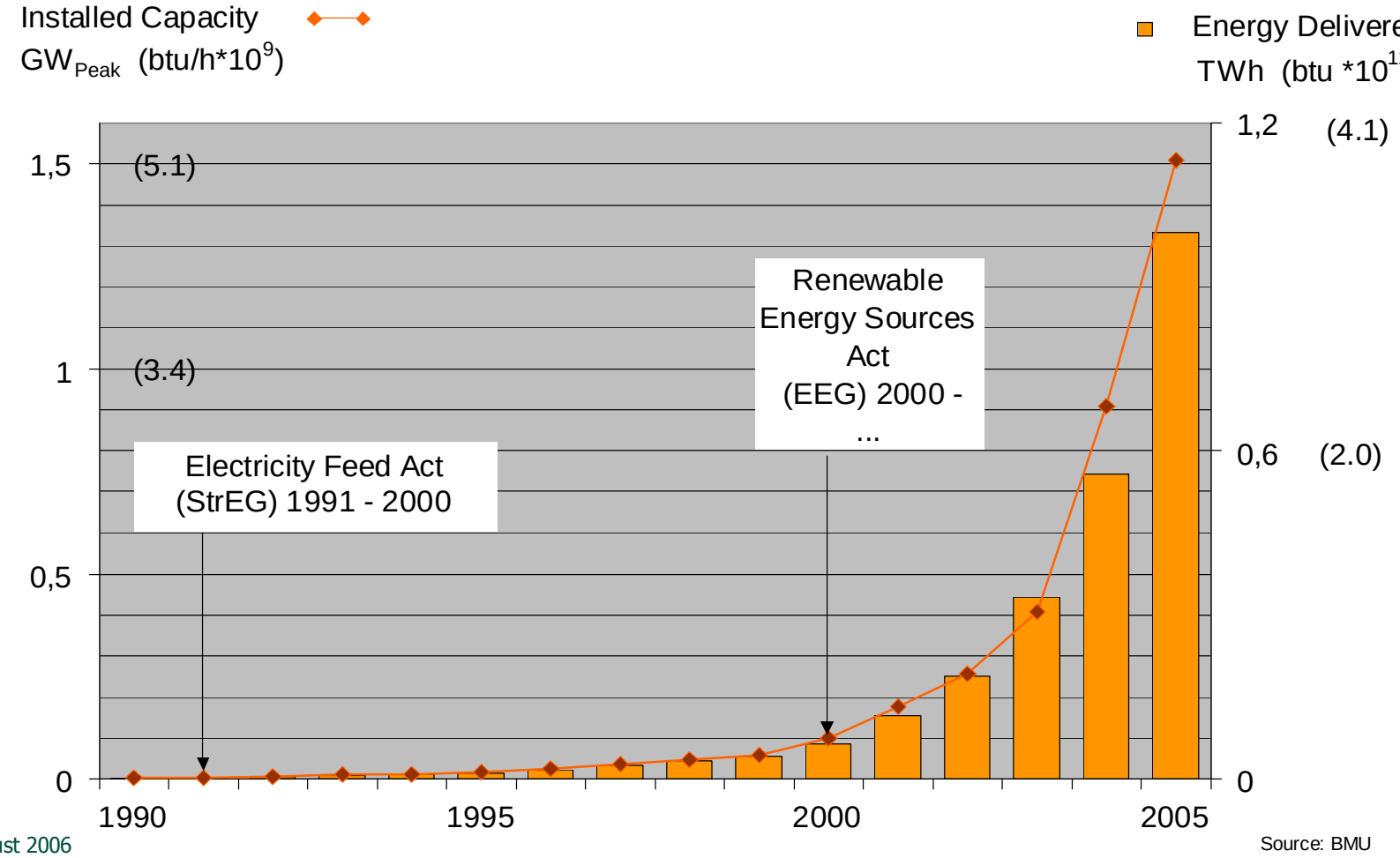
… and exponential growth of Biomass Electricity



Source: BMU

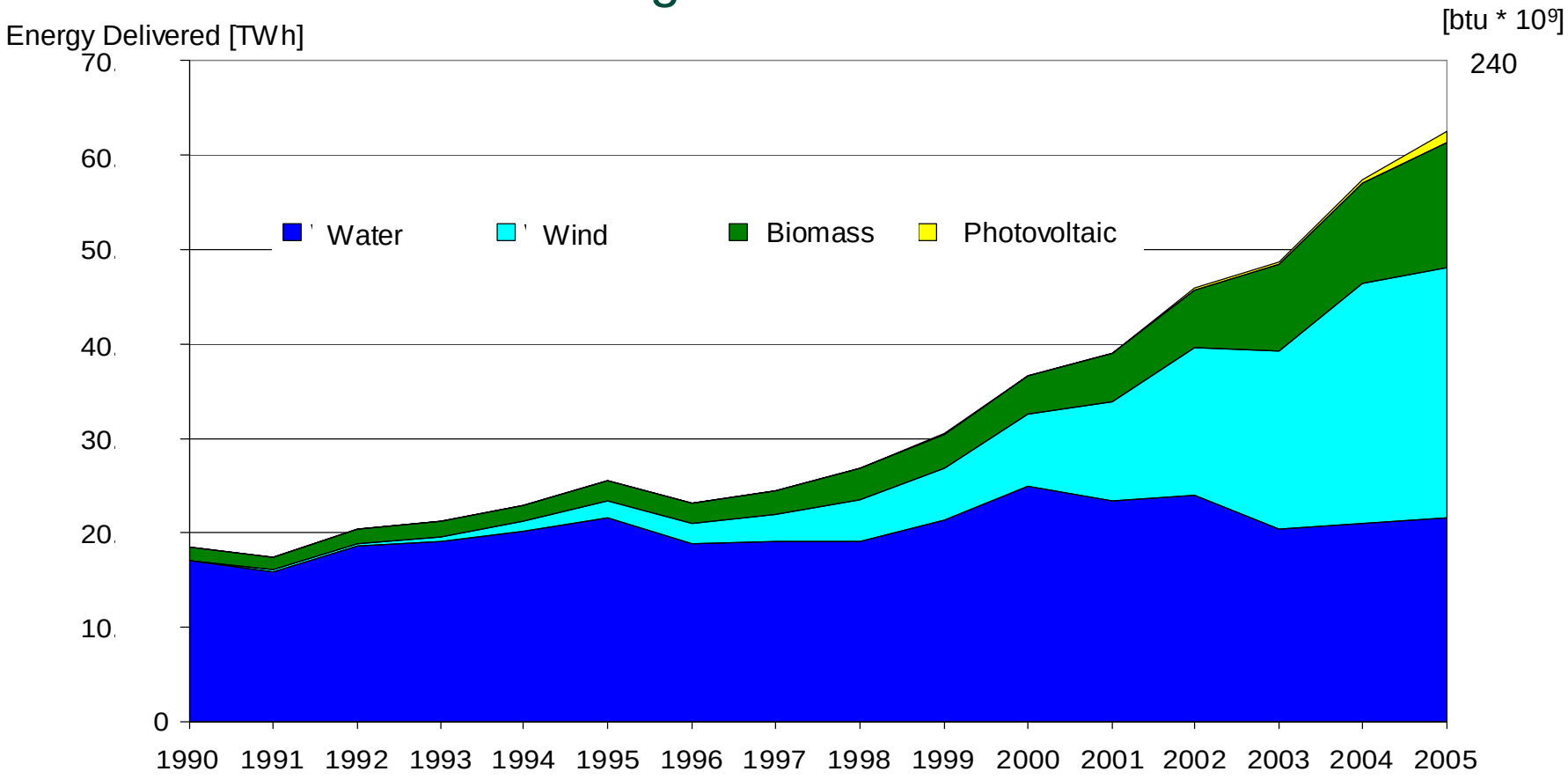

Photovoltaic Electricity

Photovoltaic exploding since 2000



Source: BMU

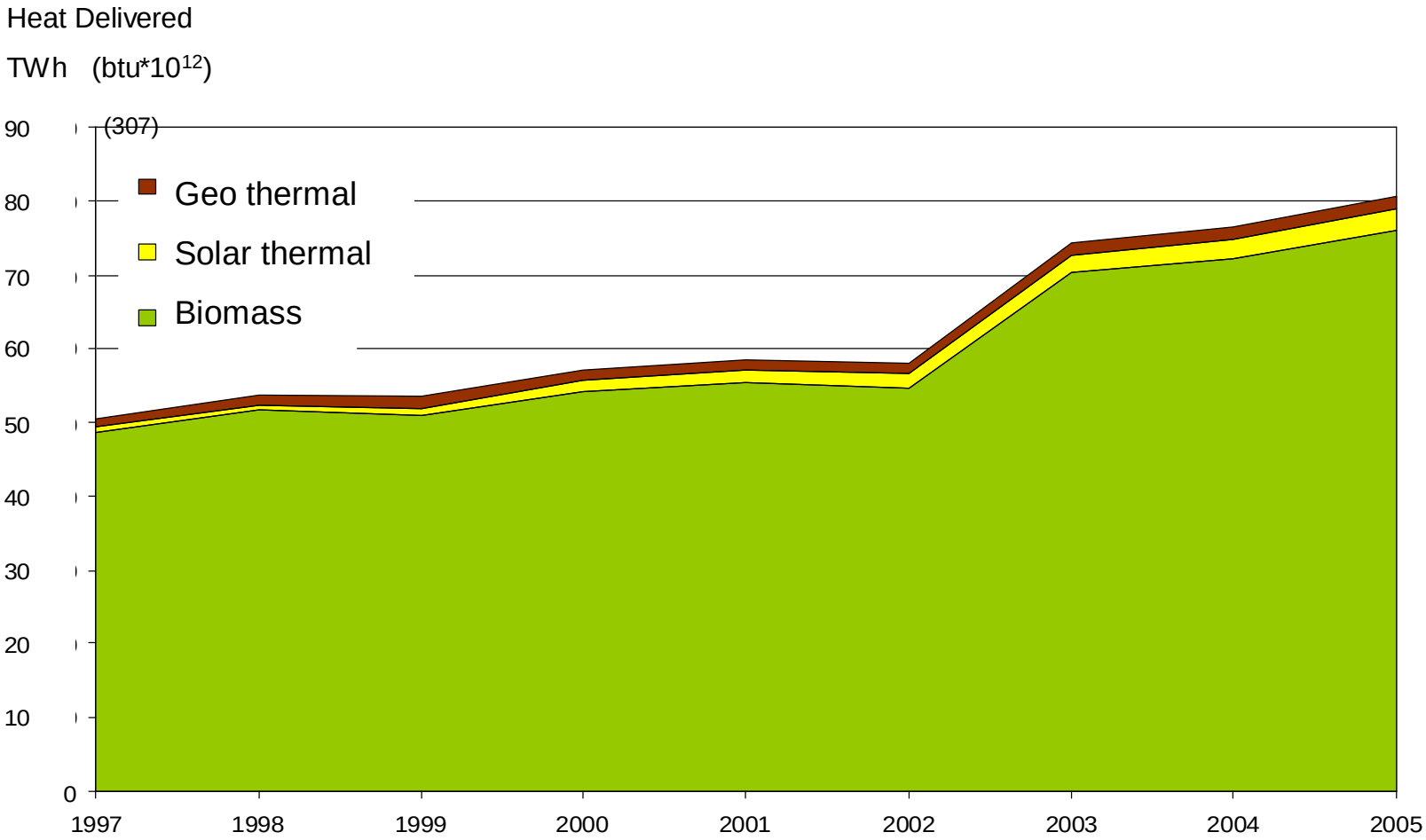
Renewable Electricity Germany tripled since 1990, Wind taking the lead in 2004



Source: BMU

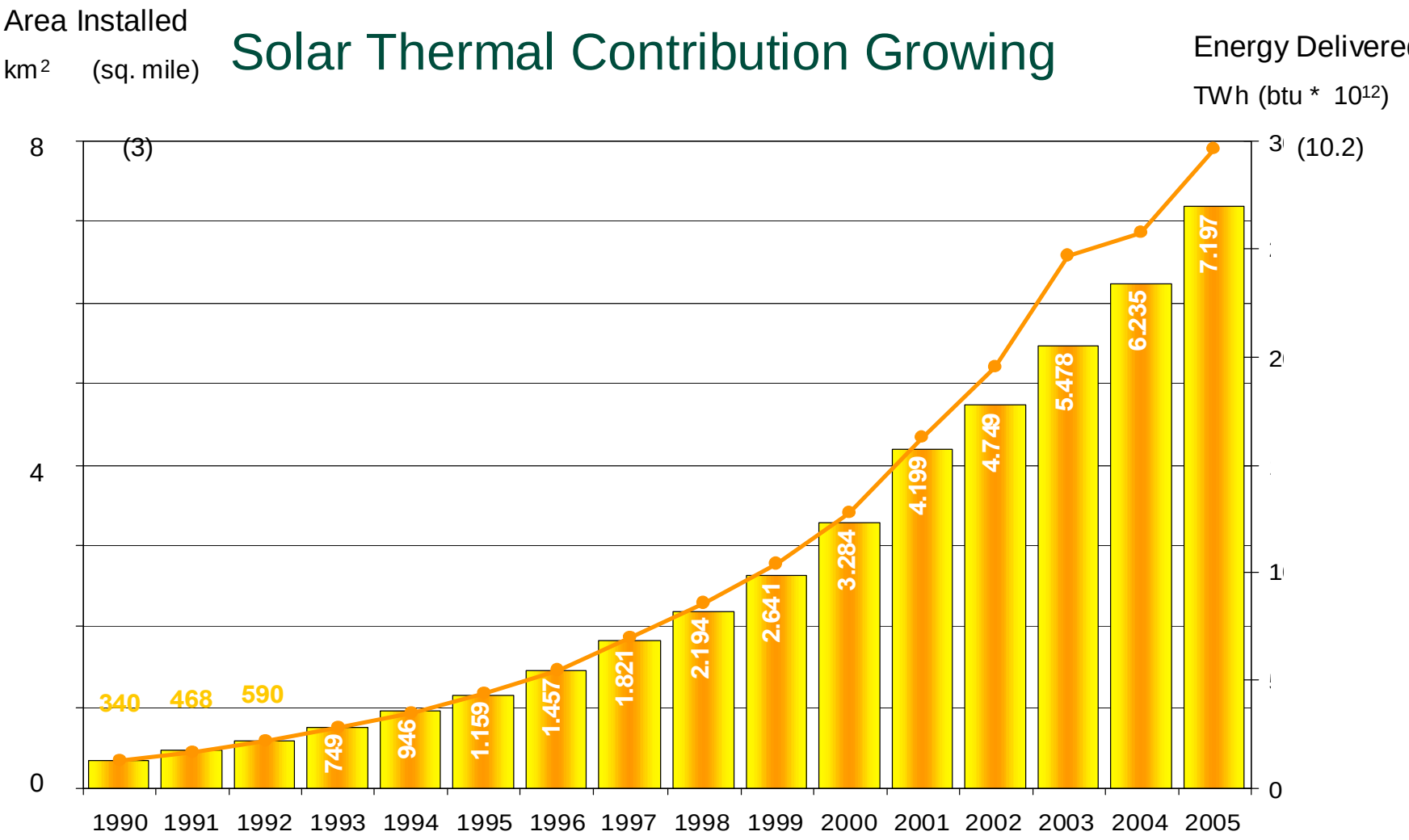

Renewable Heat

Renewable Heat Germany - Dominated by Biomass



Source: BMU

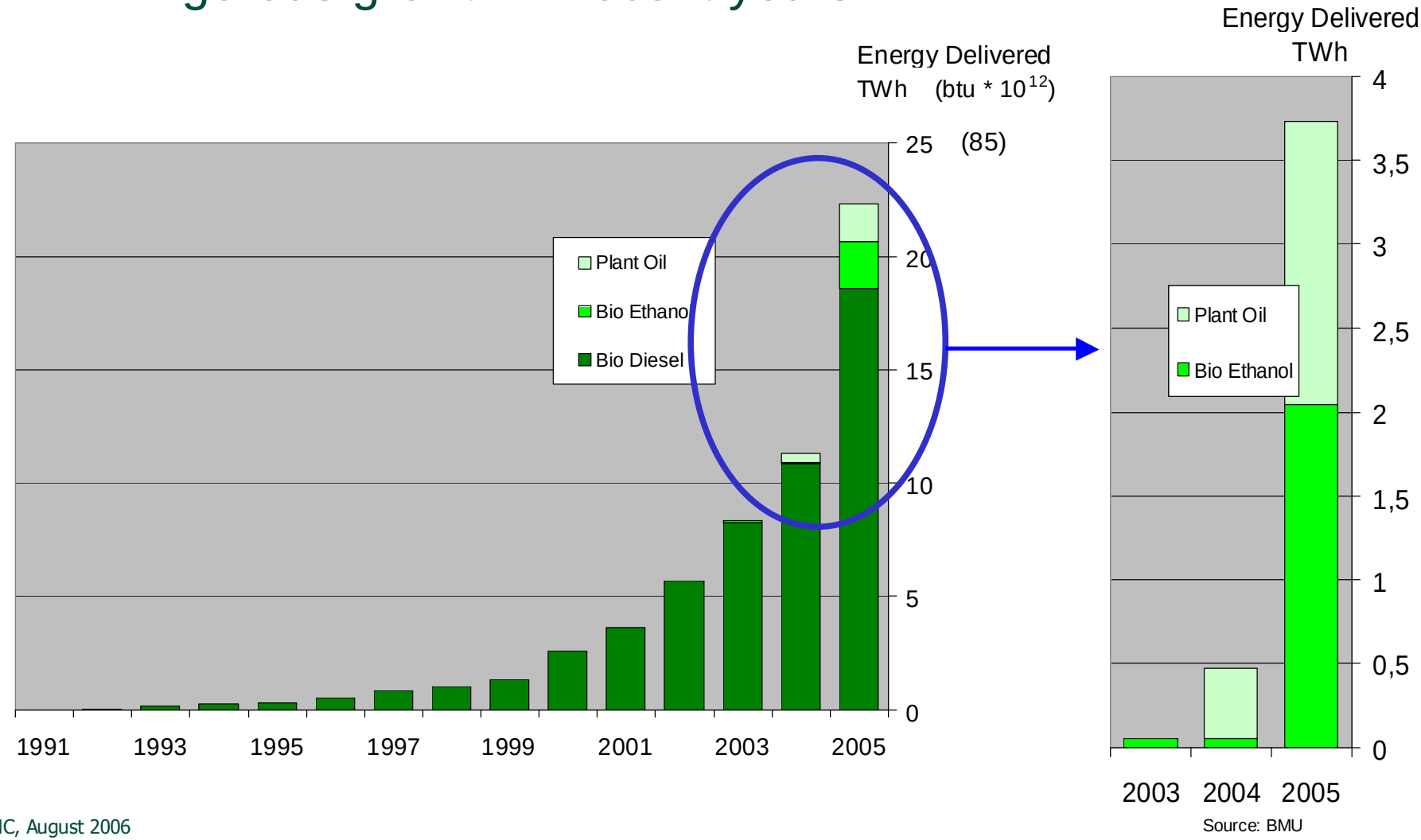
Solar Thermal Contribution Growing



Source: BMU

Biogenic Fuels Germany -

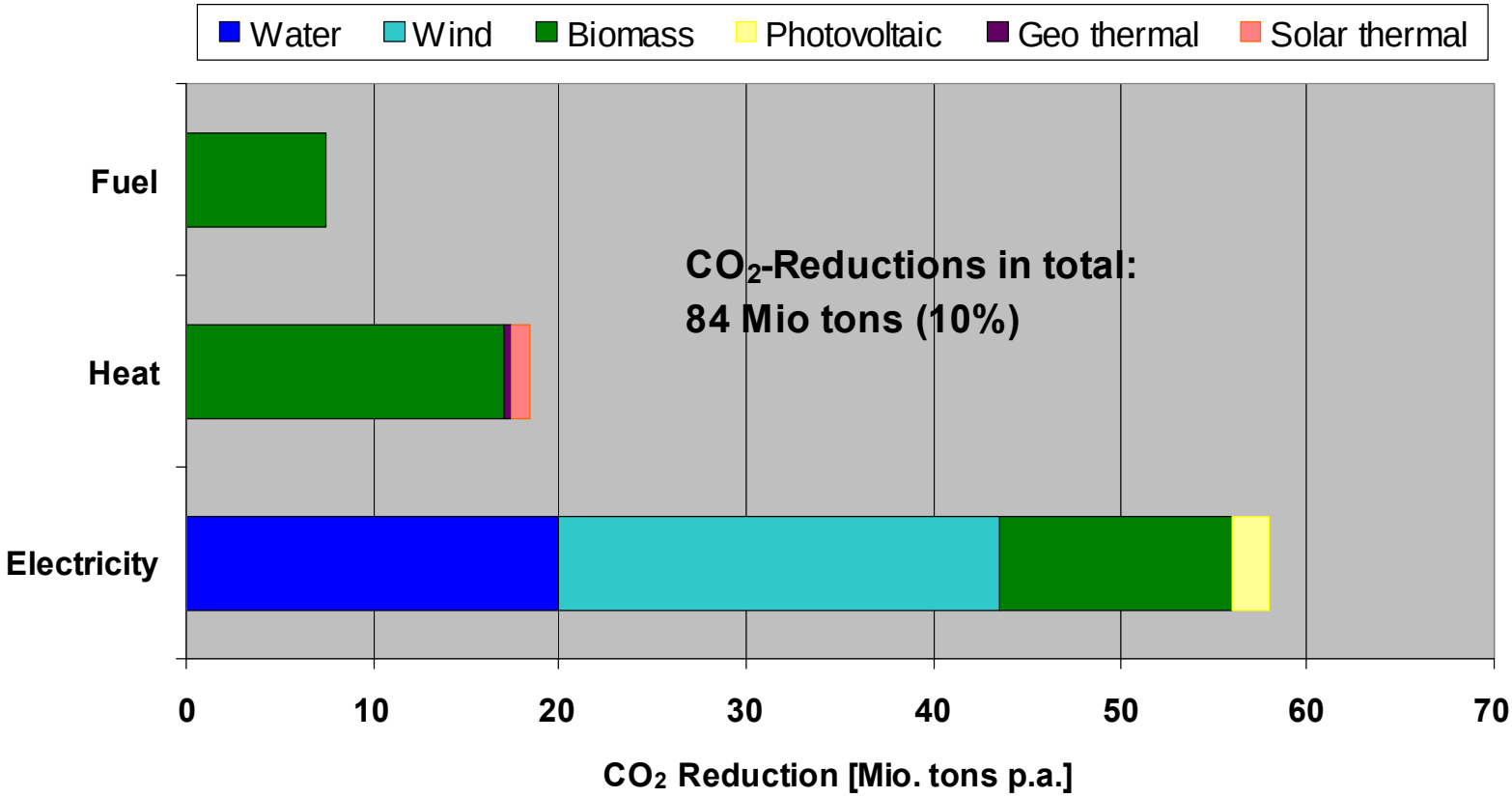
vigorous growth in recent years



Source: BMU

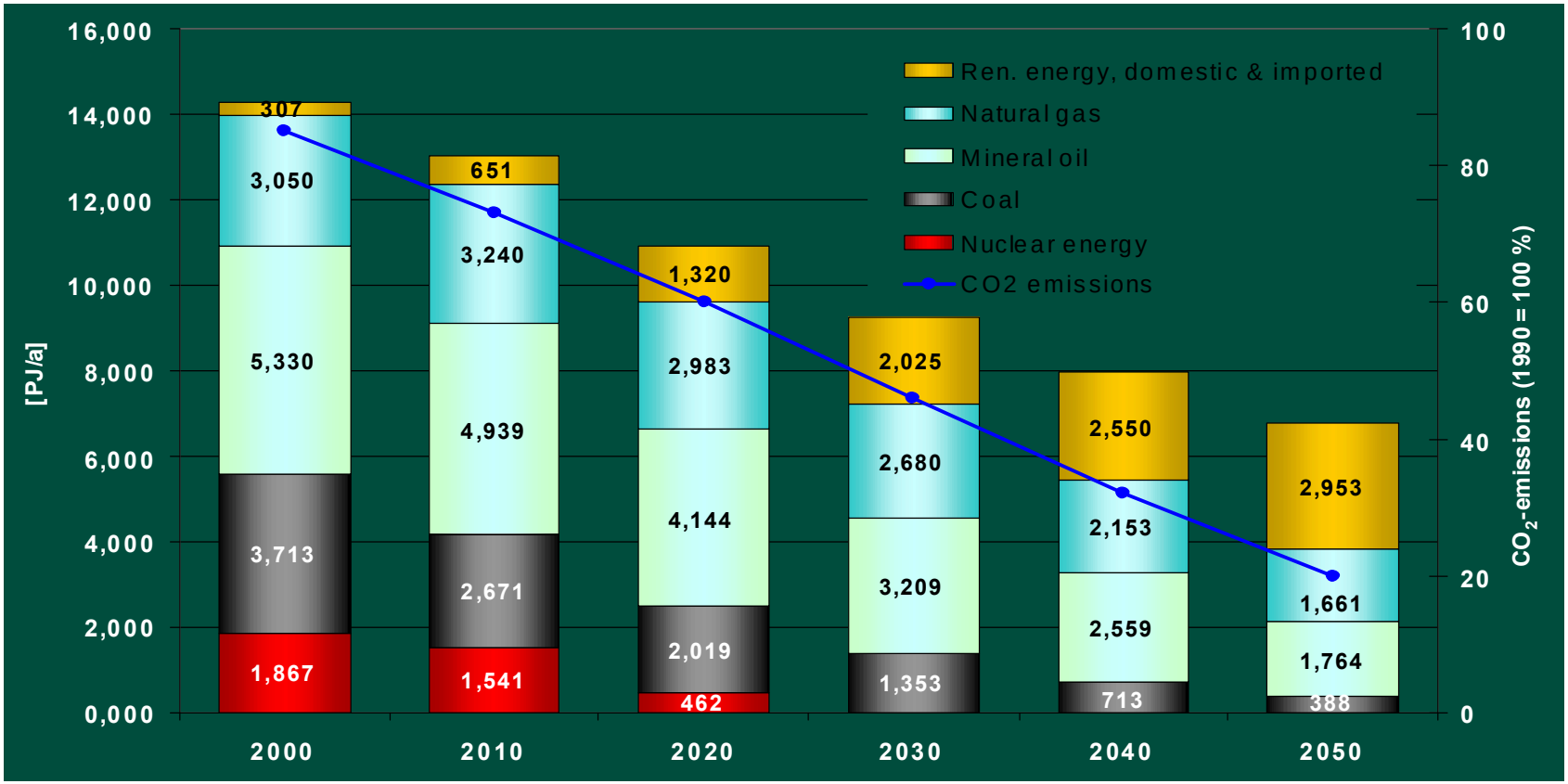
Effects on CO_2-Avoidance

10% of CO_2-Emissions Avoided by Use of Renewables in 2005



Source: BMU

Primary Energy and CO_2-Emission Scenario until 2050



Source: BMU

Housing

Overall boundary conditions imply:

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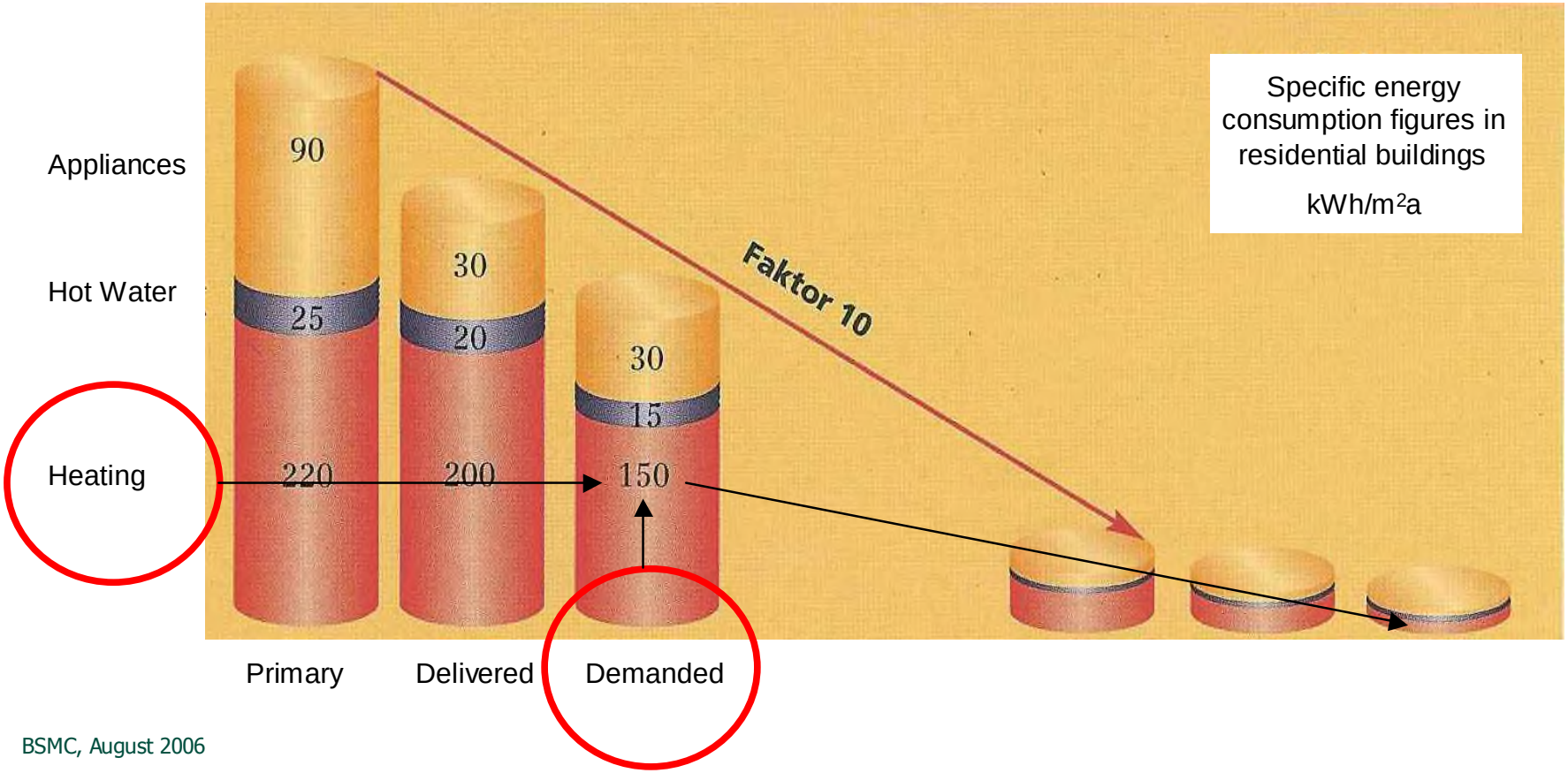
We have to improve energy performance of houses by a factor of 10 … with a focus on heating demand

Energy consumption today ... tomorrow



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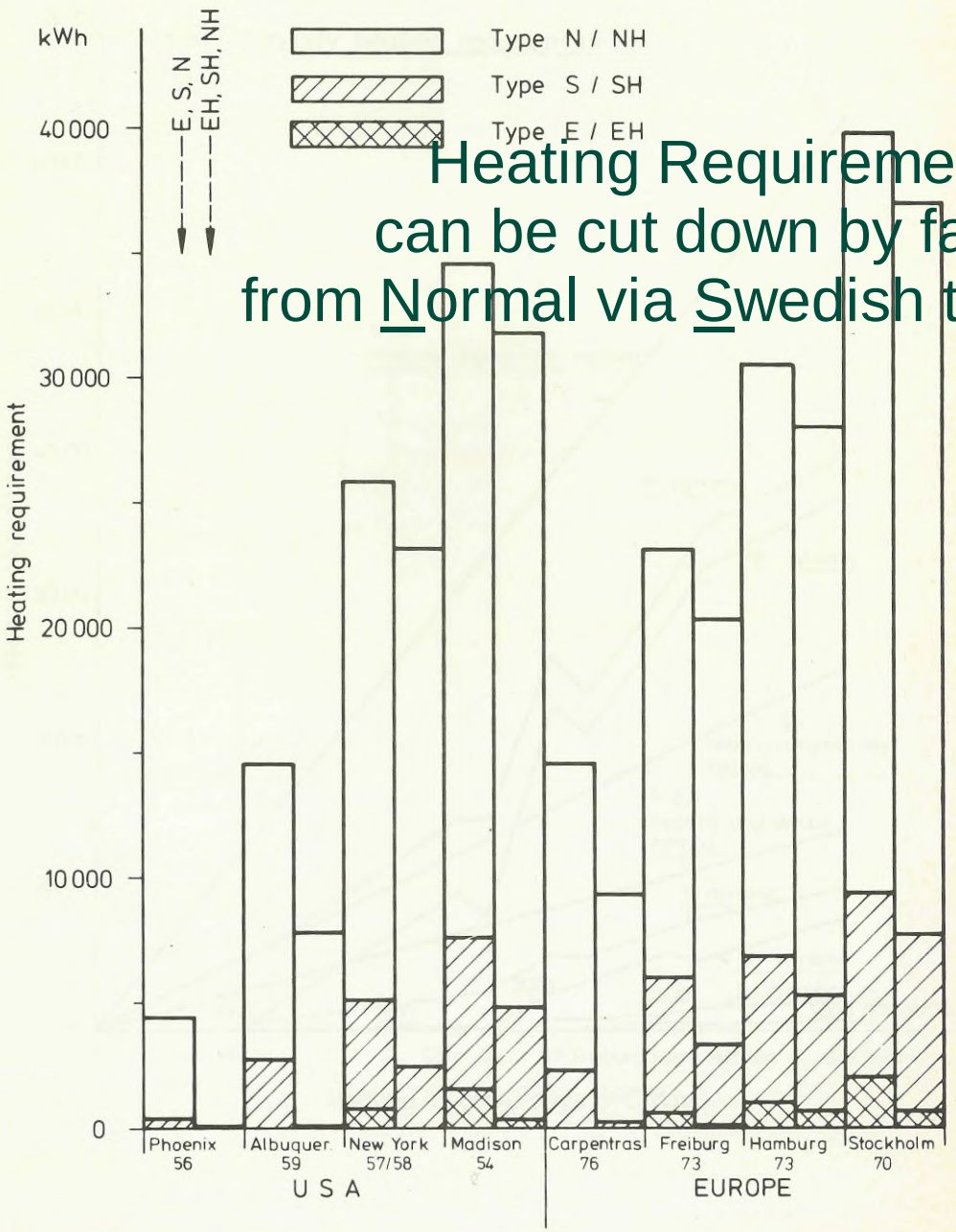
Philips Experimental House -
First (Ultra-)Low-Energy House in Germany, Aachen 1974 ff

- Super insulation: U-Value 0.14 W/m^2K (R~40)
- Efficient Window Systems: (coated double) + shutters
- Controlled ventilation, 90% air-to-air-heat recovery plus soil heat exchanger
- Heating demand 20 - 30 $kWh/(m^2a)$ (~700 – 1100 $btu/(a*ft^2)$)
- Renewable Energies
- Theory-Experiment Comparisons
- Parameter Studies US & Europe

…

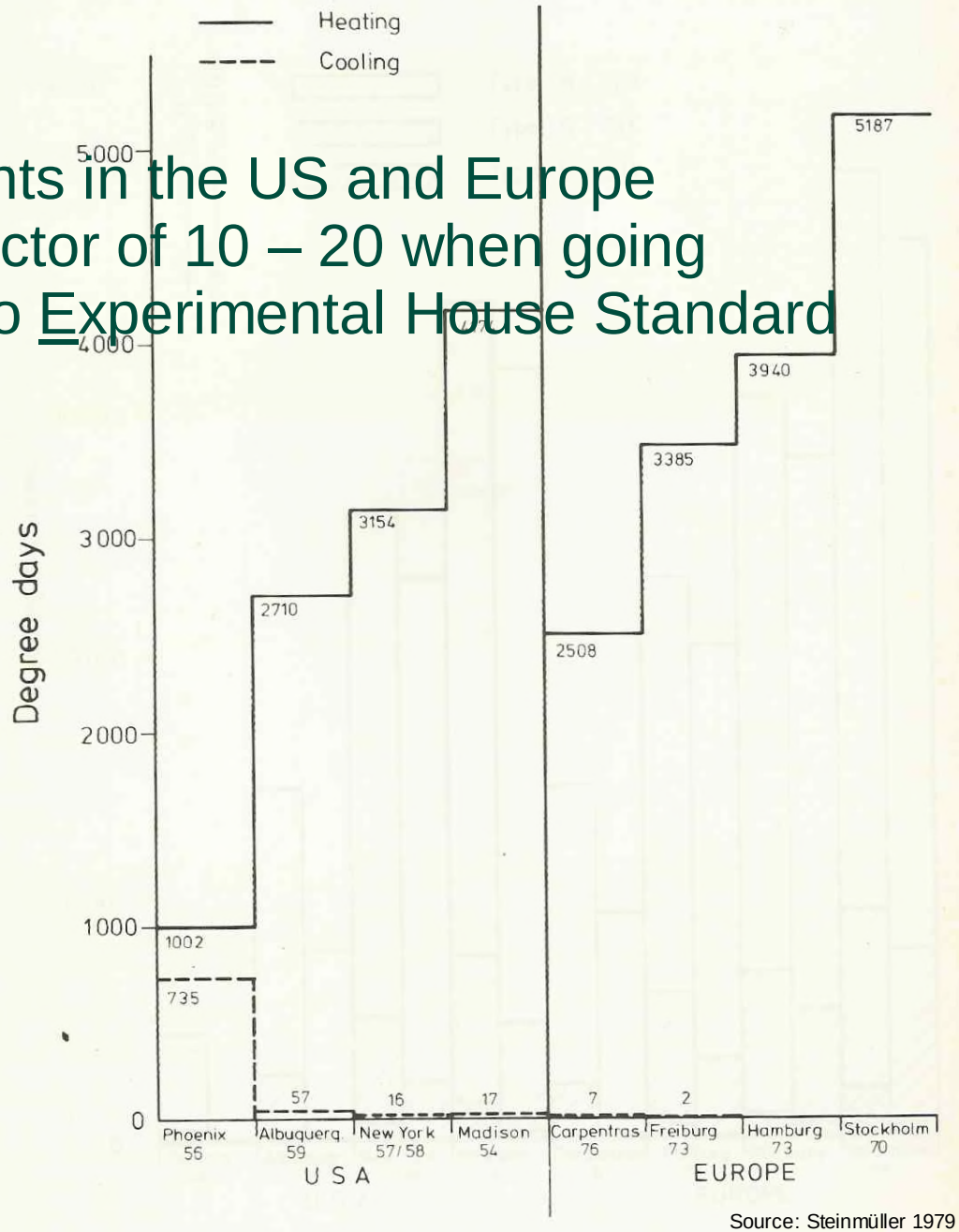
Source: Hörster, Steinmüller (PFA)

Fig. 6 a Yearly heating requirement



Heating Requirements in the US and Europe
can be cut down by factor of 10 – 20 when going
from Normal via Swedish to Experimental House Standard

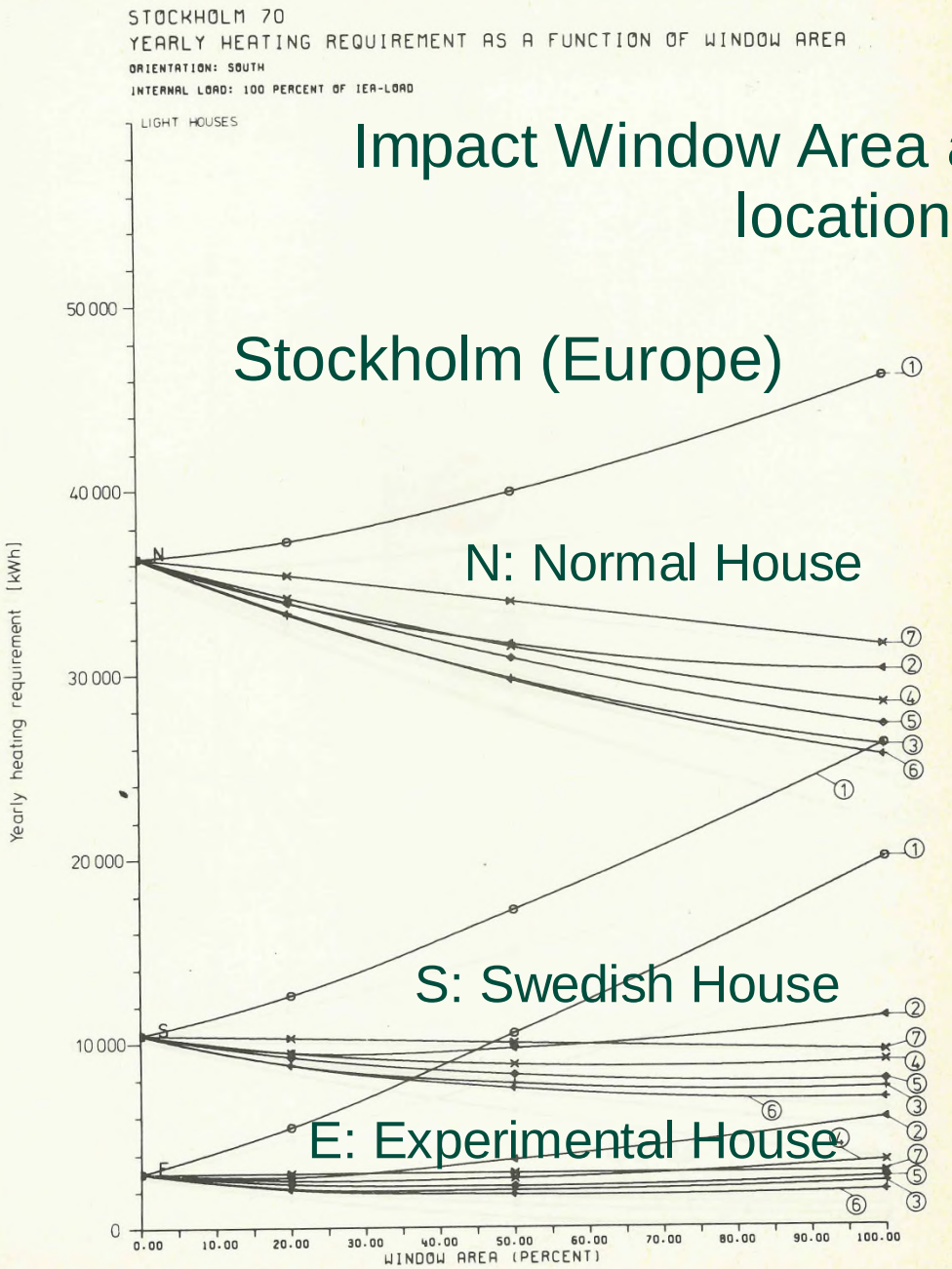
Fig. 5 Heating and cooling degree days



Source: Steinmüller 1979

Impact Window Area and Type (Passive Solar) location dependent

Fig. 15



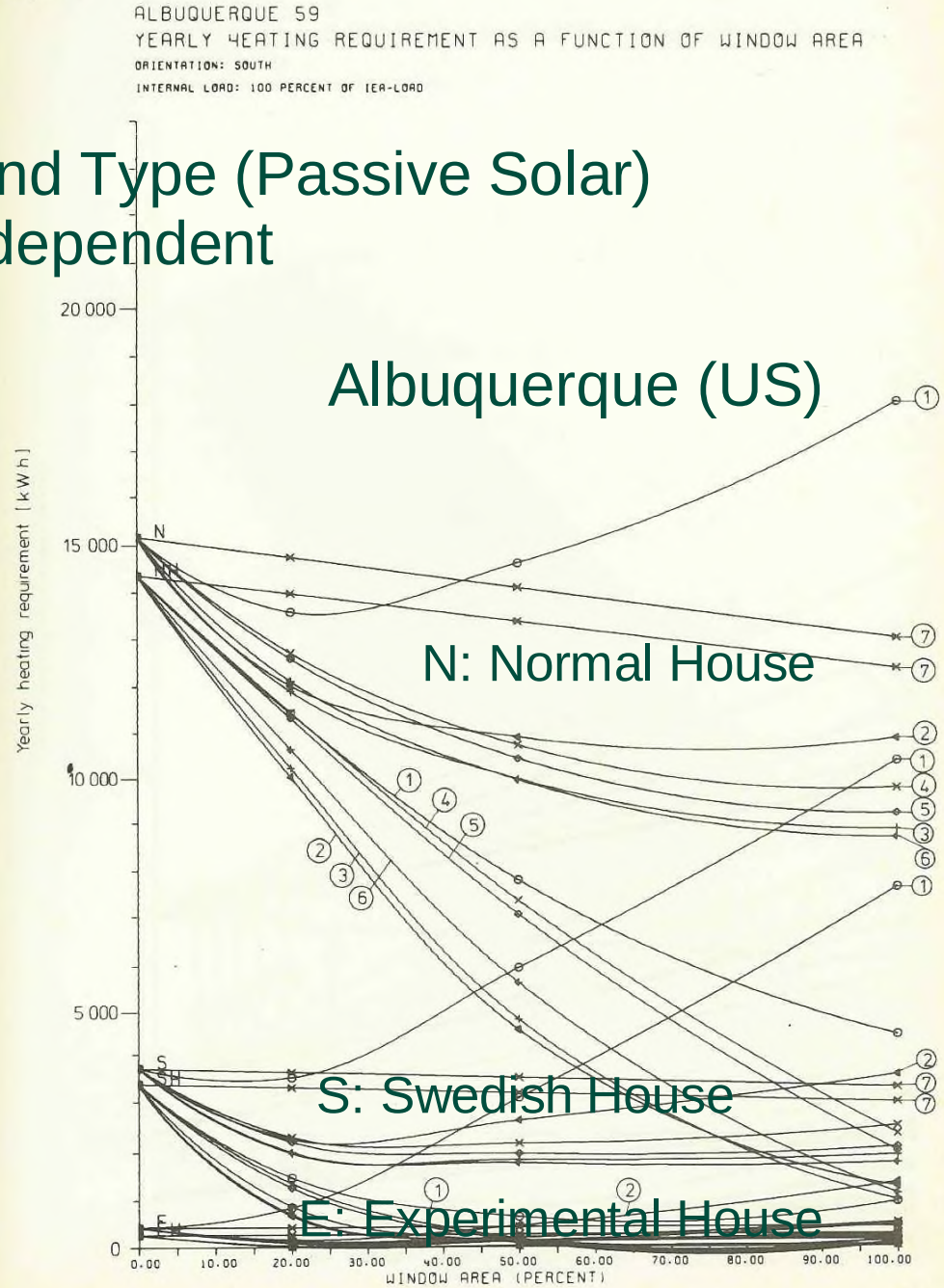
Stockholm (Europe)

N: Normal House

S: Swedish House

E: Experimental House

Fig. 26



Albuquerque (US)

N: Normal House

S: Swedish House

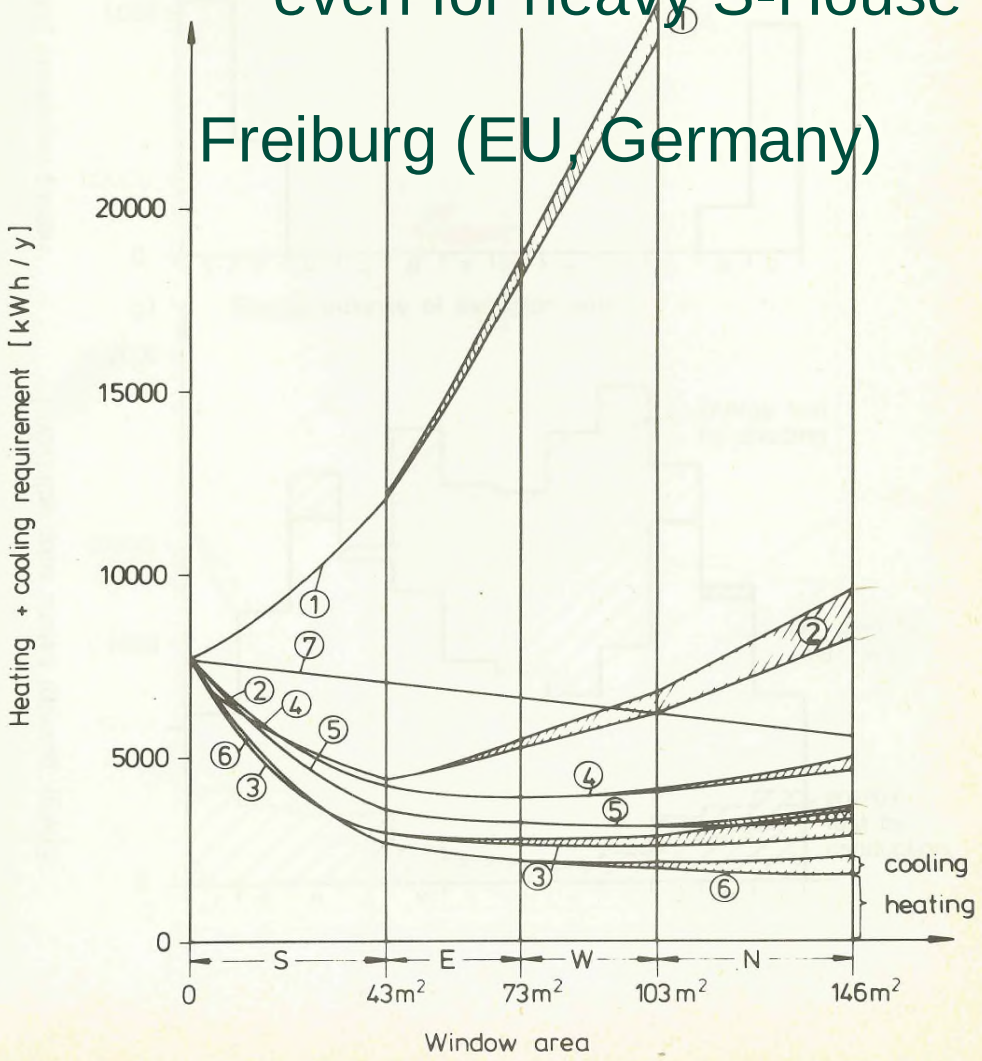
E: Experimental House

Source: Steinmüller 1979

Extensive Windowing adds Cooling Demand even for heavy S-House with reduced internal load in

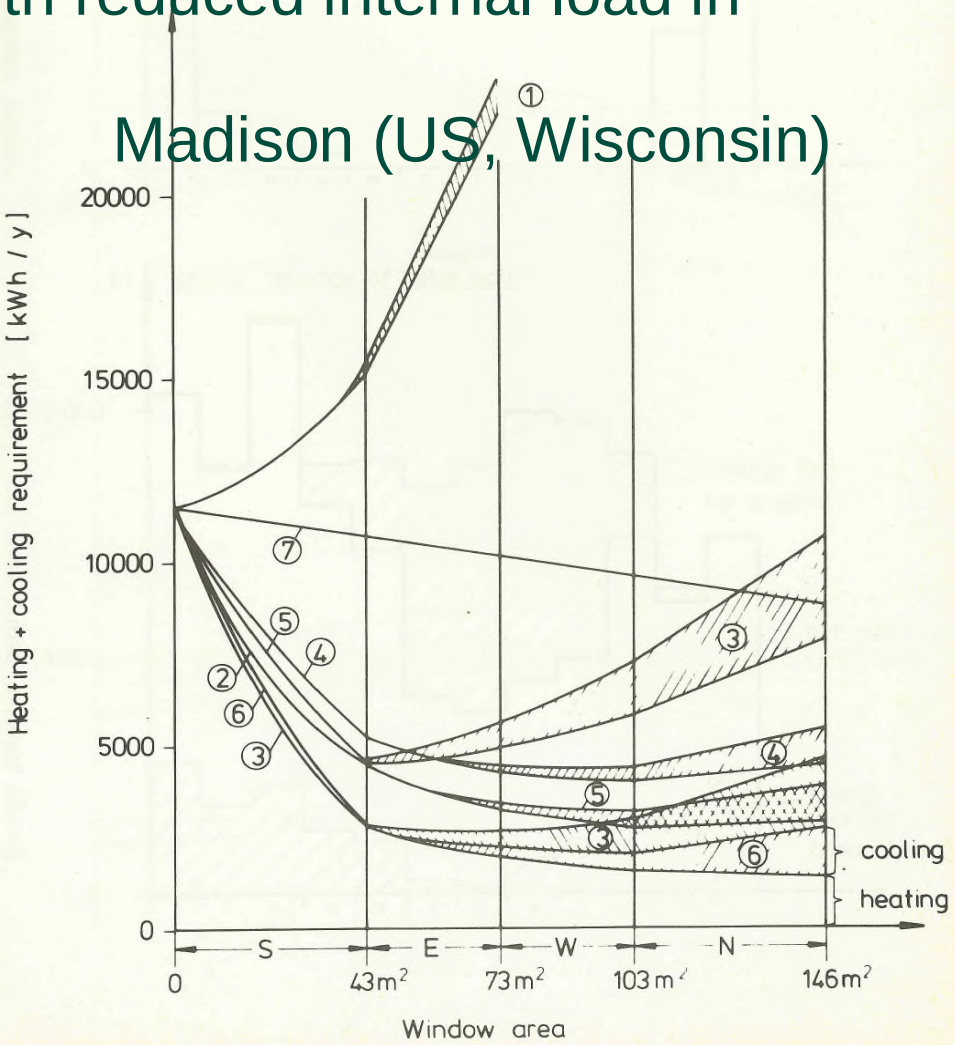
Freiburg (EU, Germany)

Fig. 20 Yearly heating and cooling requirement as a function of window area and orientation for successive replacement of walls by windows in a SH-house in Freiburg 73 (50% IEA-load)
For definition of window types ① - ⑦ see table 1



Madison (US, Wisconsin)

Fig. 22 Yearly heating and cooling requirement as a function of window area and orientation for successive replacement of walls by windows in a SH-house in Madison (50% IEA-load)
For definition of window types ①-⑦ see table 1



Source: Steinmüller 1979

Evaluation of experiences and consistent application of principles resulted in "Passive House" Concept

Passive Houses – Formal Definition

Central Requirement:

- Maximum Heating Load at Climate Extreme <= 10 W/m² (~ 1 W/ft²)
  - allows omission of traditional heating system

Secondary Requirements:

- Maximum Annual Heating Demand <= 15 kWh/m²a (4755 Btu/ft²a)
  - for south oriented buildings in Central Europe

- Overall Primary Energy Consumption <= 120 kWh/m²a (38039 Btu/ft²a)
  - Including household appliances
  - To be lowered in the future

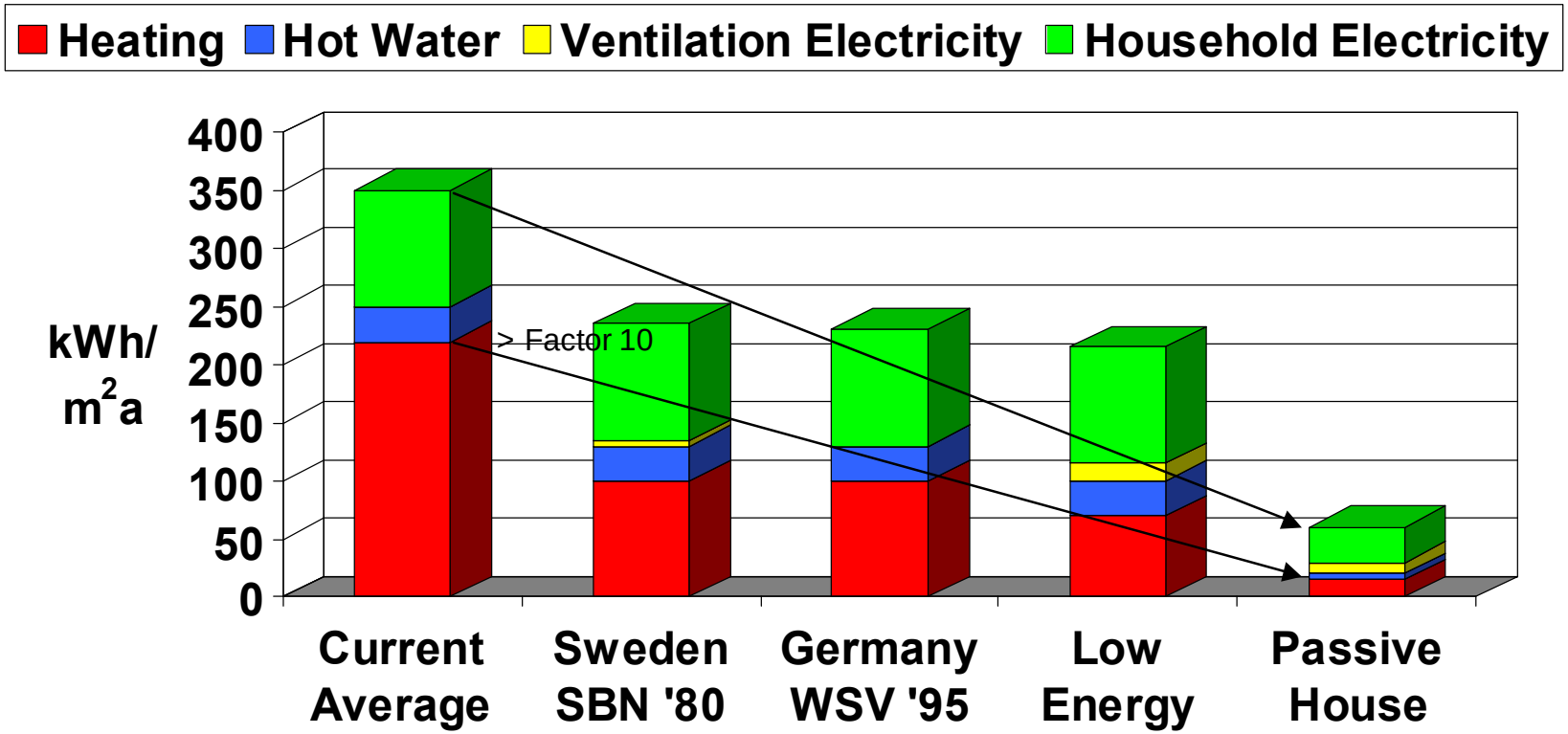
Source: PHI

Passive House – Principles

- Highly Efficient Building Envelope
  - Highly insulated components: U-factors < 0.15 W/(m²K) (0.026 Btu/h/ft²/°F), Avoidance of thermal bridges
  - Energy-efficient windows: U-factors < 0.80 W/(m²K) (0.14 Btu/h/ft²/°F), solar heat-gain coefficients ~ 50%, southern orientation (if possible) and shade provisions
  - Air-tightness: infiltration rate < 0.6 per hour in pressure test at 50 Pa
  - Compact form
- Highly Efficient Air and Heat Supply
  - No separate traditional heating system necessary
  - Energy-efficient ventilation: Highly efficient heat recovery from exhaust air > 80%
  - Hot water supply using regenerative energy sources
- Energy-saving household appliances

Source: PHI

Passive House – Primary Energy Ratings in Comparison with Current Average and Other Standards



Source: PHI

Darmstadt-Kranichstein
First Passive House in Europe/Germany 1991

- Super insulated House in a Row
  - Insulation: 10 - 18 inches, U-Value 0.1 bis 0.14 W/(m²K) → R40 to R50
  - Optimized triple panes windows with insulated frames, south oriented
  - Ventilation with heat recovery
- Rest Energy Demand
  - Heating: 12 kWh/(m²a)
  - Hot water: 8 kWh/(m²a)
  - Household appliances: 11 kWh/(m²a)
- Covered by
  - Vacuum collectors
  - Gas condensing furnace

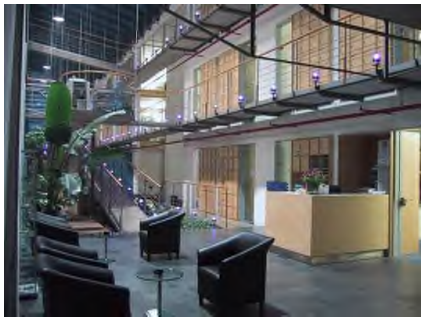
Source: Feist (IWU, PHI)

Wiesbaden-Lummerlund
First Passive House & Low Energy-Settlement in Europe 1997

- 46 Houses in a Row,
  - 50% Passive
  - 50% Low Energy
  - Building cost: 90 - 100 €/ft²
- Scientific Evaluation
  - Inhabitants highly satisfied
  - Passive Houses preferred to low energy ones
- ➢ Passive Houses enable sustainable life-style
  - Energy reduction factor 10
  - Economically attractive
  - Comfortable, healthy indoor climate
  - No sacrifices, but new degrees of freedom

Source: IWU, Rasch





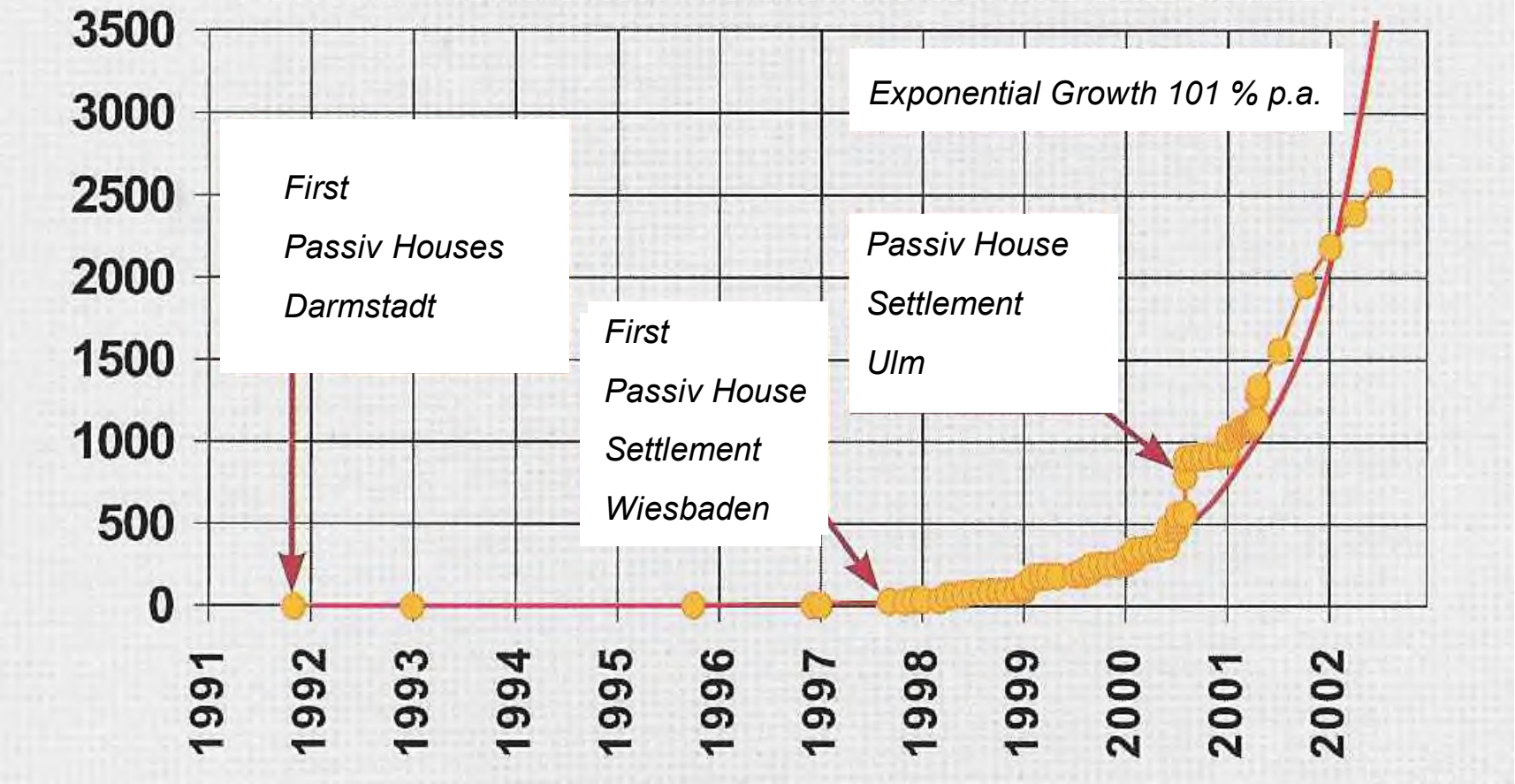






Source: BKI, BSMC, SurTec

Exponential Growth of Passive Houses in Germany



Source: PHI

Old Buildings

Old Buildings

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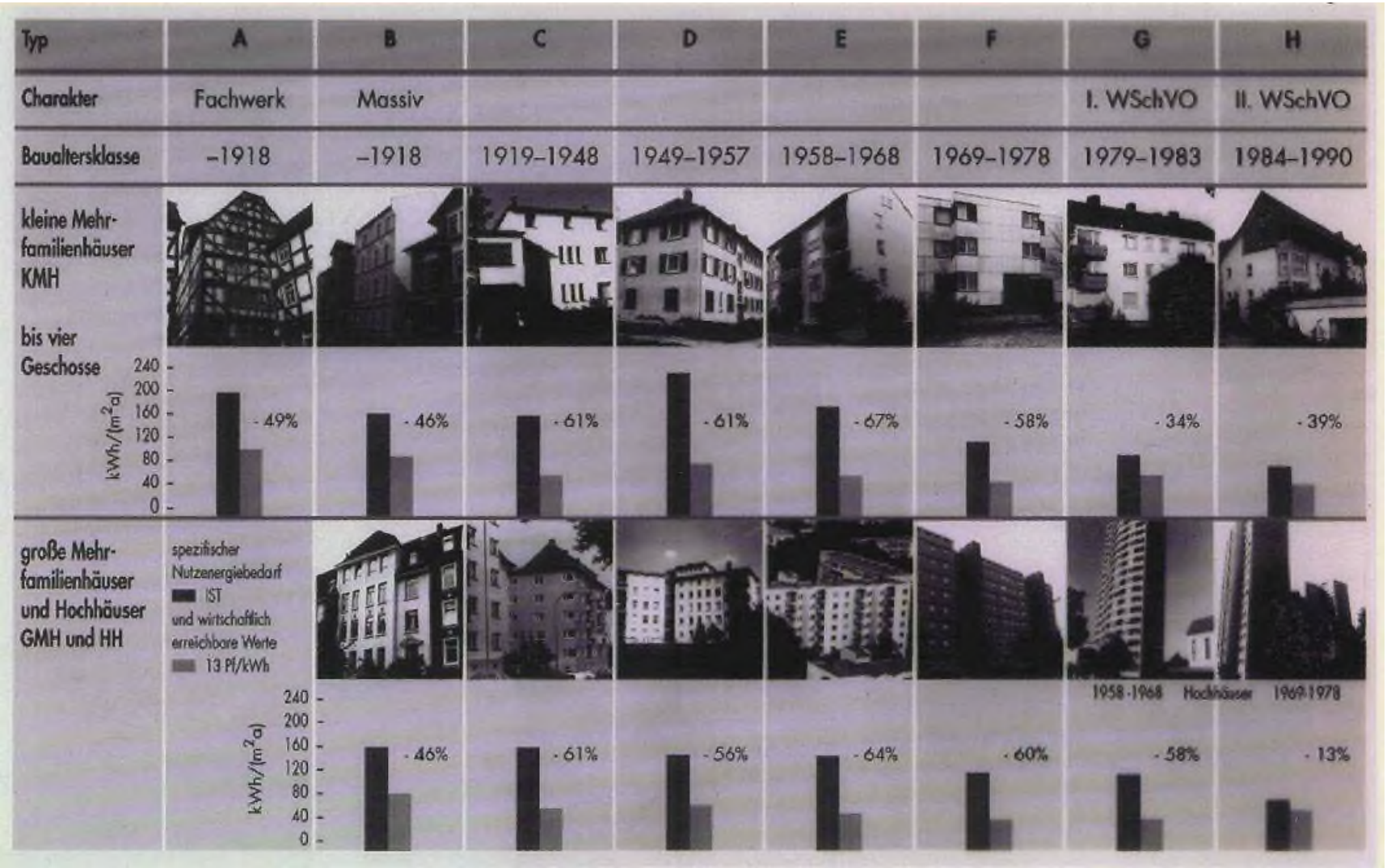

Source: IWU

Heat Saving Potential in Old and New German Dwellings

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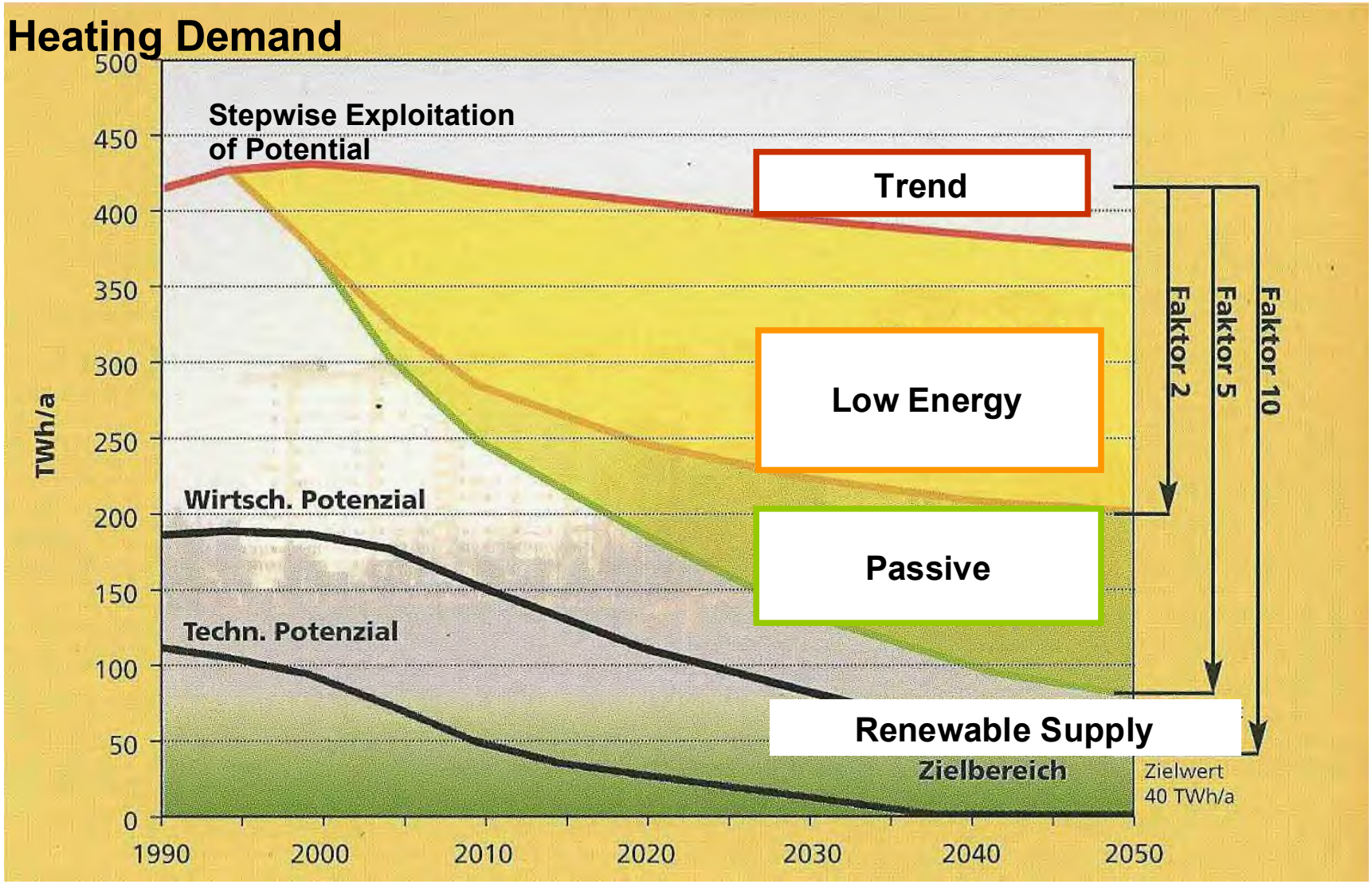


Source: IWU/BSMC

Energy Efficient Buildings - Status and Goals Germany 2006

- Status
  - New Buildings: Low energy standard prescribed
  - Old buildings:
    - 140% Low energy standard … prescribed in case of major modernization
    - Additional standards … for replacement of individual components
  - ➢ Problem:
    - ➢ Low energy standard insufficient in new as well as in old buildings
    - ➢ Modernization rates ~ 1% p.a. and modernization efficiency < 33 % by far too low

- Government Goals
  - Old buildings: Modernization rate → 4% p.a., improvement of modernization standards
  - New buildings: improved standards …to be specified
  - $CO_{2:}$ Stabilization of direct emissions from building sector at 120 Mio tons p.a. plus overall goals short term (Kyoto), long-term (-80% until 2050)

Current Political Cornerstones & Measures

- Financial Instruments
  - Federal Housing Program upsized by a factor of 4(!): special loans, subsidies, tax reductions 1.5 Bill. €/a (20p.a.p.c.)
  - Ecological Tax: up to 2 Cent/kWh (4 ... 23%) → 18 Bill. €/a (220 €/a p.c.)
- DENA Information and Innovation Campaigns
  - DENA German Energy Agency founded in 2000
  - DENA Energy Labeling, Energy Passport (inline with EU-directive)
  - DENA Advanced Retrofit Program
- Publicly funded Research < 100 Mill €/a
- Private Initiatives & Public Private Partnerships
- State & Regional Programs and Activities (Funding, Training, Research Institutes)

Progress in Modernization of Old Buildings

Regional Forerunners Identified in Competitions






Source: BSMC, IWU

Systematic National Advances via DENA-Programs

Participants Phase I

- Means
  - Demanding targets exceeding new buildings
    - Quality of building envelope
    - Primary energy consumption
    - Sustainability measures
  - Upgraded government funds
    - Higher loans
    - 15 – 20 % debt relief
- Phases
  1. 33 Buildings (2003 - 2005) multi-family
  2. > 110 Buildings (2005 - 2007) incl. single-fam.
  3. > 1000 Buildings ... under planning

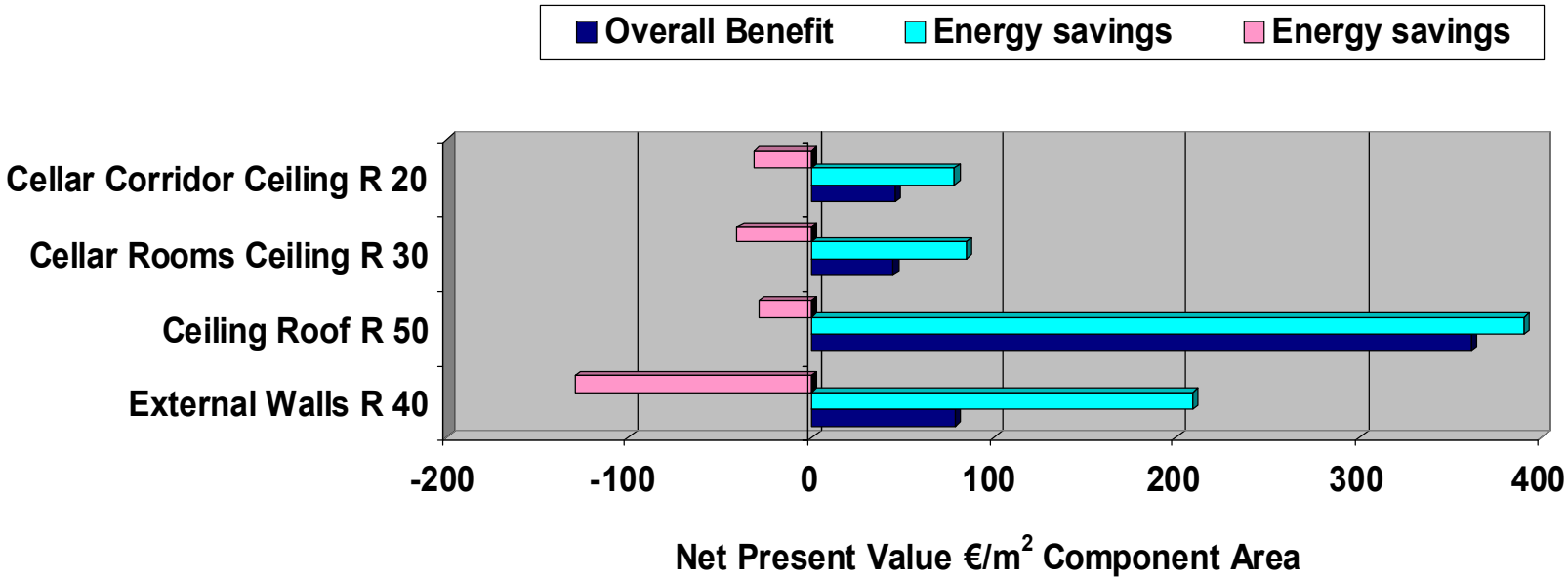
Source: DENA

Example:
Advanced Retrofit of 8-Family House in Bielefeld

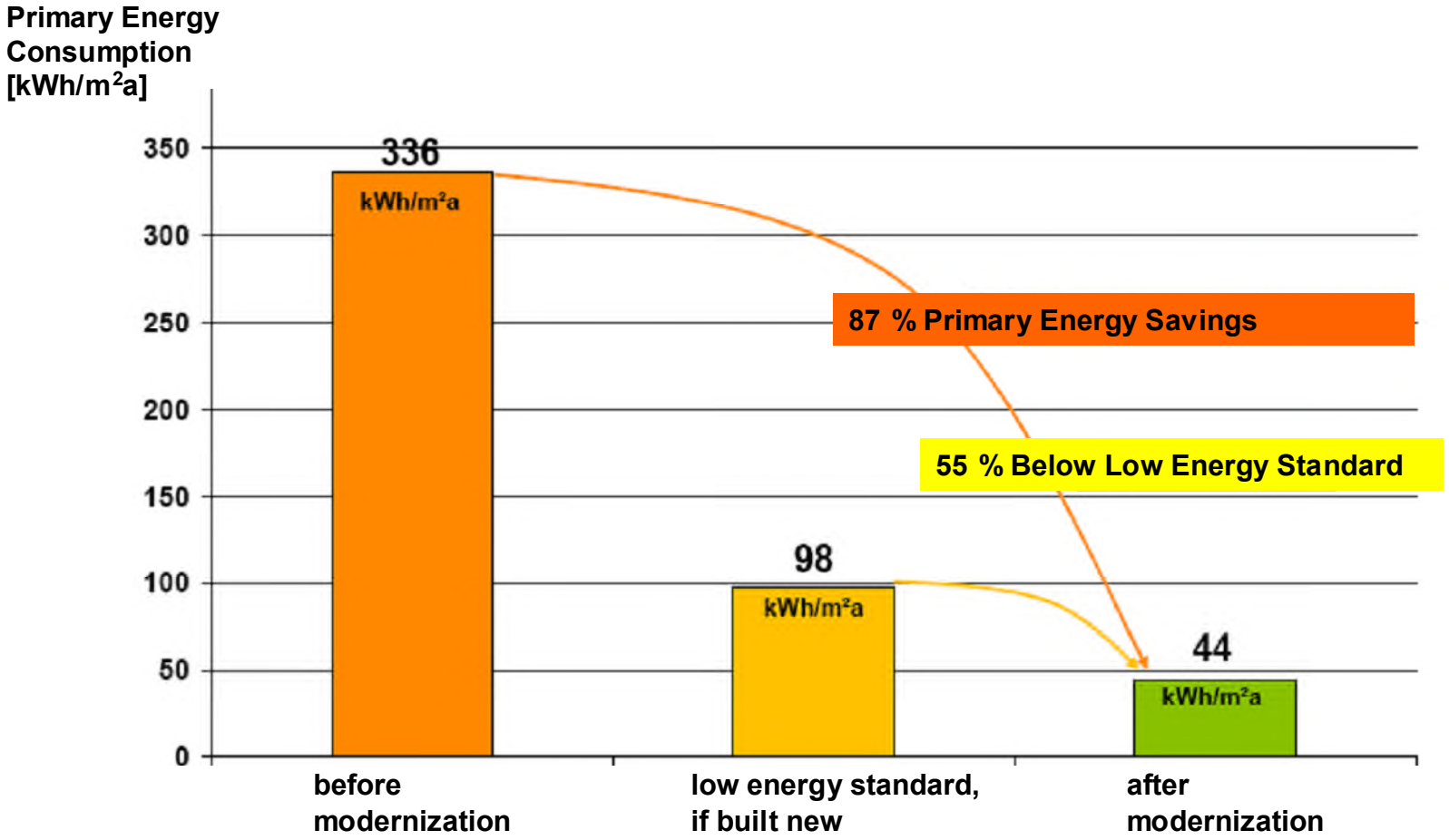
- Sustainability Approach
  - Life-Cycle Optimization Energy and Economy
  - Long-term Usability, adaptability
- Passive House Technologies
  - Roof 15, Wall 8, Cellar 4 inches additional high performance insulation
  - Reduction of Thermal Bridges
  - Passive House Windows
  - Ventilation 90% heat recovery
  - Solar assisted hot water
- Factor 10 savings
  - In Energy & CO_2-Emissions
  - Economically “multipliable” and even optimum for most measures

Source: BSMC

Example Insulation:
Overall Benefits ranging from 45 to 360 €/m²



Results Phase I: On the Average 87% Savings for all Buildings



Source: Dena

… a glance and outlook at Europe

CEPHEUS Cost Effective Passive Houses as European Standard 1998 - 2001

- First European Research & Development Project, sponsored by the EU-Joule-Thermie Program
- Erection and Scientific Evaluation of about 250 passive houses/living units
- Demonstrating cost-effective passive houses in 5 European countries
- Creating preconditions for market penetration
- Presenting full primary-energy and climate neutral approach combined with use of renewable at the World EXPO 2000

Source:Energieinstitut Vorarlberg

Passive House Conference May 2006: signals spread-out in and outside Europe

- Passive House projects under way in almost each European Country
- Passive House Interest Groups coordinating and spreading the information (see map)
- Completed passive house projects confirm the applicability of the passive house concept to a broad spectrum of climate conditions and building types
- Passive House Technology is increasingly applied to „old“ buildings
- Interest from outside Europe emerging
- Passive House Projects in Asia and America under way

Source: PHI

Conclusions

- Non-renewable energy consumption has to be reduced by a
  - factor of 2 world wide
  - factor of 10 in the western world …. at least
- This can only be achieved by combining
  - Drastic energy efficiency & saving measures (factor 5 and more)
  - Promotion of renewable energies (factor 2 at least)
  - In all sectors: industry, traffic and housing
- The Housing sector is of special importance
  - Causing 40% of energy consumption in Europe and the US
  - Offering large “no-regret” saving potentials and huge quality of life with proven, promising technologies waiting for local application
- Sustainable life starts at home …


… thus join in and tell your neighbors!


Thank You!