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Future Energy Supply

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- World Energy Supply 2009
- Driving forces of Future Energy Trends
- Statements on Future Energy Supply
- General Consequences

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World Energy Demand 2009 (~11630 Mtoe)

1 Mtoe = 1 million tons oil equivalent

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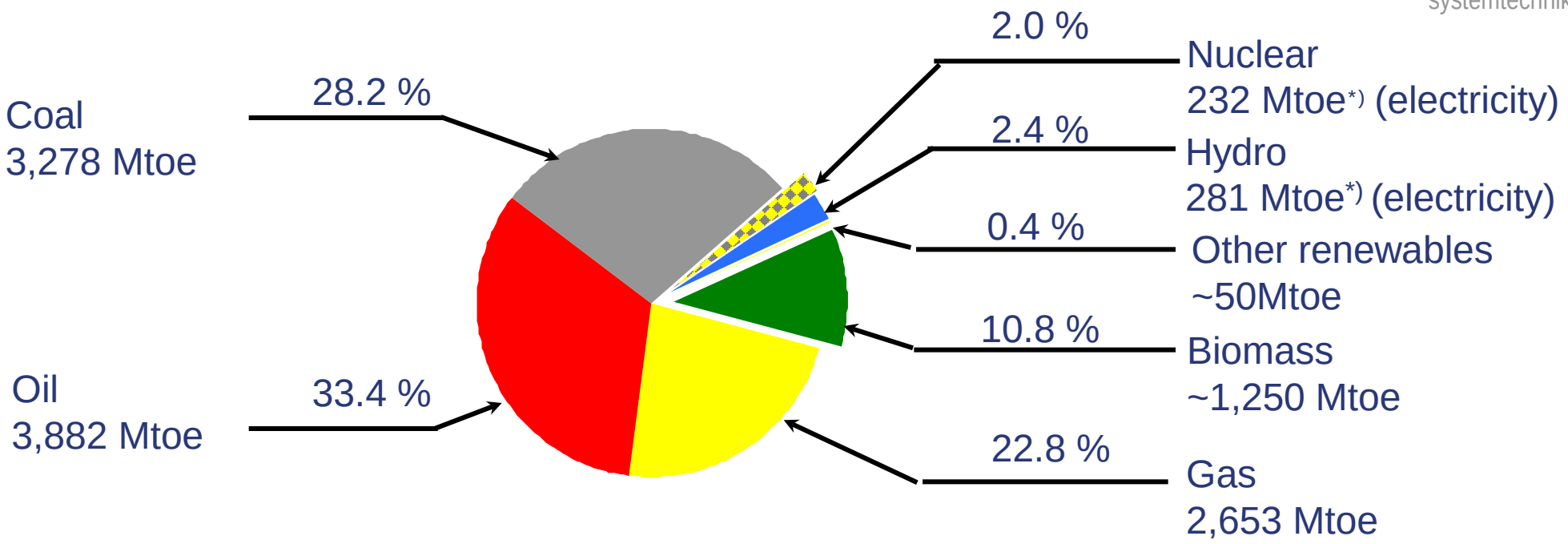

*) Conversion into primary energy gives:
- Nuclear Power 610 Mtoe,
- Hydropower is 717 Mtoe,
- other renewables ~130 Mtoe

Other renewables:

Wind Energy	~340 TWh_{el}
Solar Electricity	~ 26 TWh_{el}
Solar thermal	~ 137 TWh
Geothermal	~ 83 TWh_{el}

Source: BP Statistical Review of World Energy 2010
Renewables: LBST estimate based on WEO 2010, GWEC 2011, EPIA 2011, ESTIC 2011

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- World Energy Supply 2009
- Driving Forces
  - limited sinks (climate change)
  - limited sources (Resources)
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- Five Statements on Future Energy Supply
- General Consequences

Unresolved antagonism of World Energy Supply/Demand-Patterns

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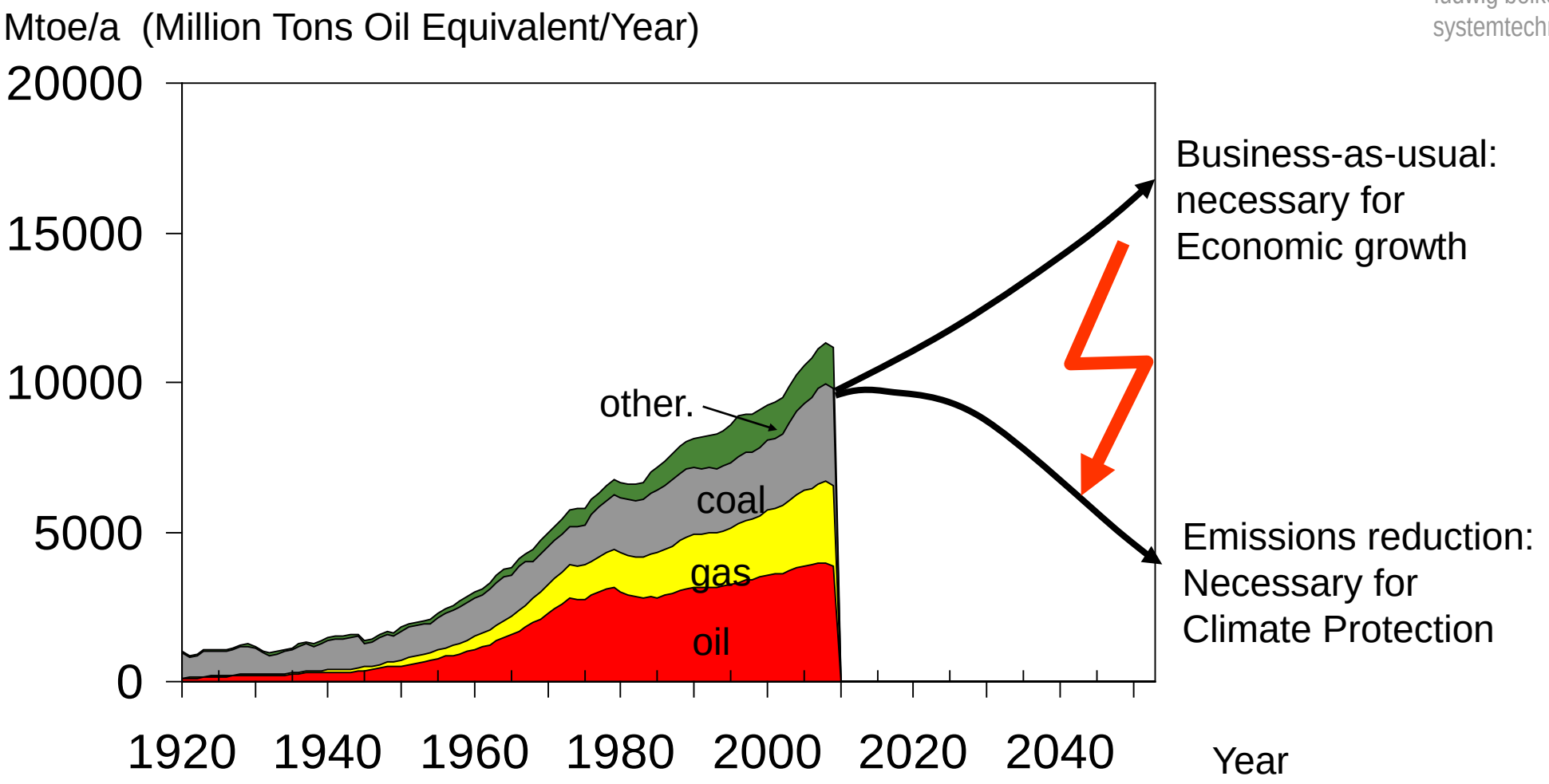

Source: BP Statistical Review of World Energy

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Warning Statements of Industrial CEOs on imminant oil crises

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- We are now facing a global energy crisis. I know you´ve heard this before, but this time it´s for real.

  Hiroyuki Yoshino, CEO Honda December 1998

- My forecast is that between 2000 and 2005 the world will be reaching peak production from our known fields, and after that, output will decline.

  Franco Bernabe, Ex-ECO ENI 1999

- We should leave the oil before the oil leaves us

  Fatih Birol, Chief Economist, International Energy Agency 2008

Wordl Oil Supply – International Energy Agency (WEO)

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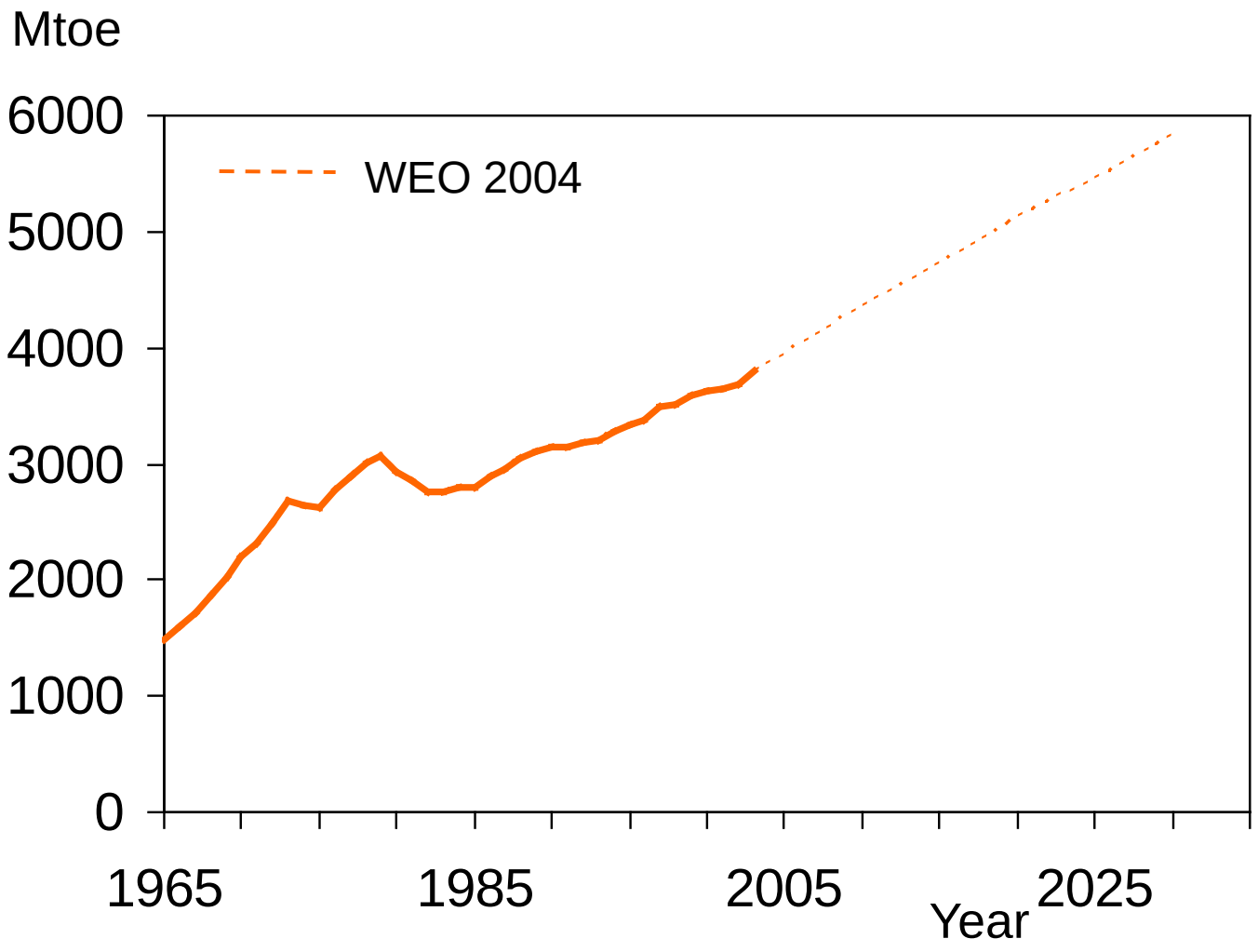

Governments should
Be concerned about
Reserves-data problems

Source: Historical data - BP Statistical Review of World Energy
Outlook - International Energy Agency 2009

Wordl Oil Supply – International Energy Agency (WEO)

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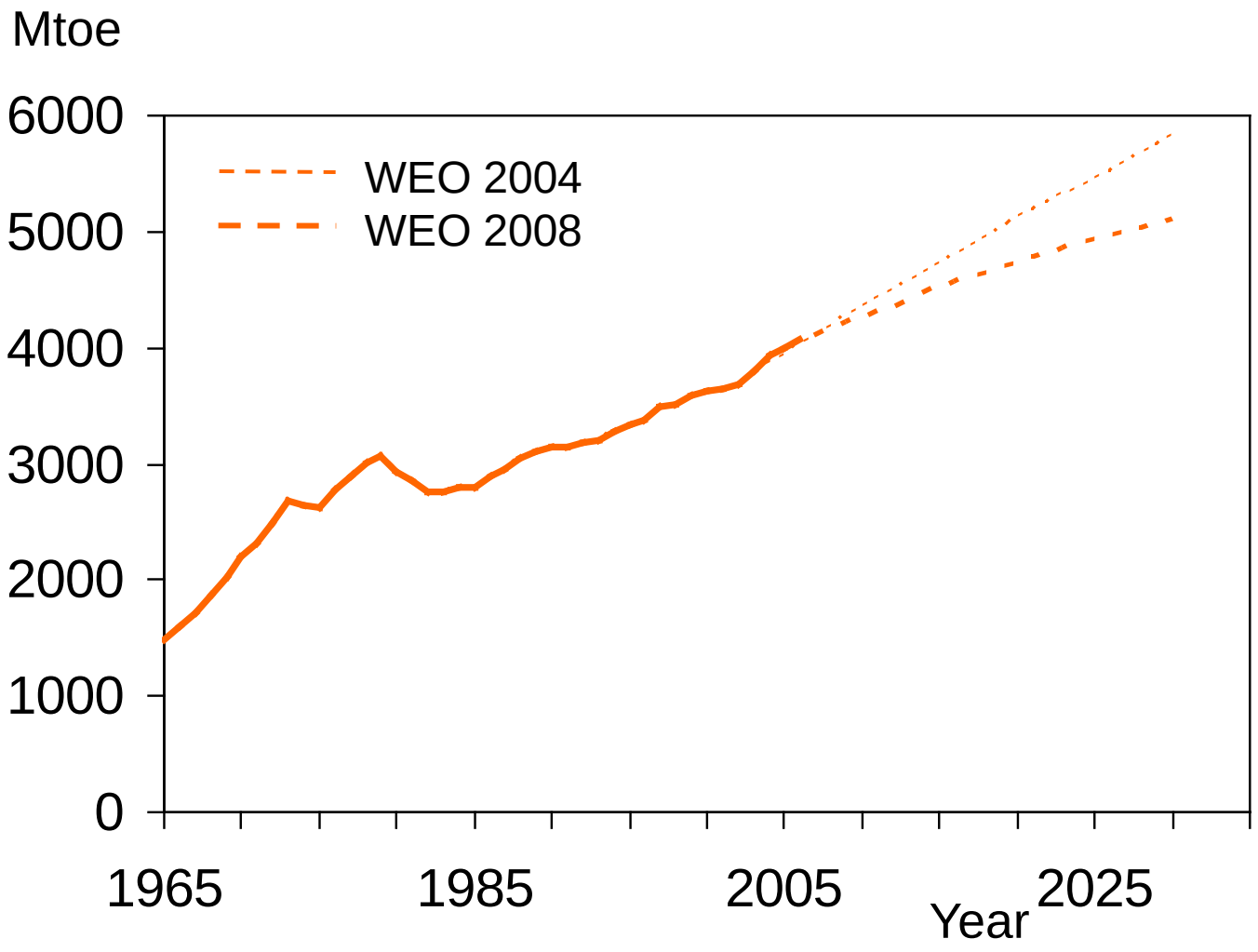

Governments should
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The sources of oil to meet
Rising demand….are
Extremely uncertain,
Perhaps more than ever

Source: Historical data - BP Statistical Review of World Energy
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Wordl Oil Supply – International Energy Agency (WEO)

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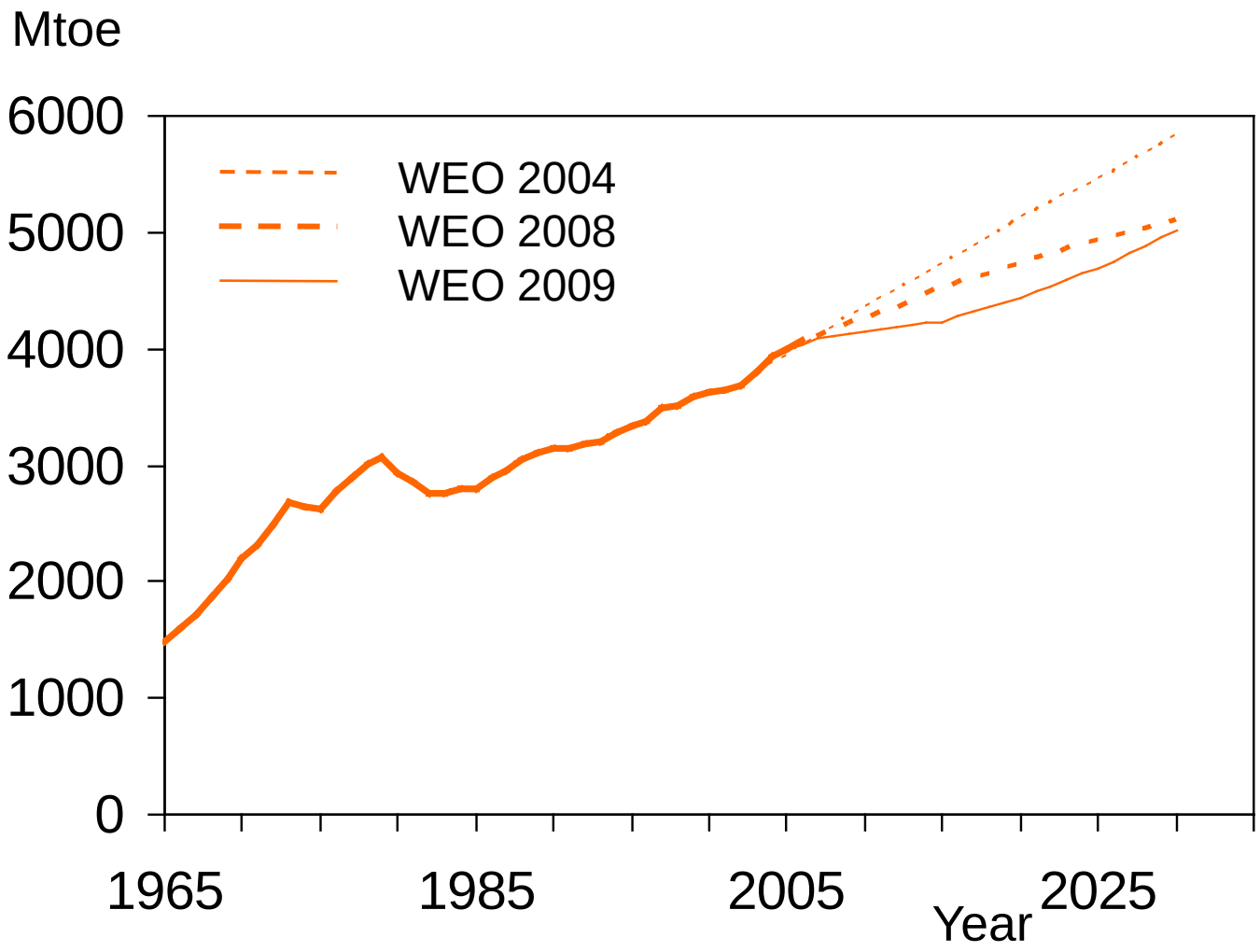

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The sources of oil to meet
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The financial crisis has cast
A shadow over whether
All the energy investment
Needed to meet growing
Energy needs can be
mobilised

Source: Historical data - BP Statistical Review of World Energy
Outlook - International Energy Agency 2009

Wordl Oil Supply – International Energy Agency (WEO)

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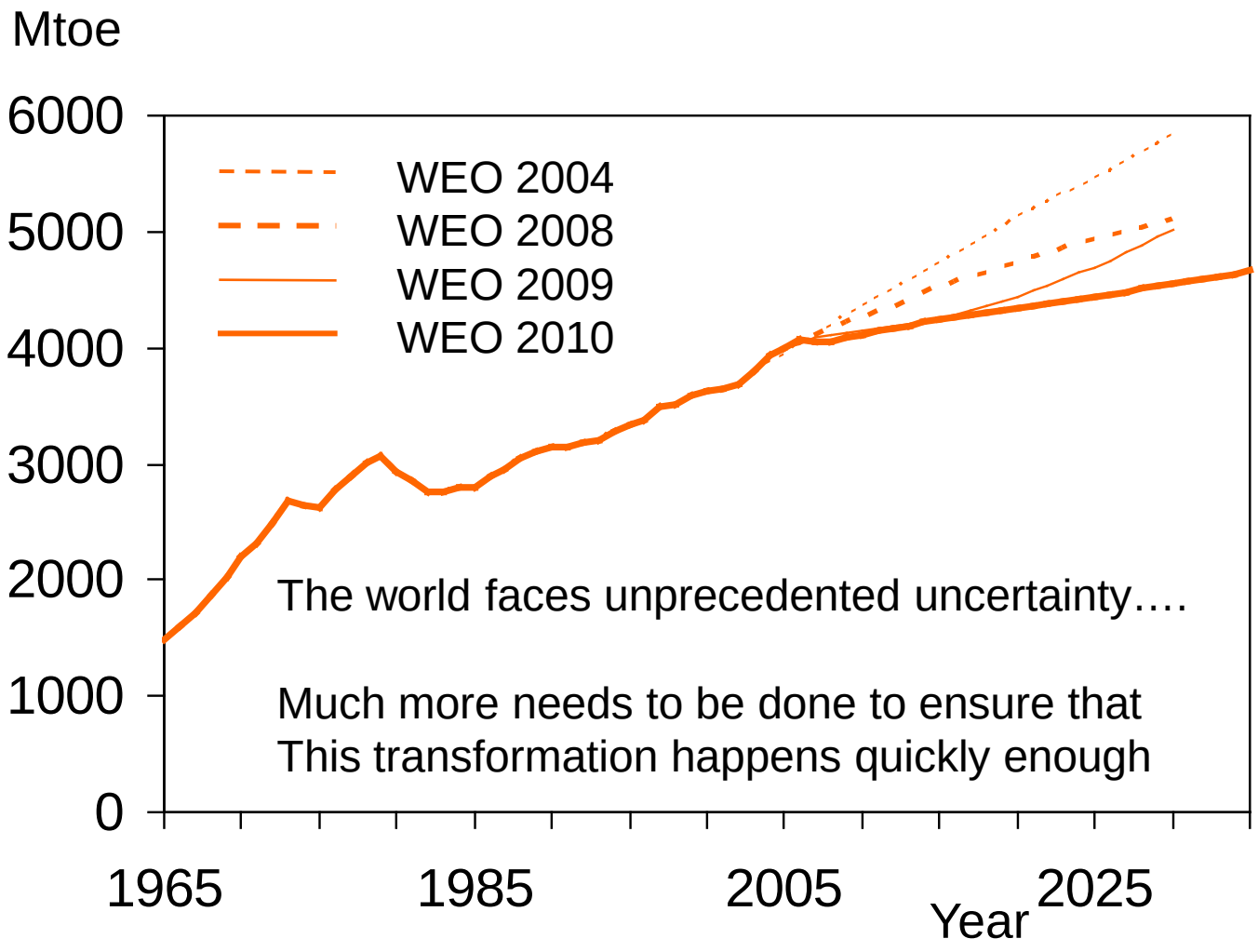

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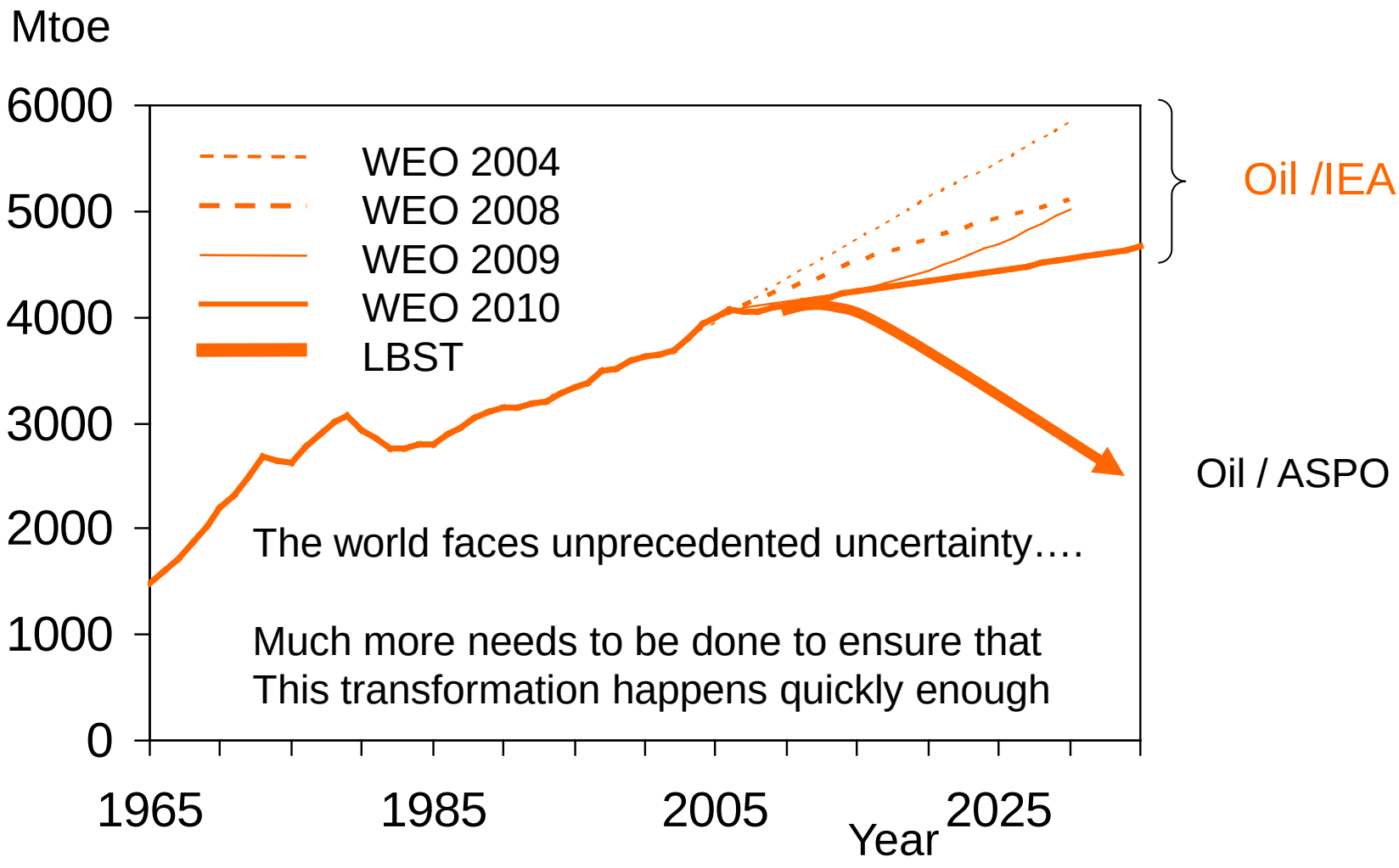

Source: Historical data - BP Statistical Review of World Energy
Outlook - International Energy Agency 2009

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- The challenge of „Peak Oil“

The World‘s Oil Supply 1930 – 2050

C.J. Campbell, J. Laherrere, Petroconsultants 1995

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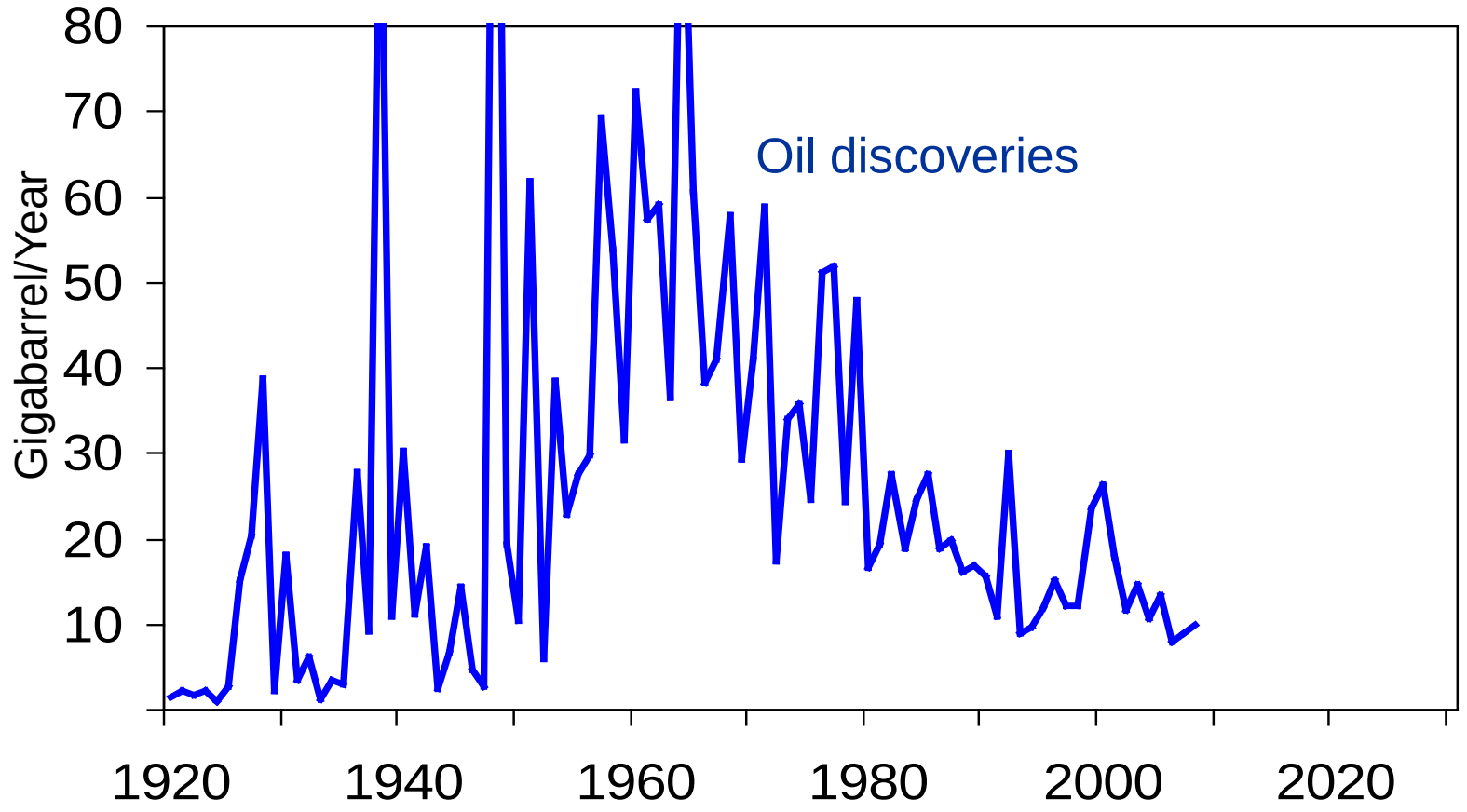
- Discoveries are fundamental, not „proved“ reserves („backdating of reserves“)



The World‘s Oil Supply 1930 – 2050

C.J. Campbell, J. Laherrere, Petroconsultants 1995

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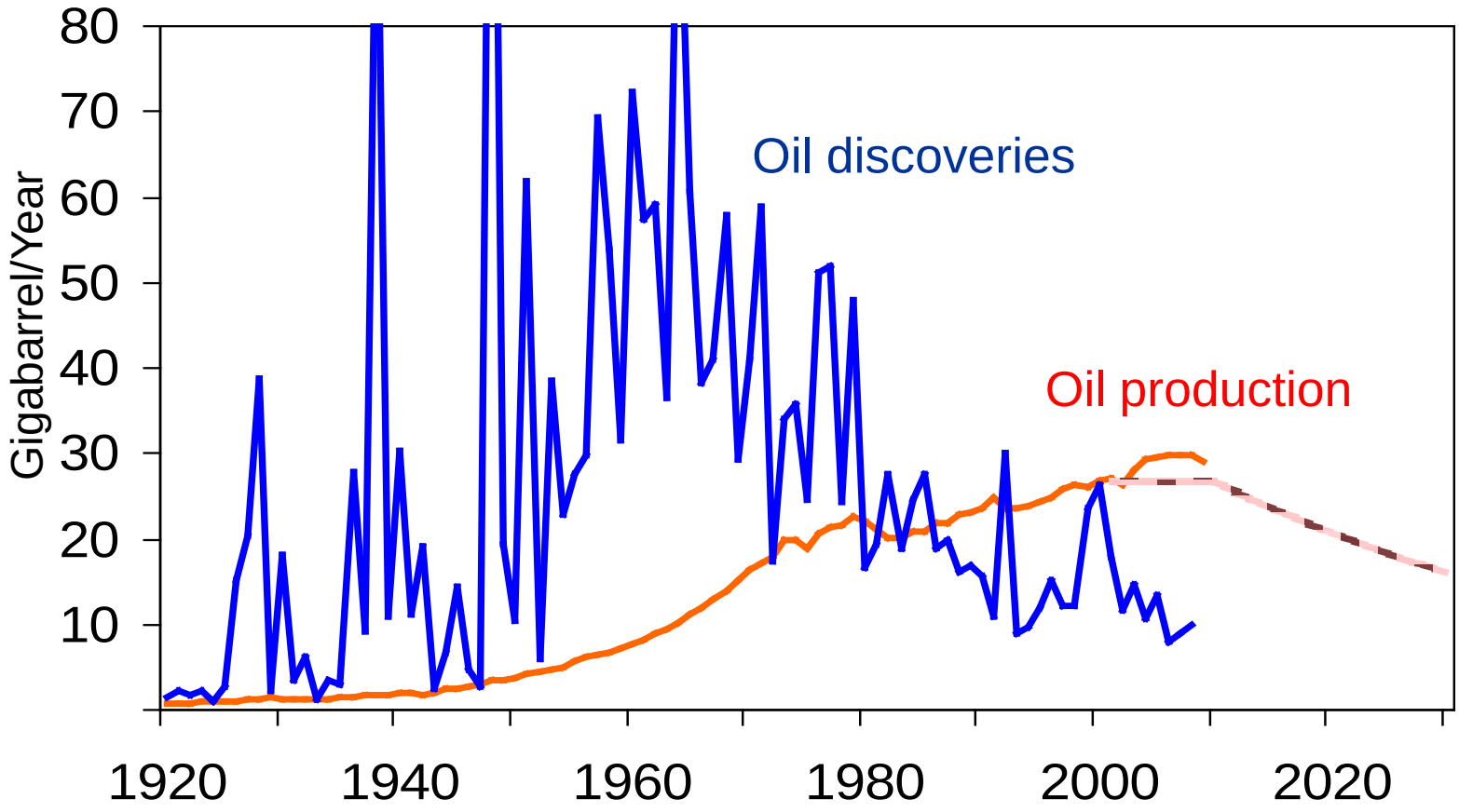
- The production profile has to follow the discoveries



Campbell 1995

The World‘s Oil Supply 1930 – 2050

C.J. Campbell, J. Laherrere, Petroconsultants 1995

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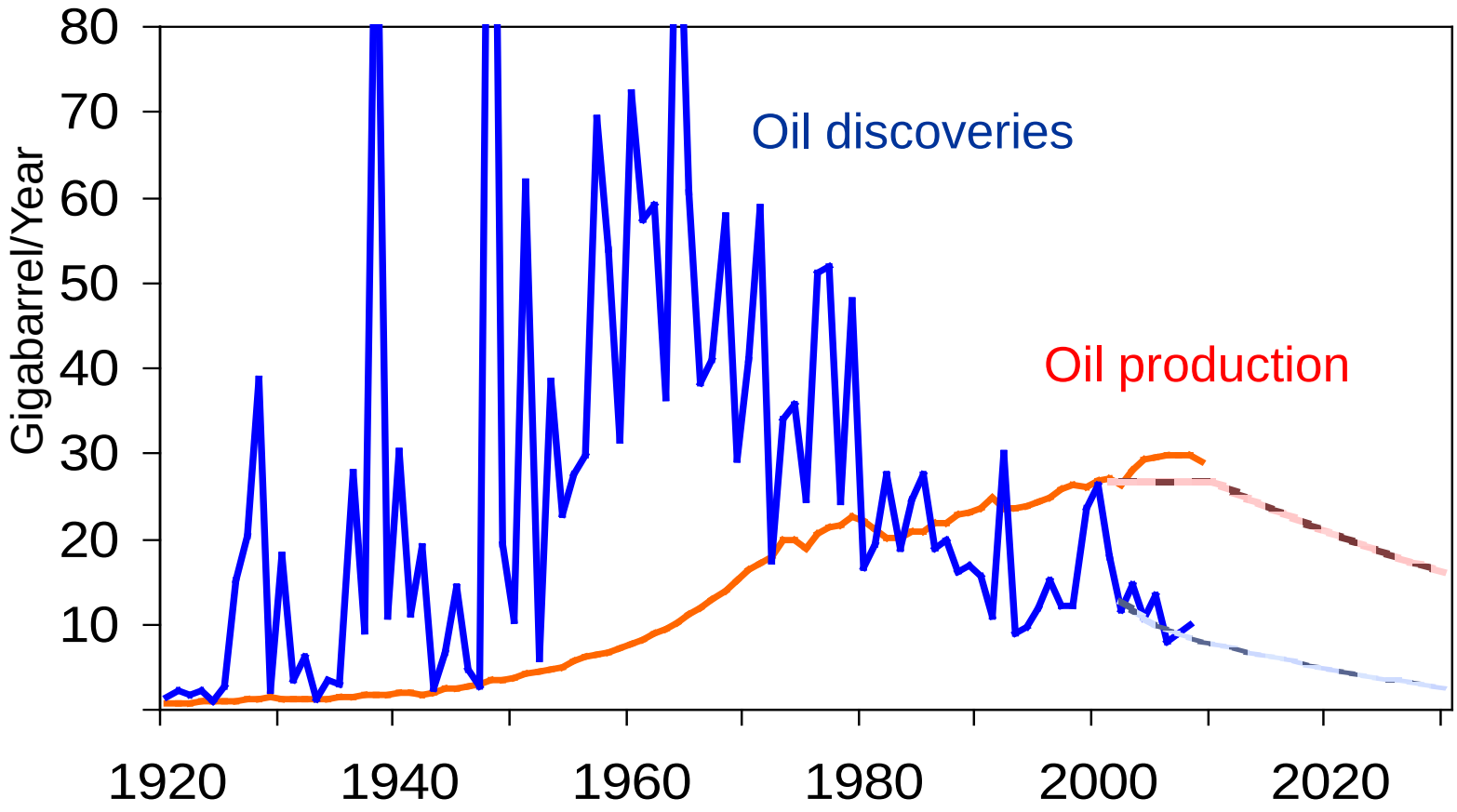
- The history of discoveries allows to extrapolate probable future discoveries



Campbell 1995

Why do „proven reserves“ grow over time?

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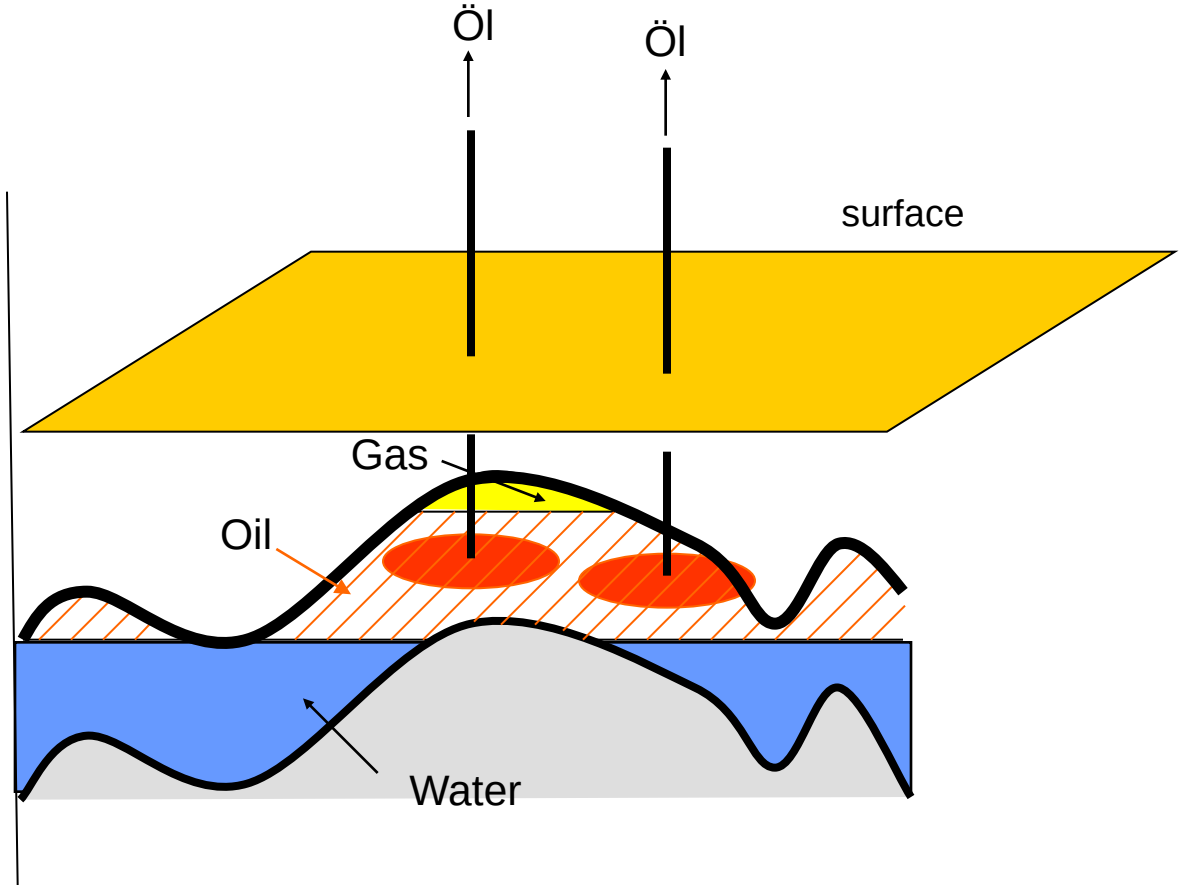
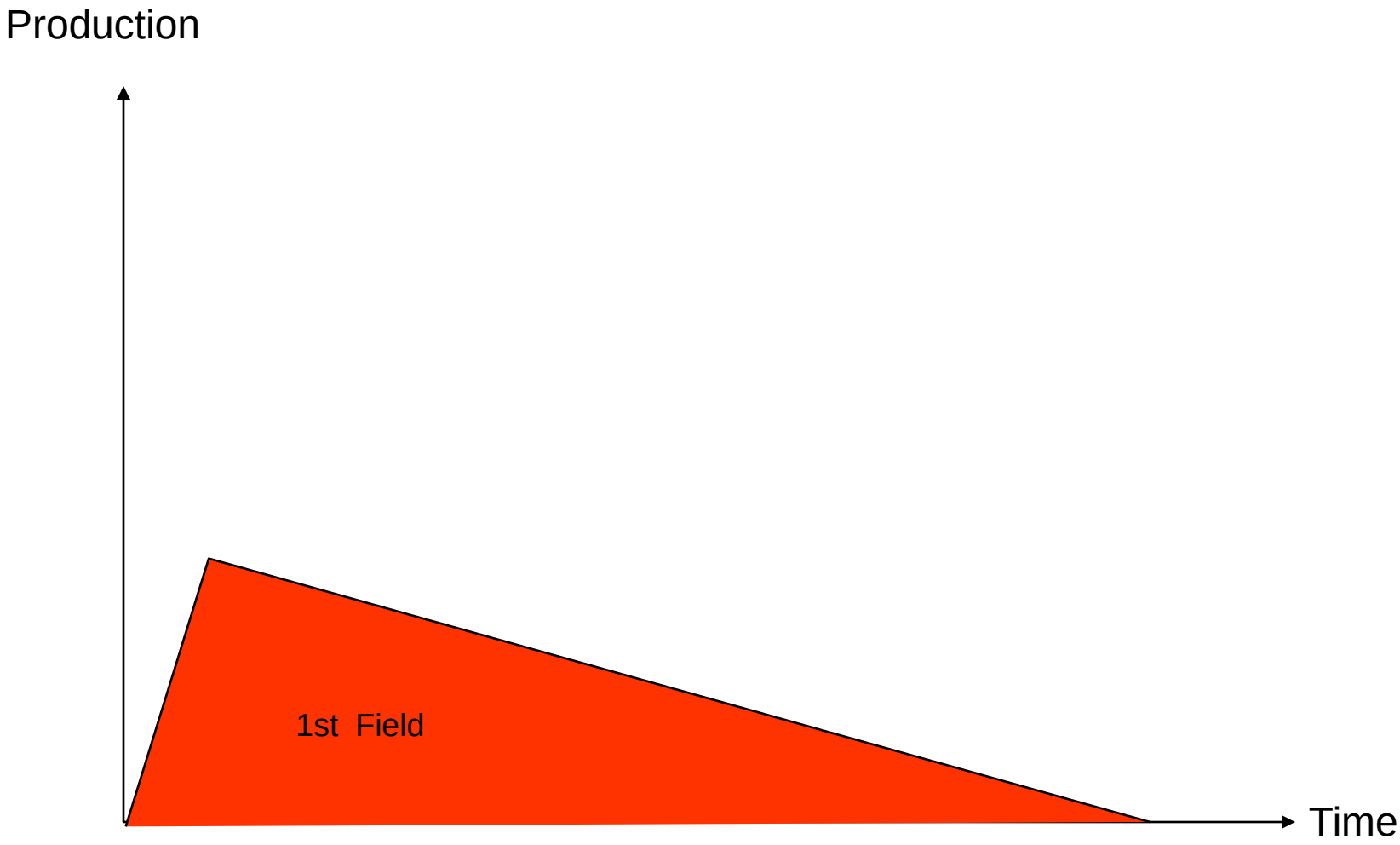
Geologist‘s estimate: as largge as honestly possible
Economist‘s view: as small as cautiously possible
Annual Reporting: Those volumes which can be extracted with existing or planned well capacity

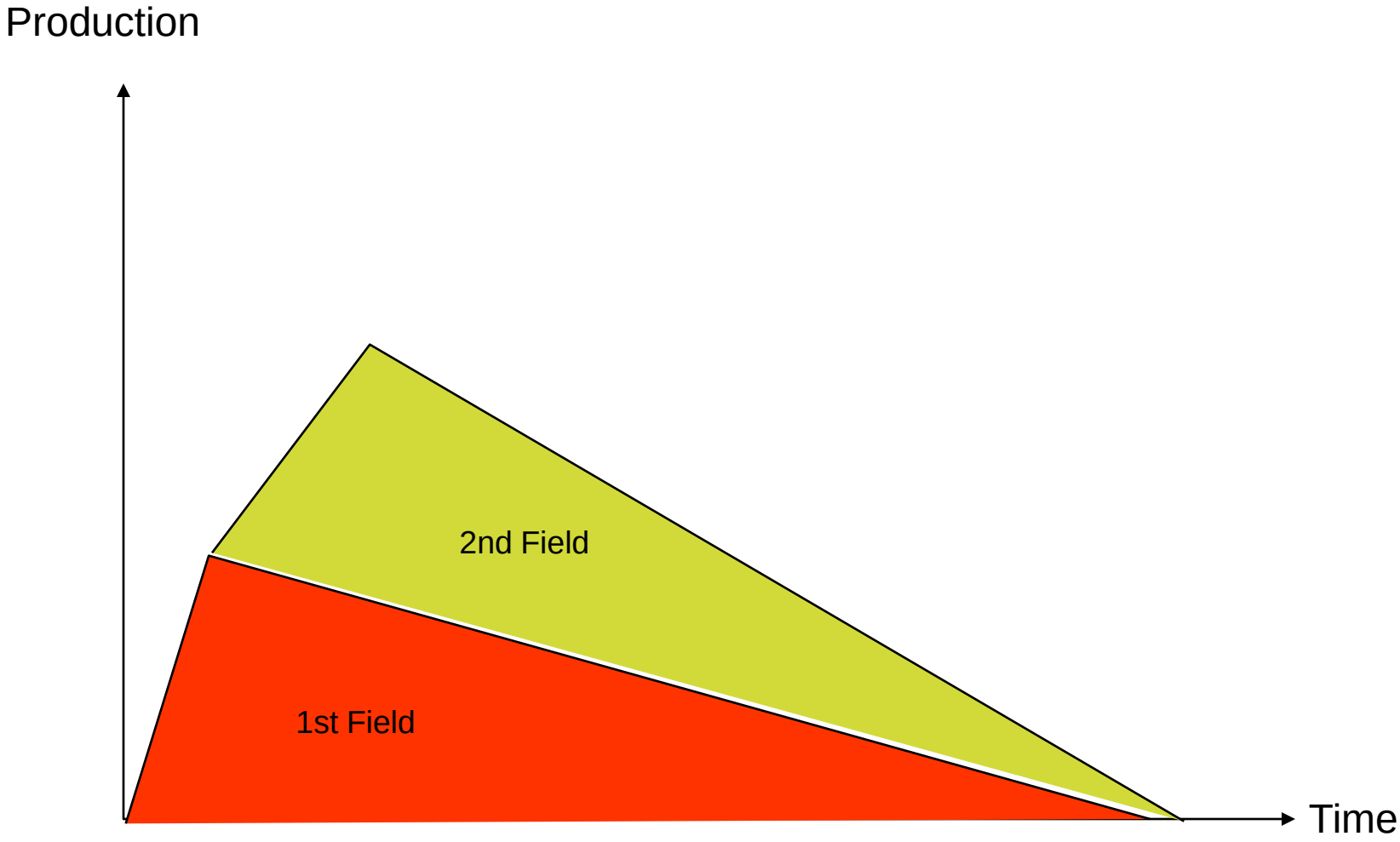
=> New wells increase reserves



Regional Oil Production: Typical Production Profile of a Single Oil Field



Regional Oil Production: Adding New Fields



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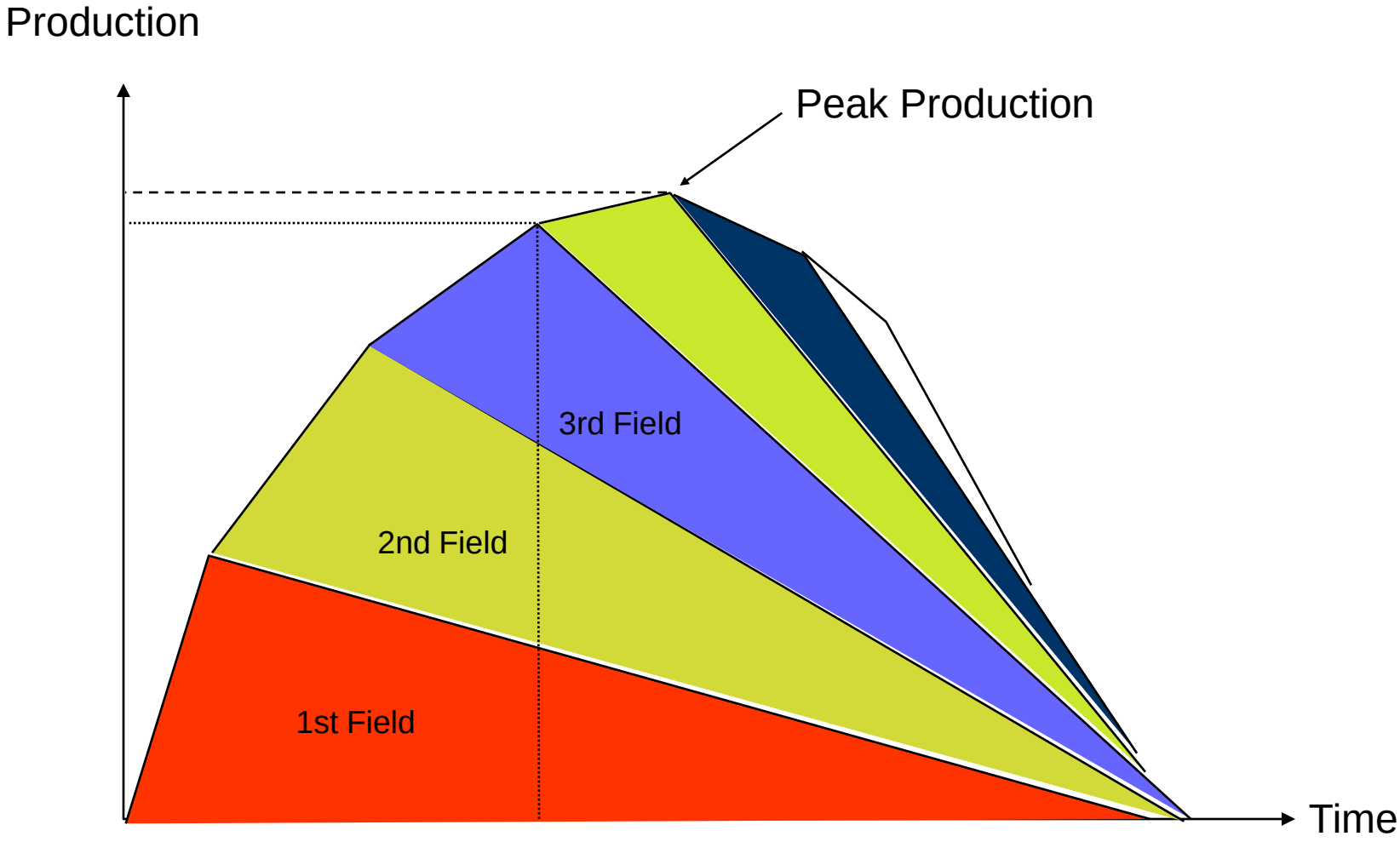
Regional Oil Production: Peak of Regional Production



Norway: Crude Oil Production of all Fields at End of Okt 2009

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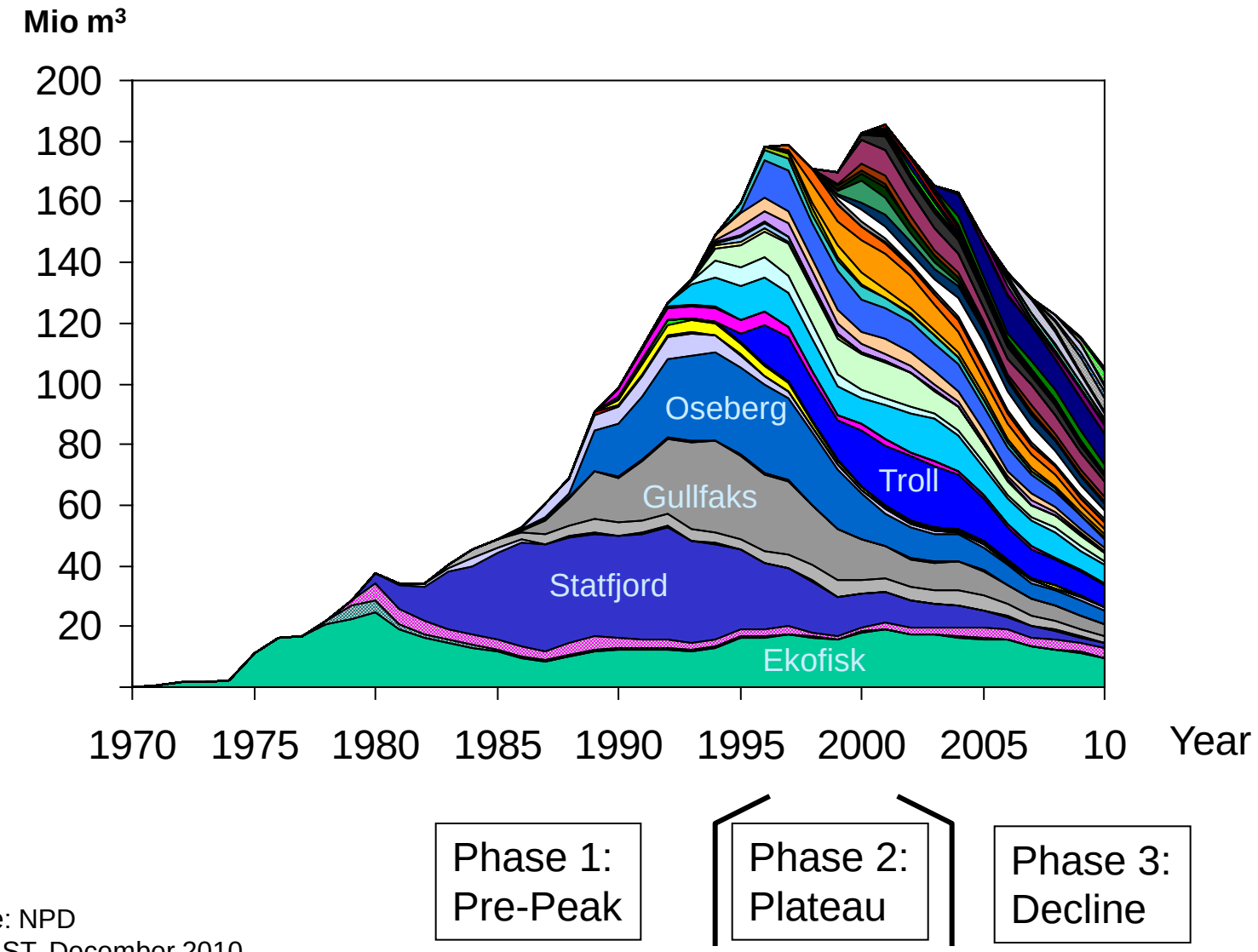
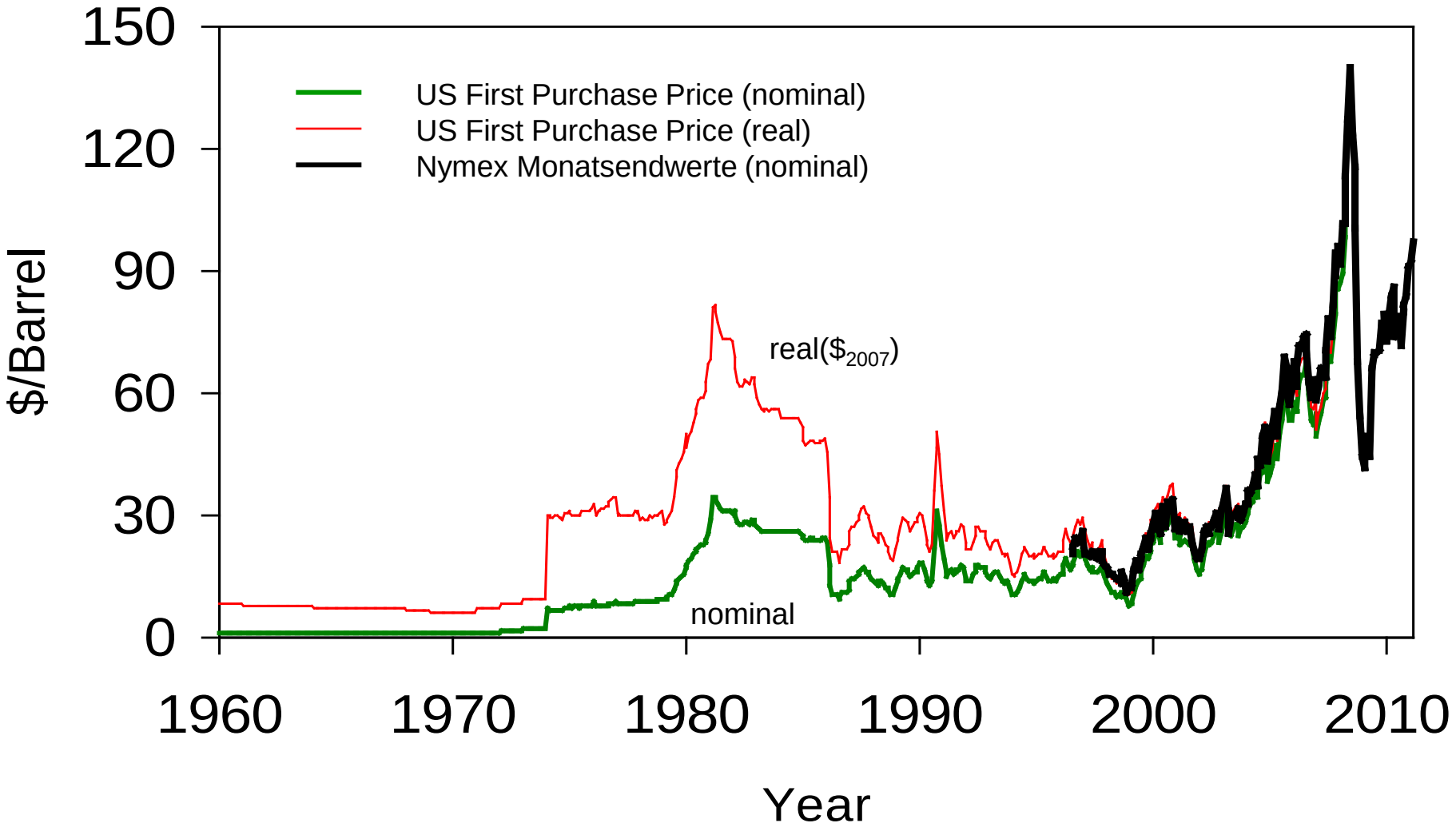


Data Source: NPD
Analysis: LBST, December 2010

Nymex Crude Oil Price



Quelle: Die Monatswerte des „US First Purchase Price“ wurde den Internetseiten des US DoE entonommen. Die Daten vor 1974 wurden durch Anpassung der Datensätze für 1974 aus BP Statistical Review of World Energy errechnet.
Die näherungsweise Umrechnung in reale Preise erfolgte durch die LBST anhand von jährlichen US-Inflationsraten aus http://inflationdata.com
Die Nymex Monatsendwerte wurden
http://futures.tradingcharts.com/chart/CO/M/?saveprefs=t&xshowdata=t&xCharttype=b&xhide_specs=f&xhide_analysis=f&xhide_survey=t&xhide_news=f
entnommen

World Oil Supply 1900 - 2009
(Crude Oil, Condensate, NGL, Heavy Oil, Oilsand)

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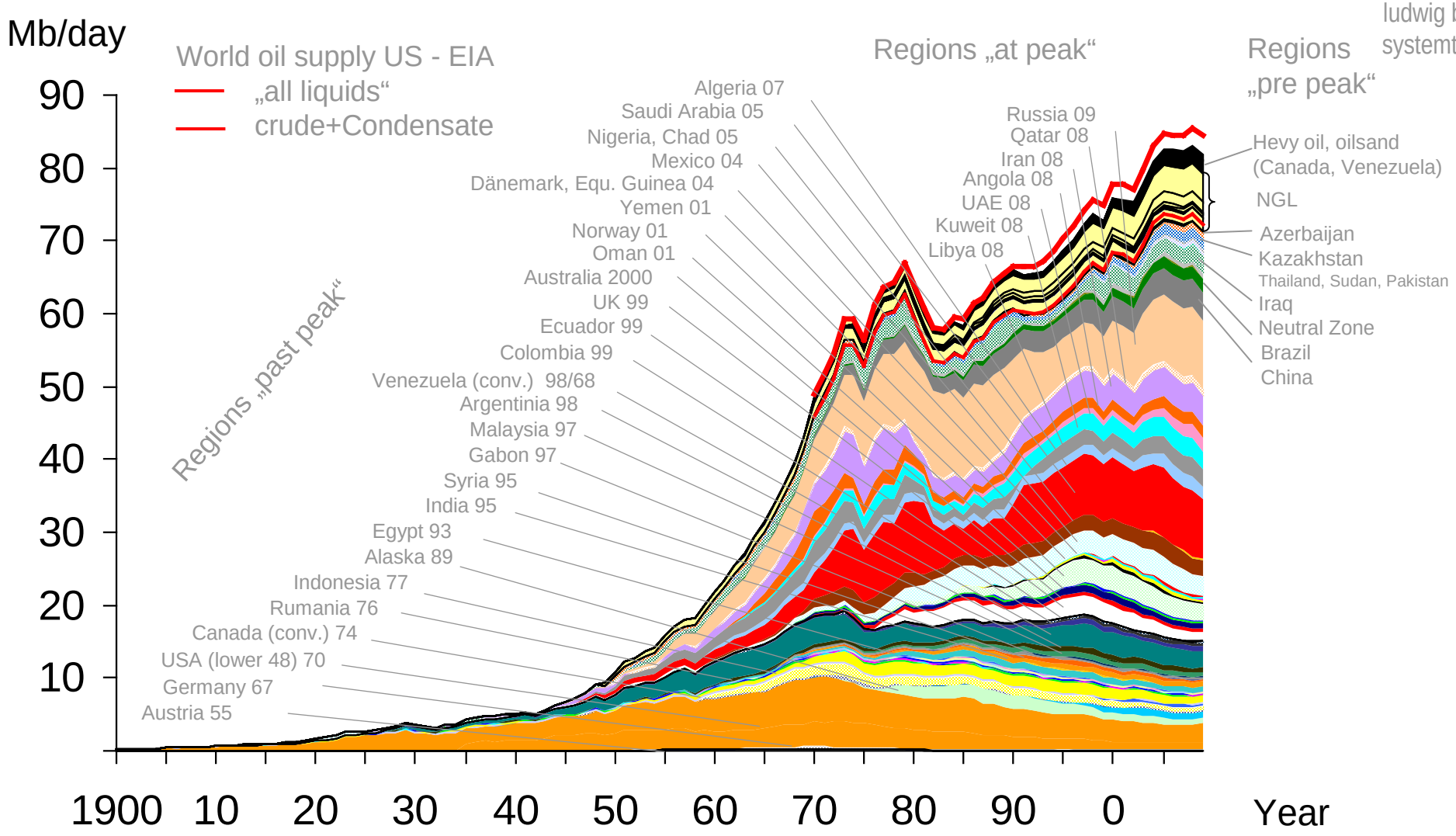

Data Source: Österreich, Deutschland, USA, Kanada, Niederlande, UK, Norwegen, Dänemark, Saudi Arabien, Braslien: Statistiken nationaler Behörden/Firmen;
Für andere Staaten US-EIA, soweit verfügbar. Für die verbleibenden Staaten BP Statistical Review und LBST-Schätzung
Historische Zahlen bis 1970 bzw. für manche Staaten bis 2005: IHS-Energy soweit nicht aus oben genannten Quellen ermittelt; Analyse LBST Feb 2010

World Crude Oil Supply 1950 - 2050
(Crude Oil, Condensate, NGL, Heavy Oil, Oilsand)

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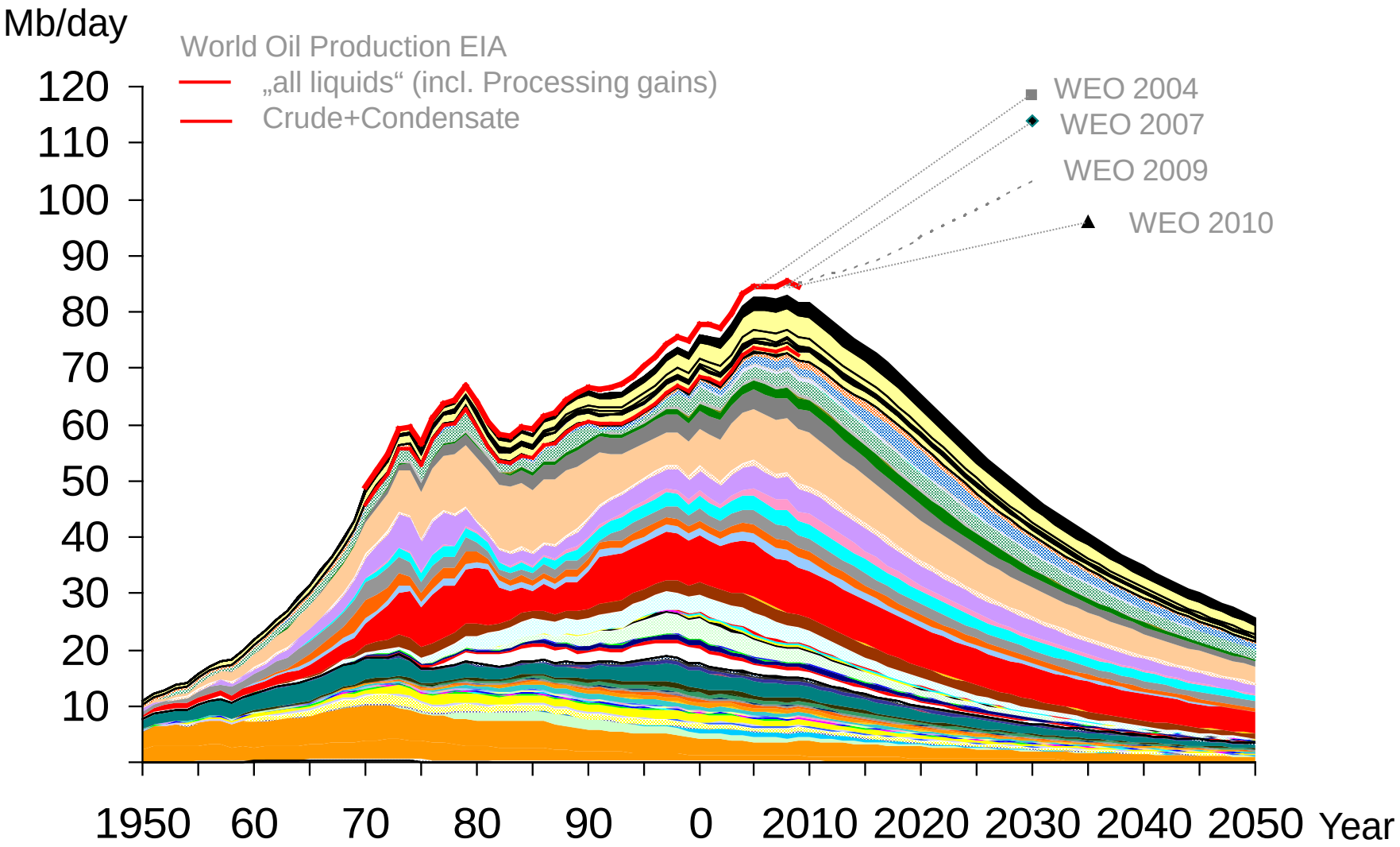

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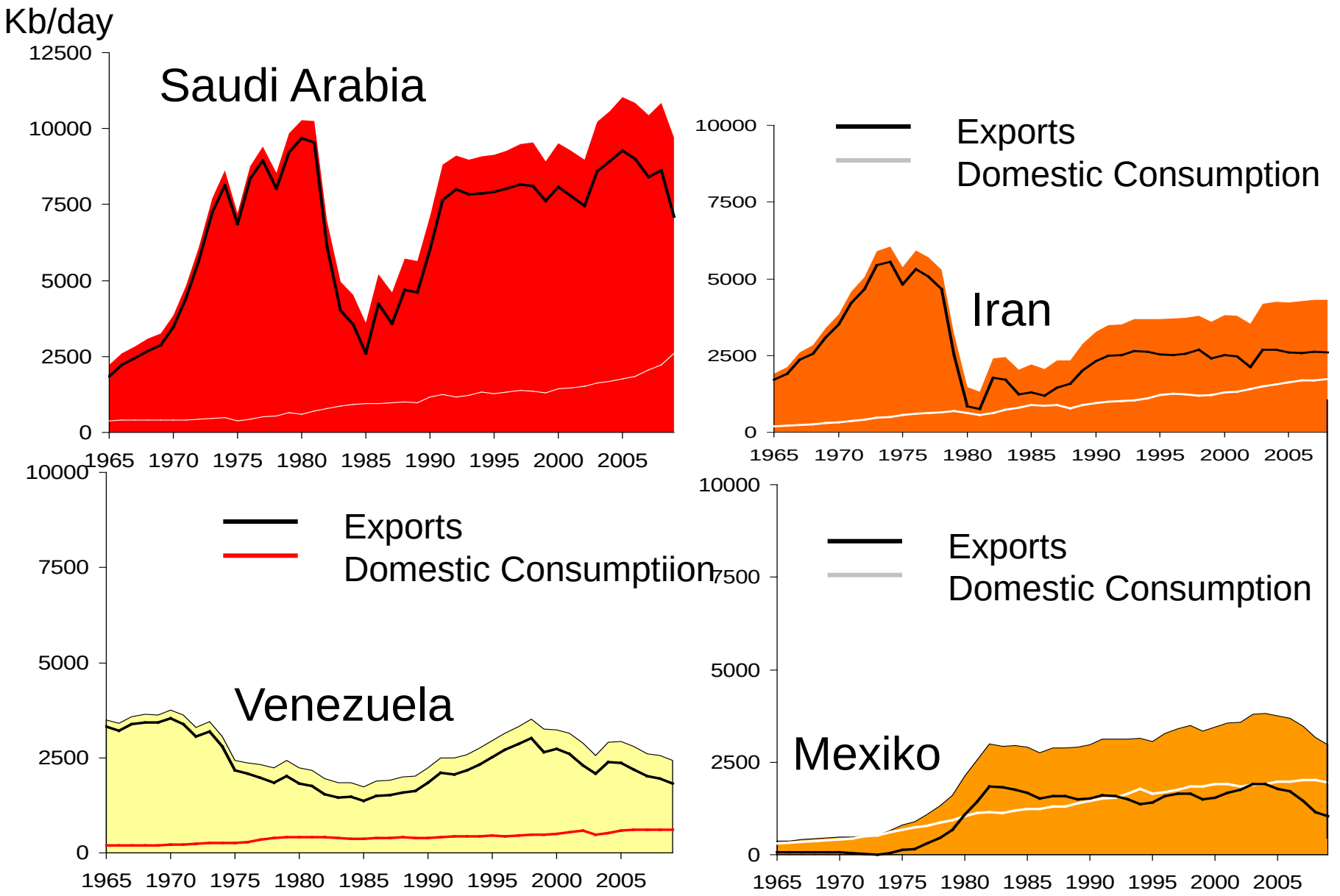
Historische Zahlen bis 1970 bzw. für manche Staaten bis 2005: IHS-Energy soweit nicht aus oben genannten Quellen ermittelt; Analyse LBST November 2010

Export Volumes Decline Faster Than Regional Production



Source: BP Statistical Review 2010

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Production - Consumption – Exports/Imports

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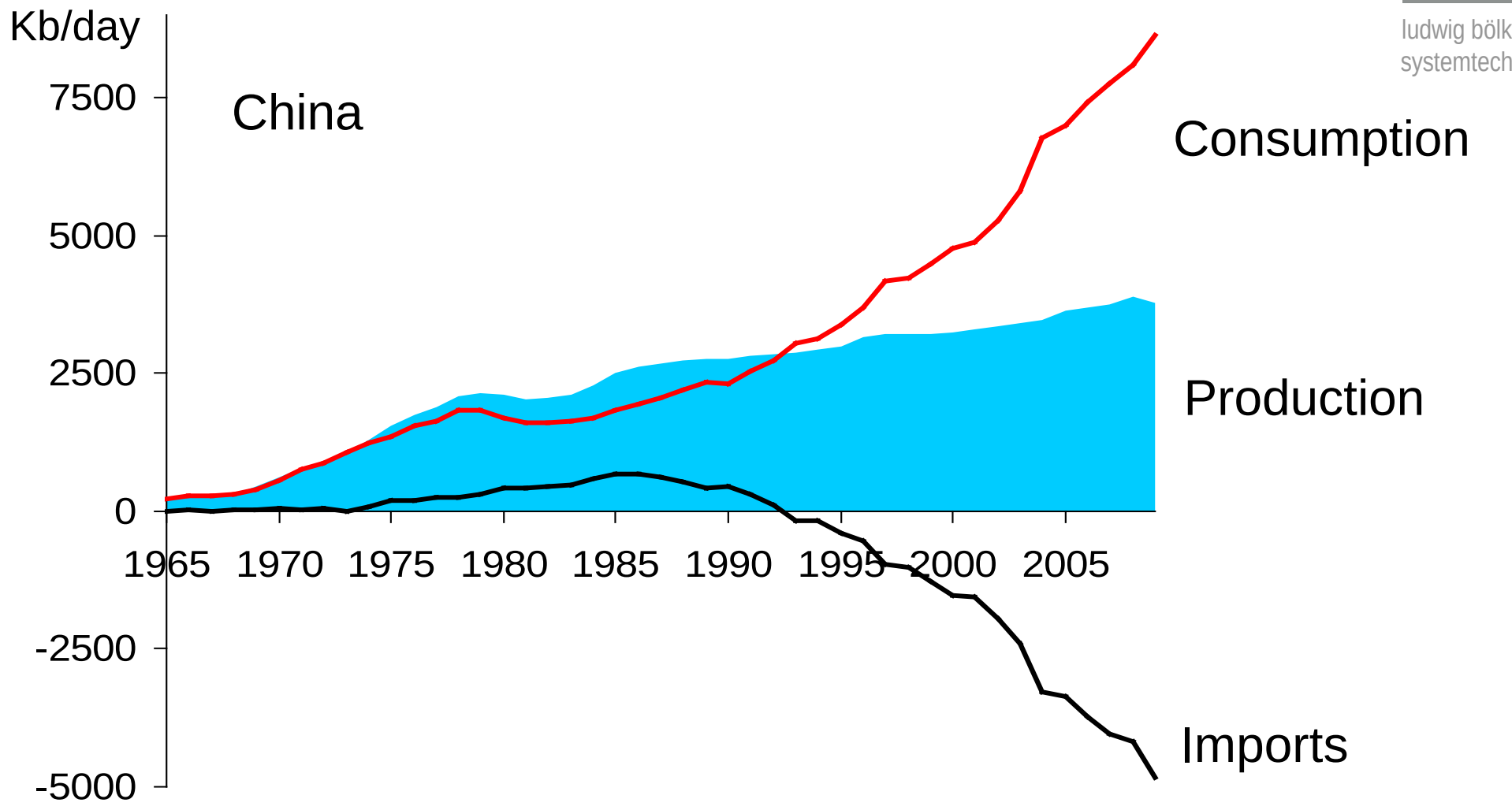

Source: BP 2010; Analyse: LBST

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- The future availability of natural gas

Gas Production in UK: Decline since 2001

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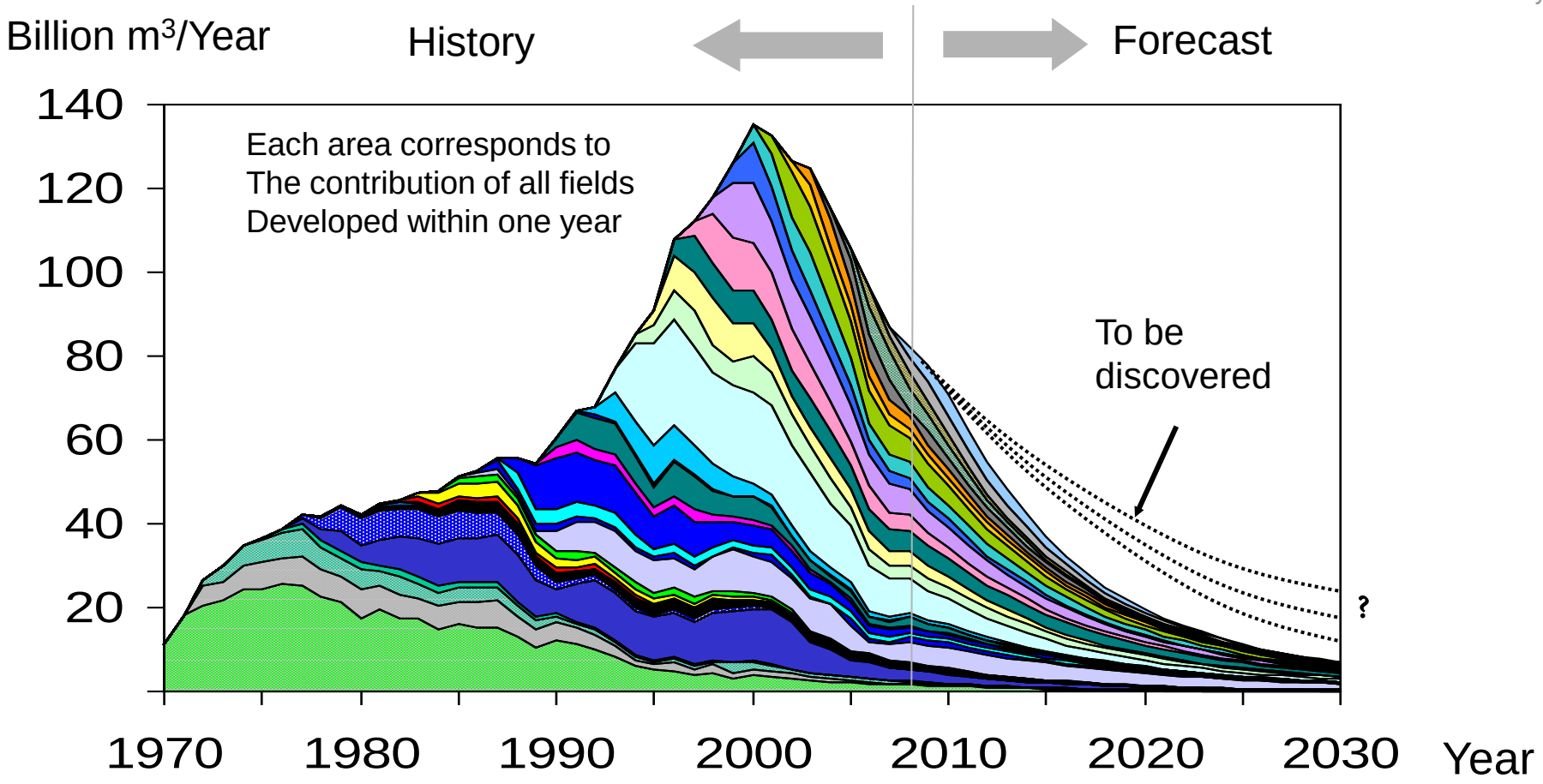
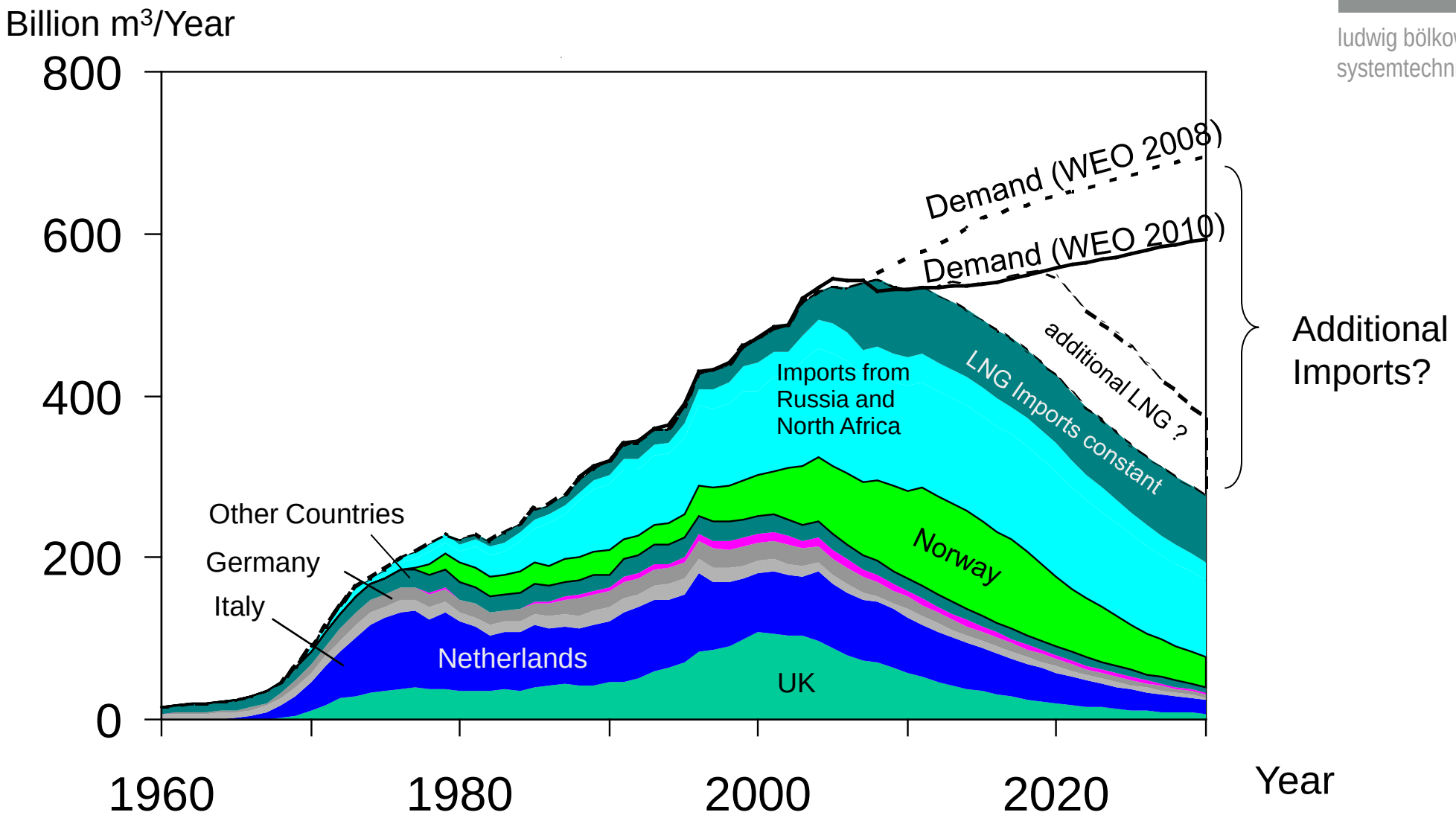


Historical Data: DTI, February2009, Extrapolation: LBST

Gas Supply of OECD Europe



Historical data: OECD 2008, DTI 2010, NPD 2011, BP 2010; Forecast: LBST 2009

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- The future availability of coal

Coal Production in UK

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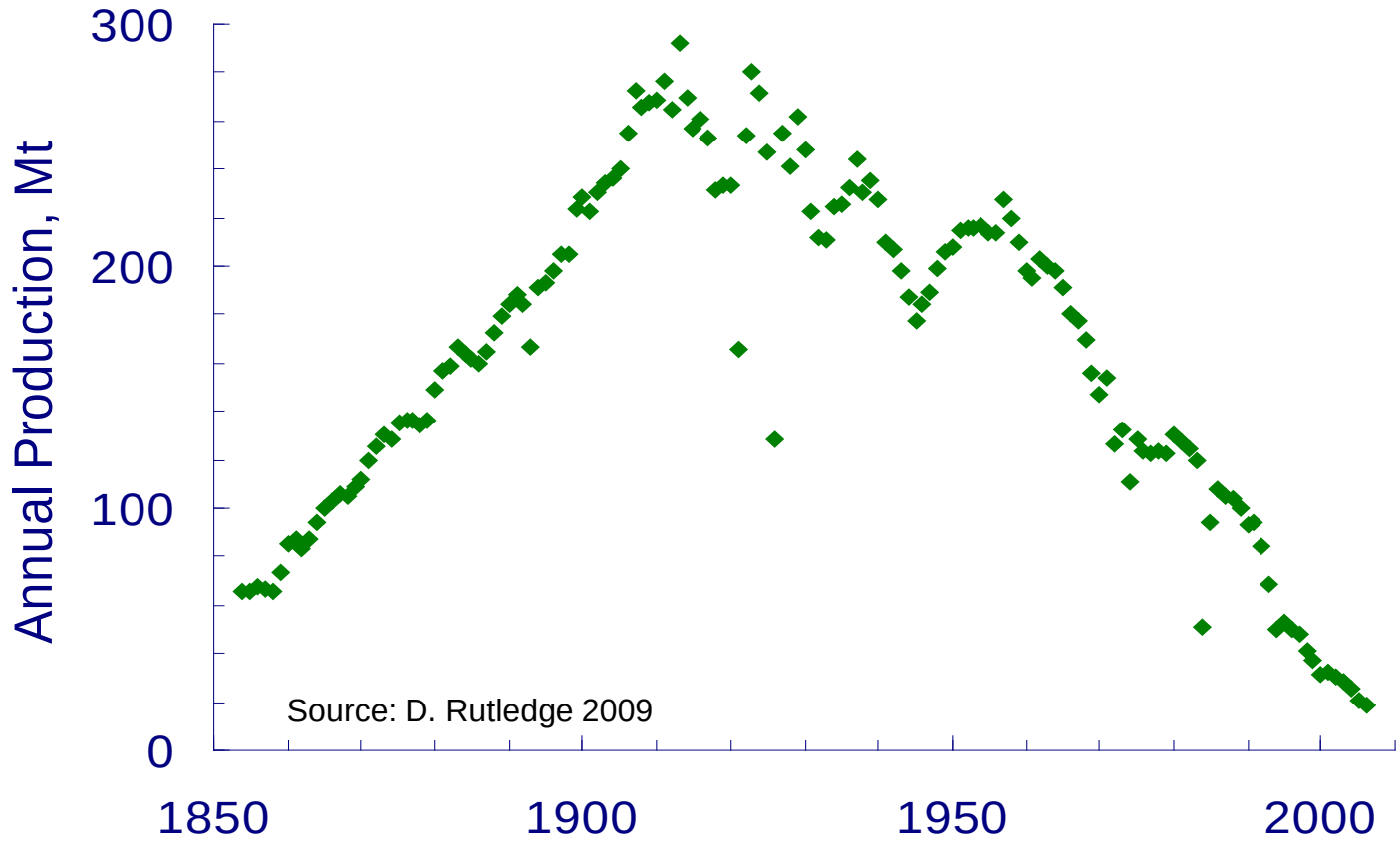
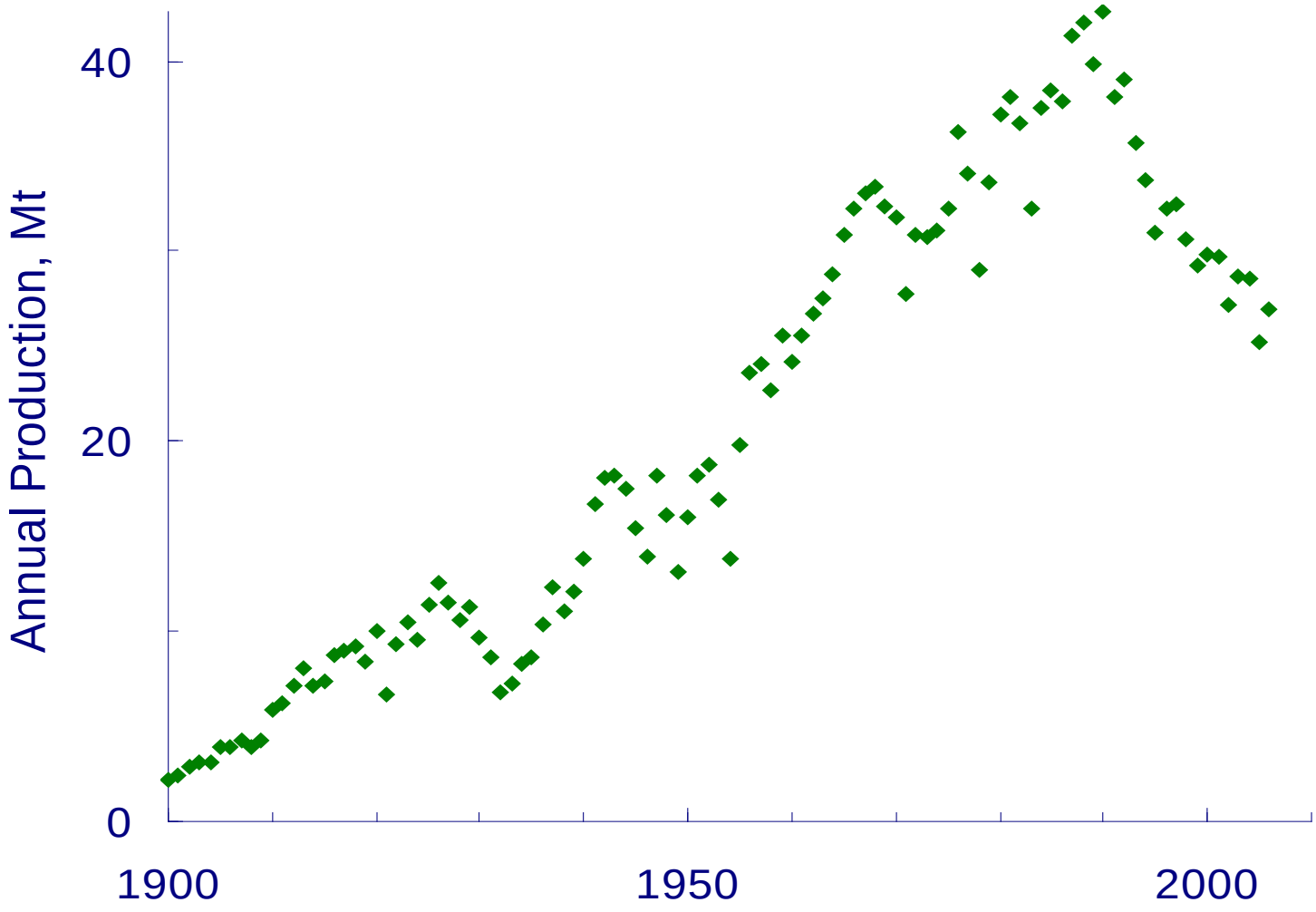


- Daten von US National Bureau of Economic Research (1854-1876), Durham Coal Mining Museum (1877-1956), und British Department of Trade and Industry (1957-2006)

Coal Production in Virginia, USA



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Million Tons

Worldwide possible hard coal production

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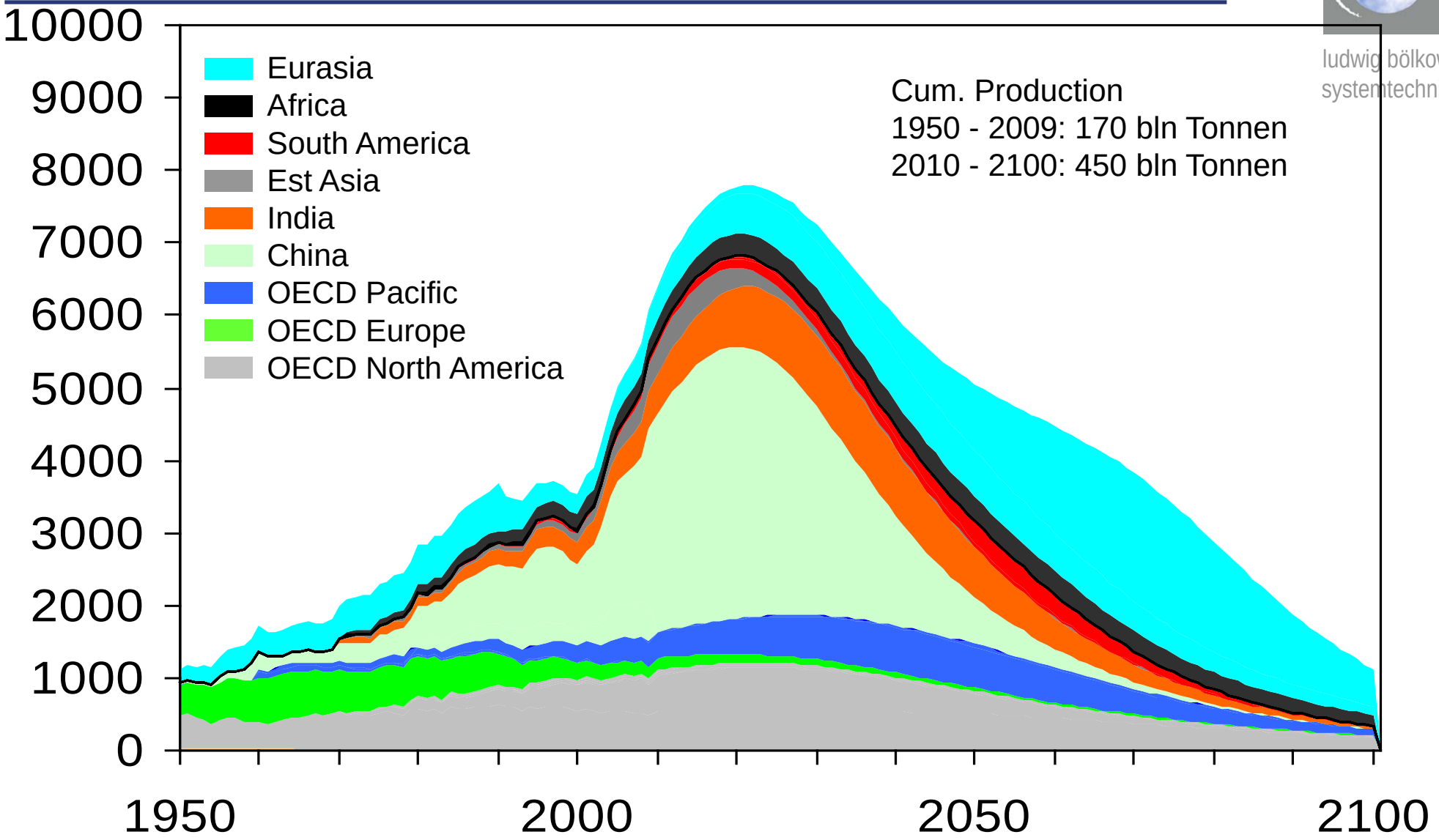

2010-update of EWG-report, LBST 2010

Bln Tons Coal

South Africa

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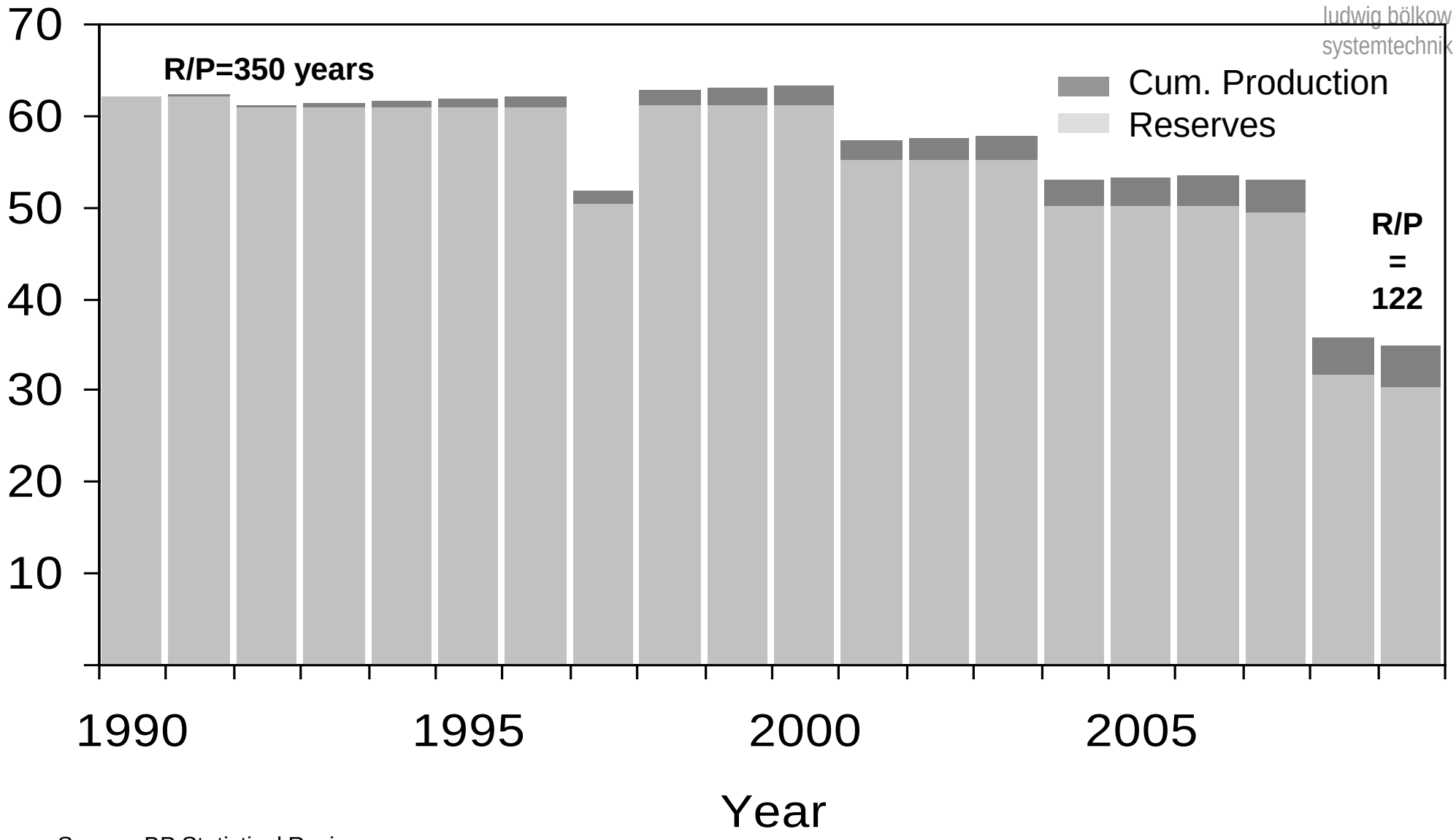

Source: BP Statistical Review

South African Coal Production: Productivity

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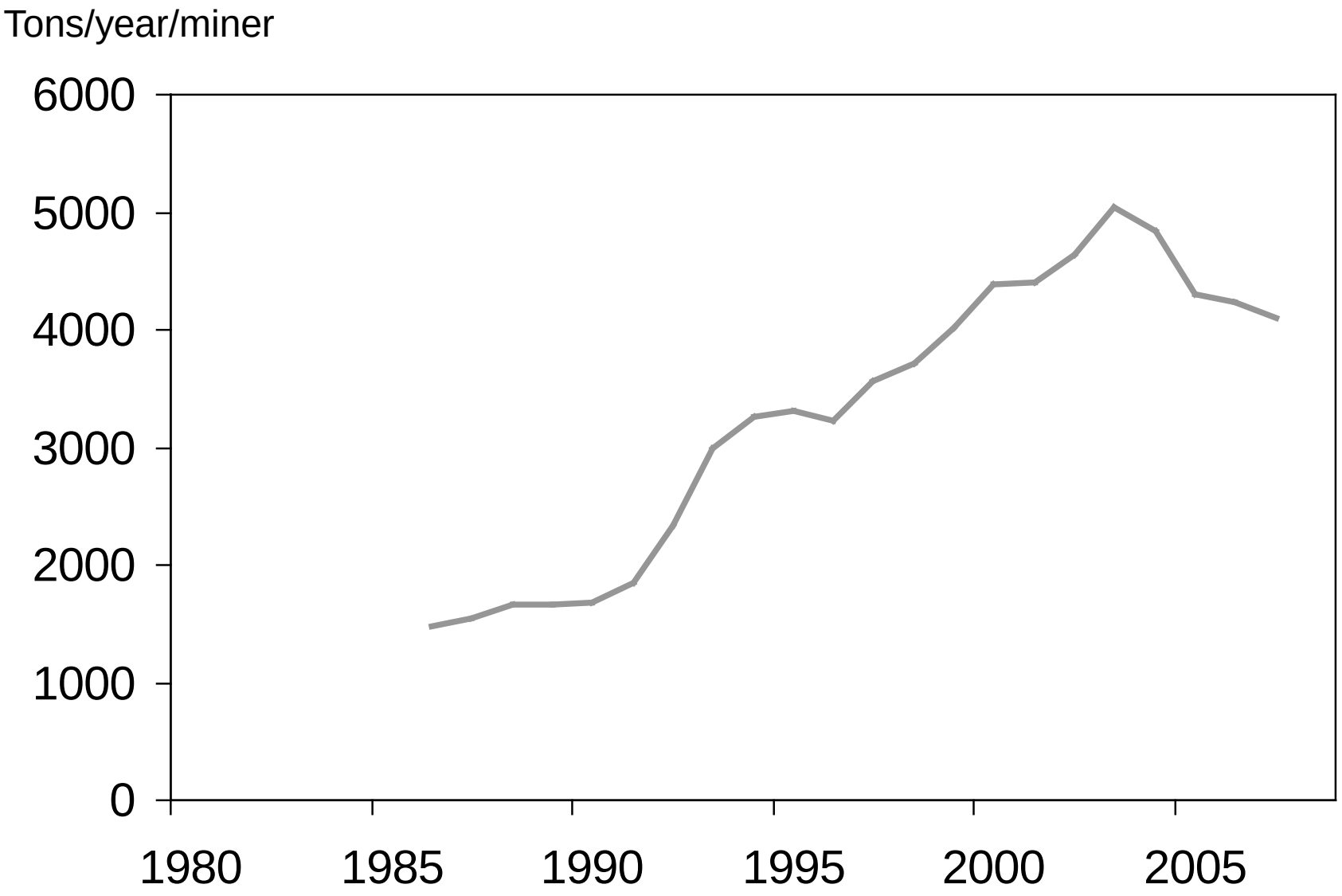

Source: Statistics South Africa, 2010

World Coal Exports and Imports

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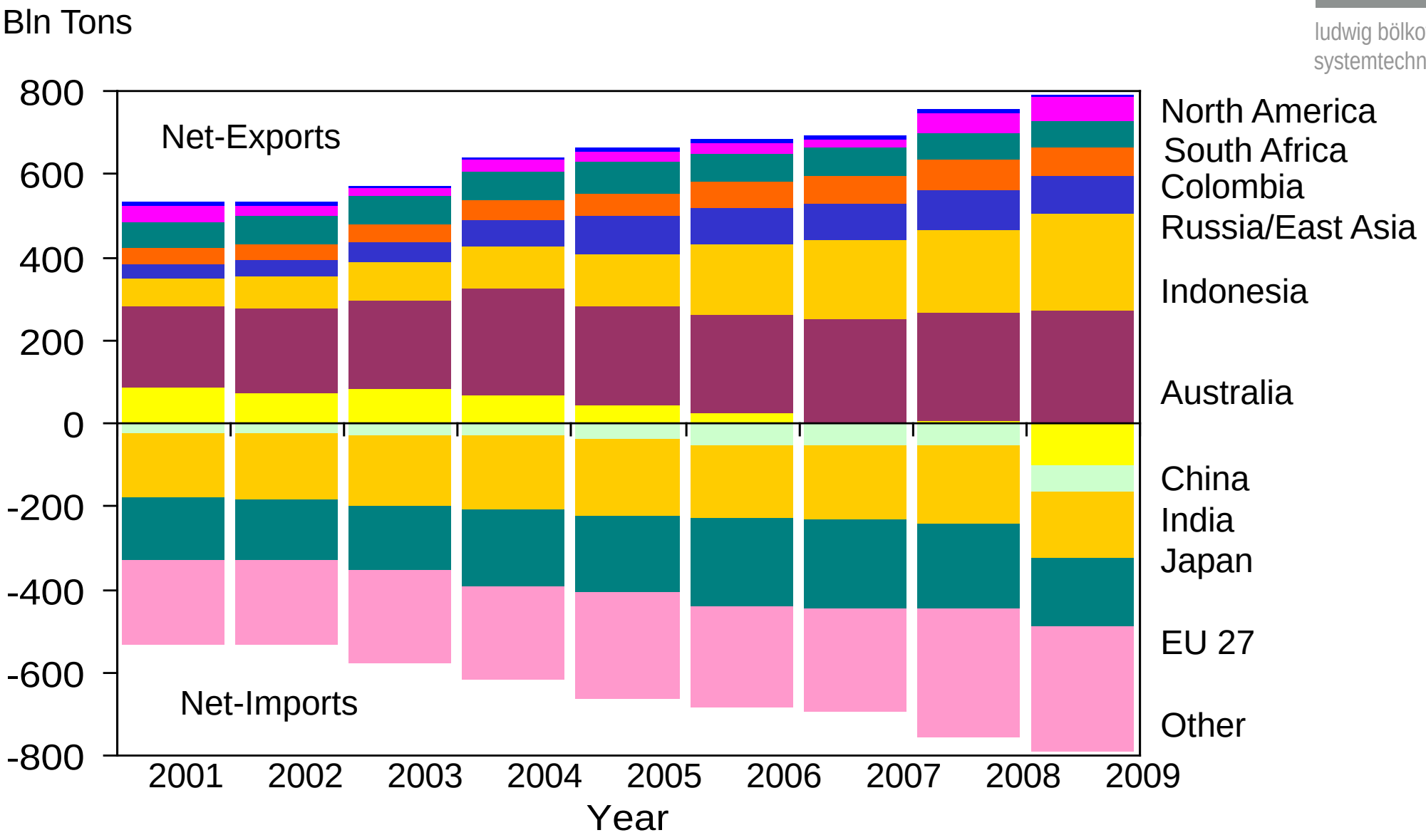

Source: Verband der Kohleimporteure, 2010

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- Nuclear Energy

Worldwide Production of Nuclear Electricity

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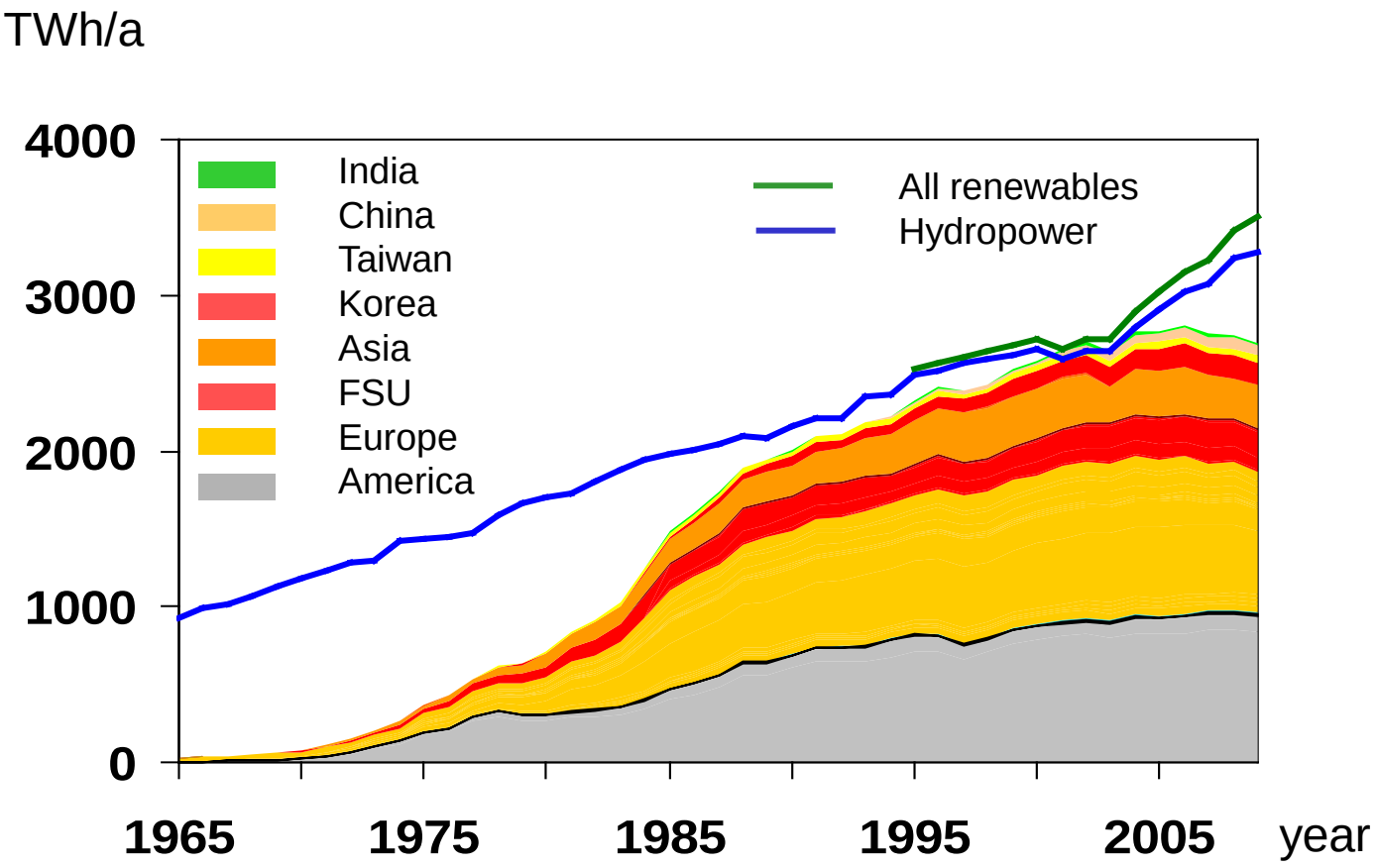

Source: BP Statistical Review of World Energy 2010

Nuclear capacity additions worldwide (construction start)

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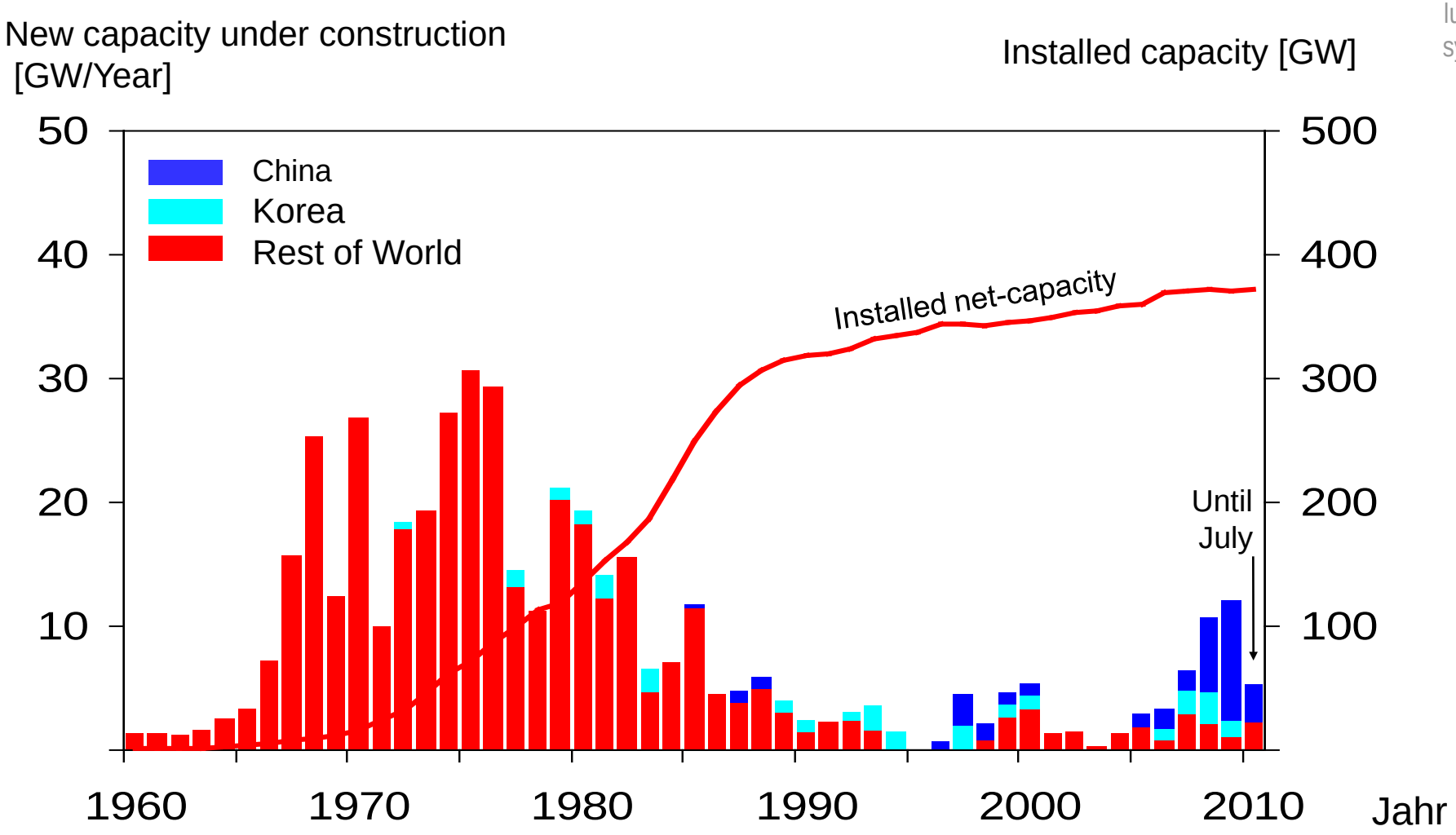

Source: International Atomic Energy Agency (IAEA), June 2010

Necessary construction starts to keep total capacity constant

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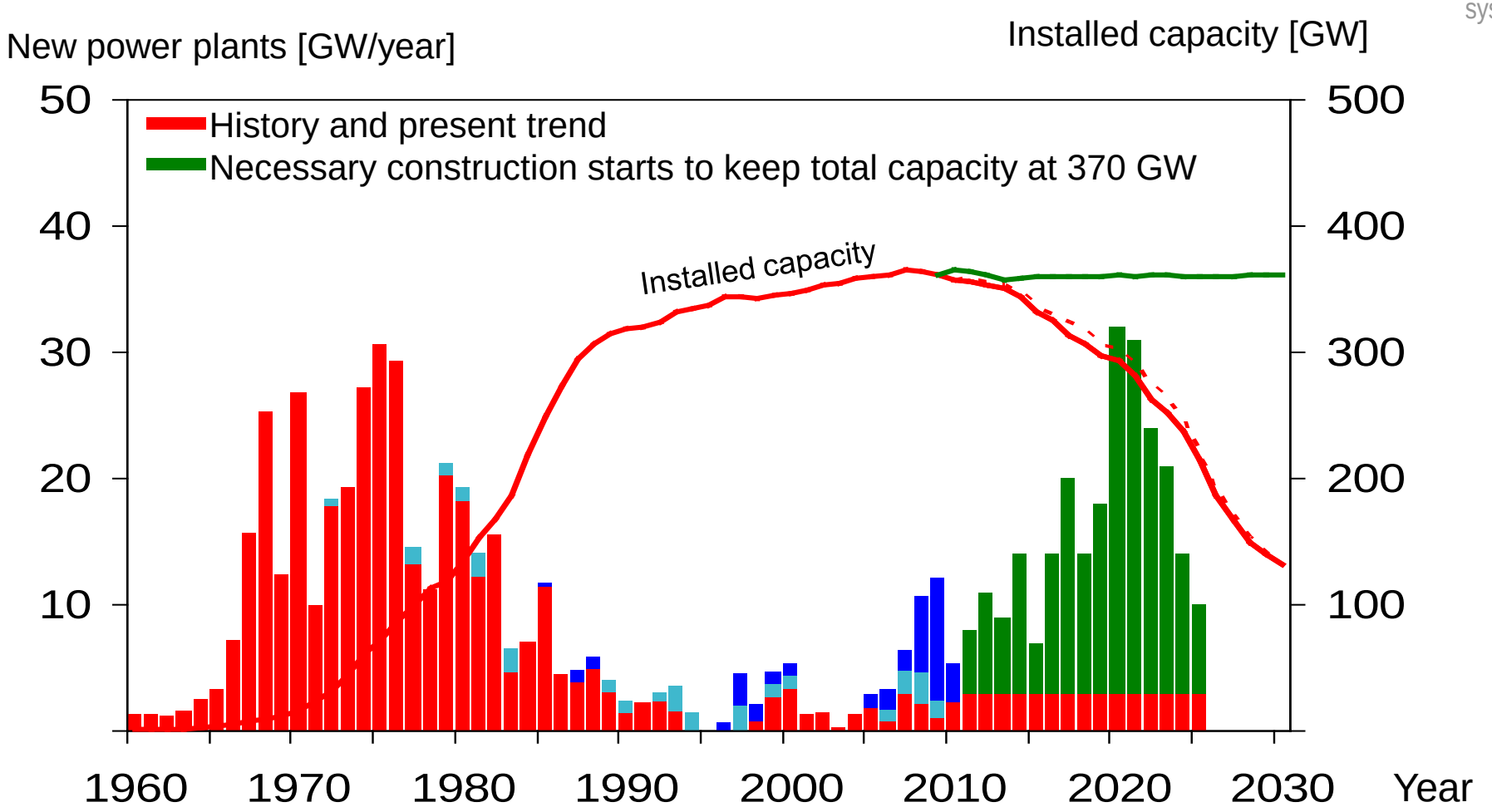

Source: International Atomic Energy Agency (IAEA), Februar 2008

Forecast: LBST, October 2008; Assumptiion: Operational life time 40 years, construction time 5 years

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Worldwide Renewable Electricity Production (without Hydro Power)

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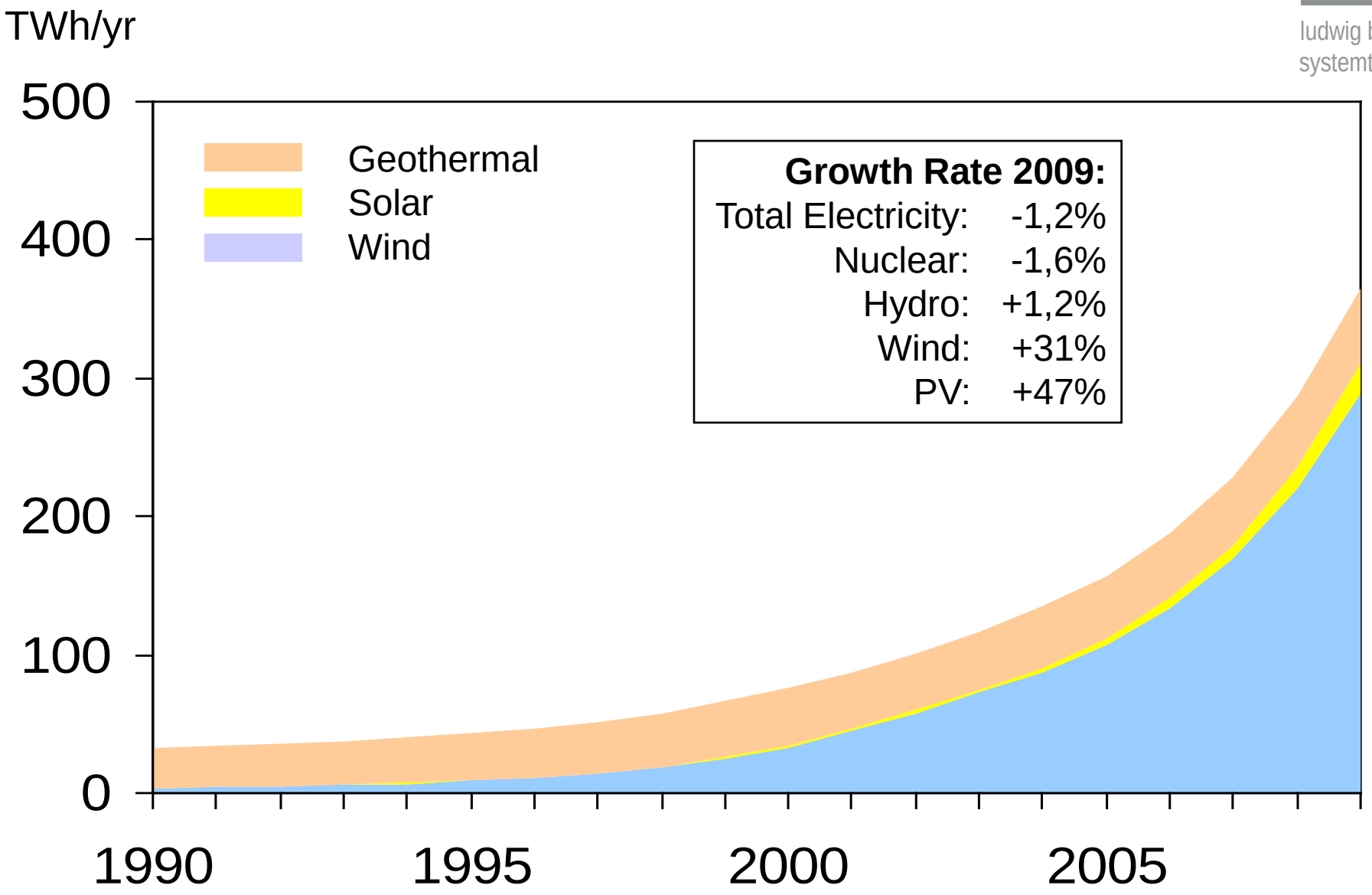

Source: BP 2010

Extrapolation until 2020 with constant growth rate (as in 2009)

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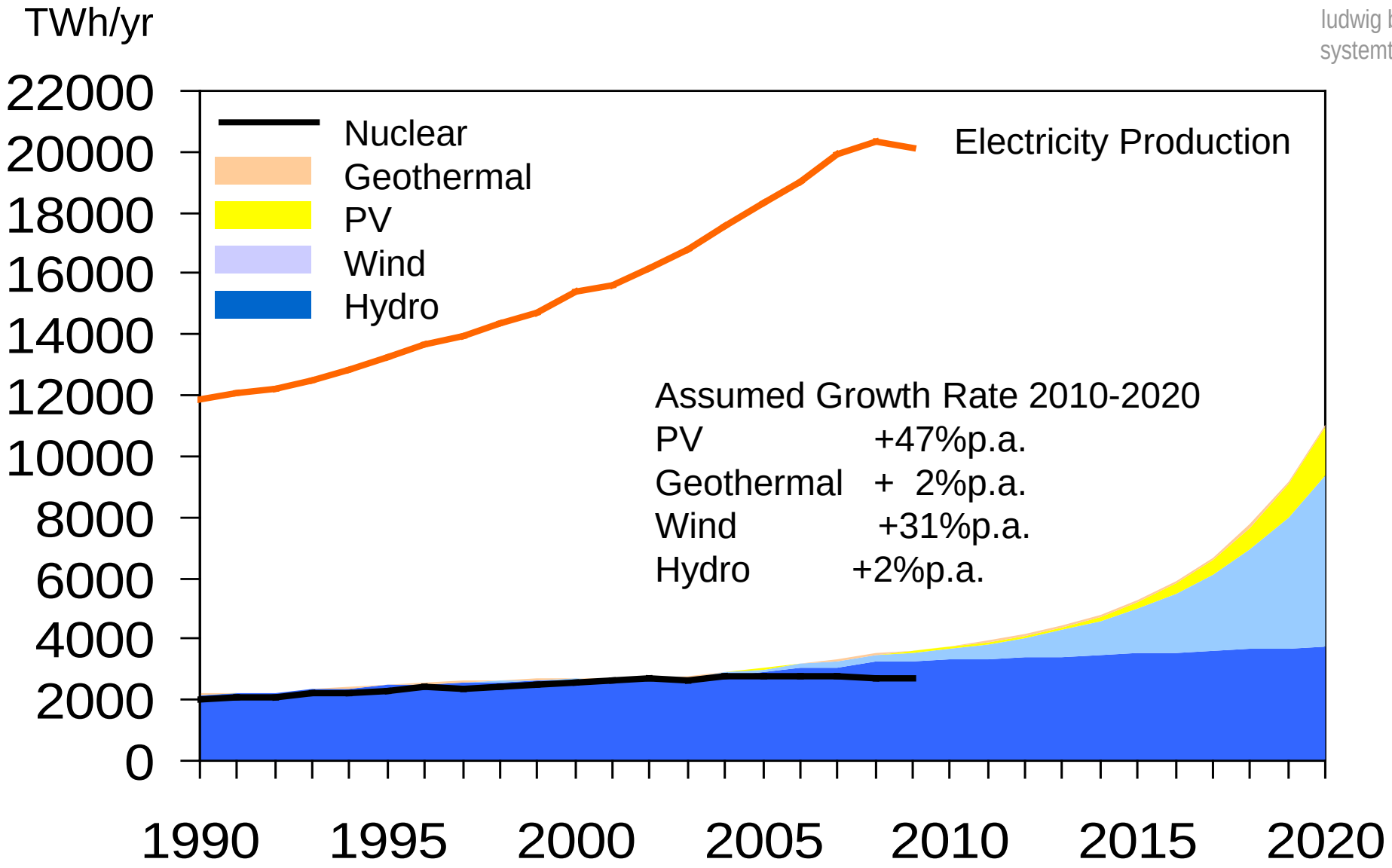
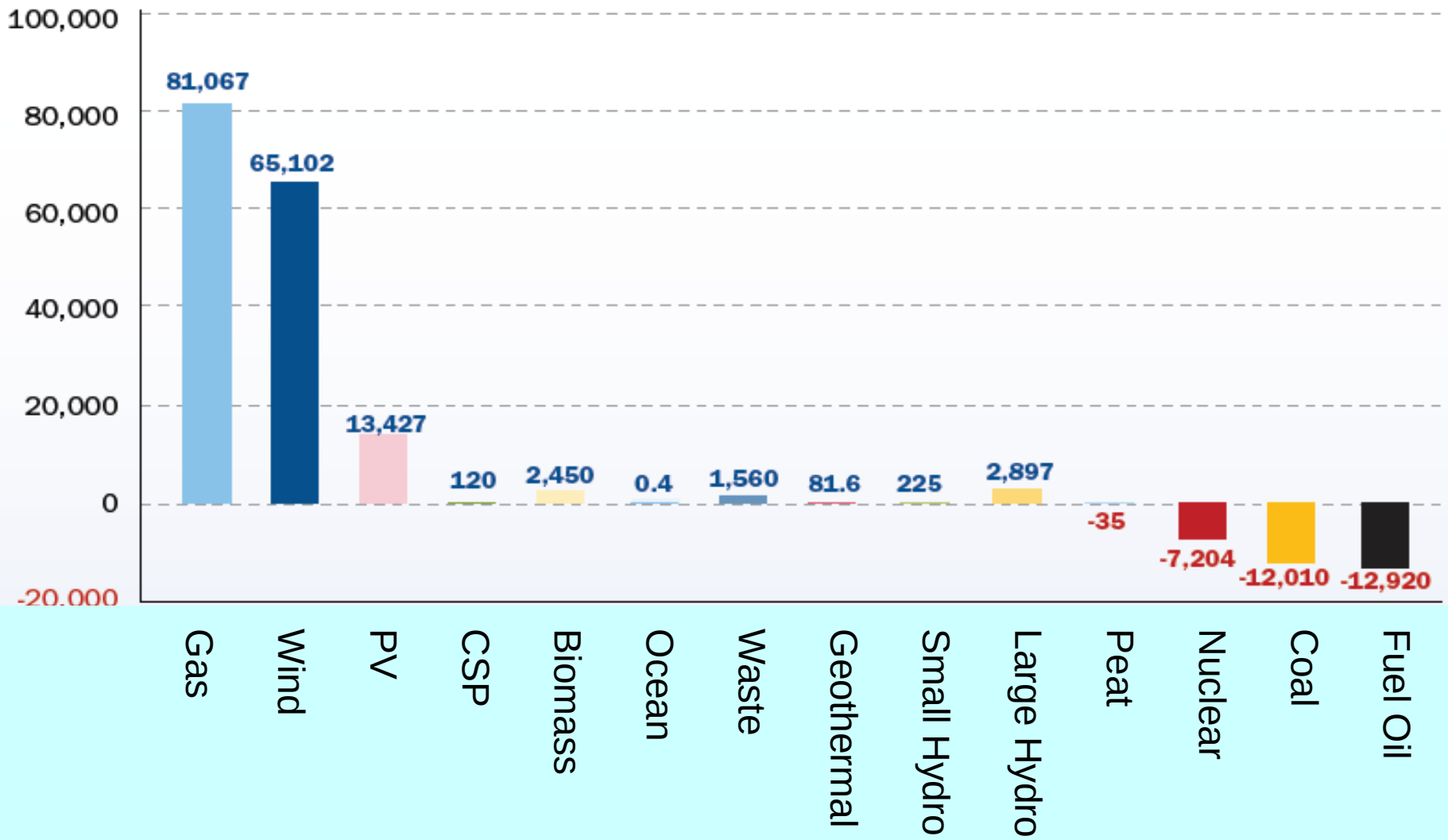


Source: BP 2010, Projection LBST

Net electricity Generating Installations in EU 2000-2009 in MW

NET ELECTRICITY GENERATING INSTALLATIONS IN EU 2000 - 2009 IN MW

FIGURE 2.2



Source: EWEA, Wind in Power Feb 2010

Worldwide Installed Wind Energy Capacity

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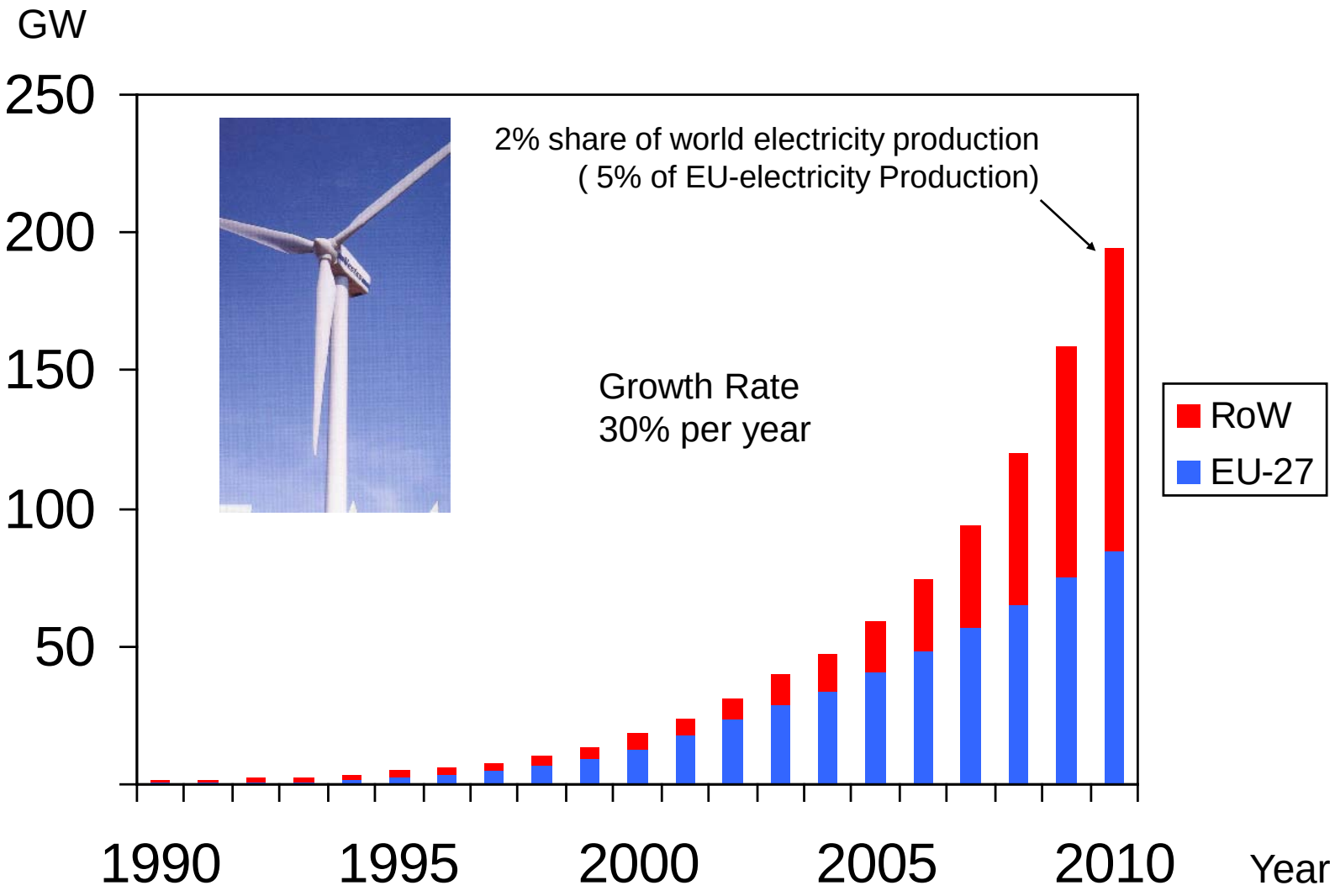

Source: EWEA 2011

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Statement 1: „BAU“ is not a solution

Statement 2: The Future is electricity dominated

Statement 3: Biomass is not an option for the transport sector

Statement 4: The transport sector goes „electric“

Statement 5: Industrialised nations cannot keep the present living standard

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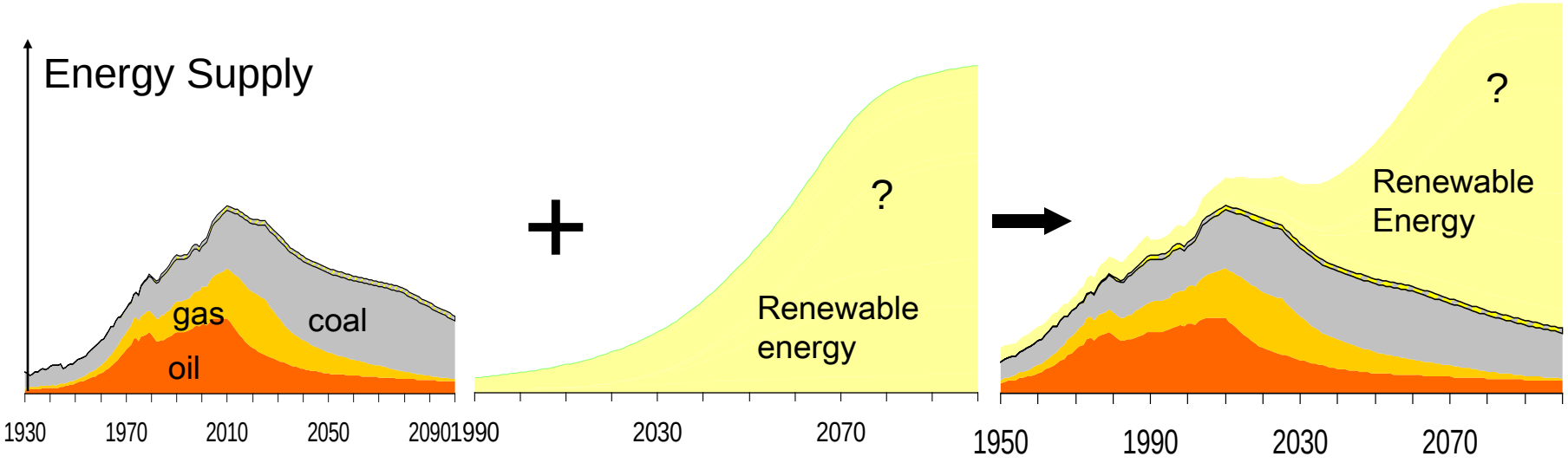
Statement 1: „BAU“ is not an option

We are at the beginning of a structural change which will force to change the economic patterns



Quelle: AWEO 2006, LBST

- Having passed „Peak“ new investments will drive new technologies
- Energy efficiency gains importance

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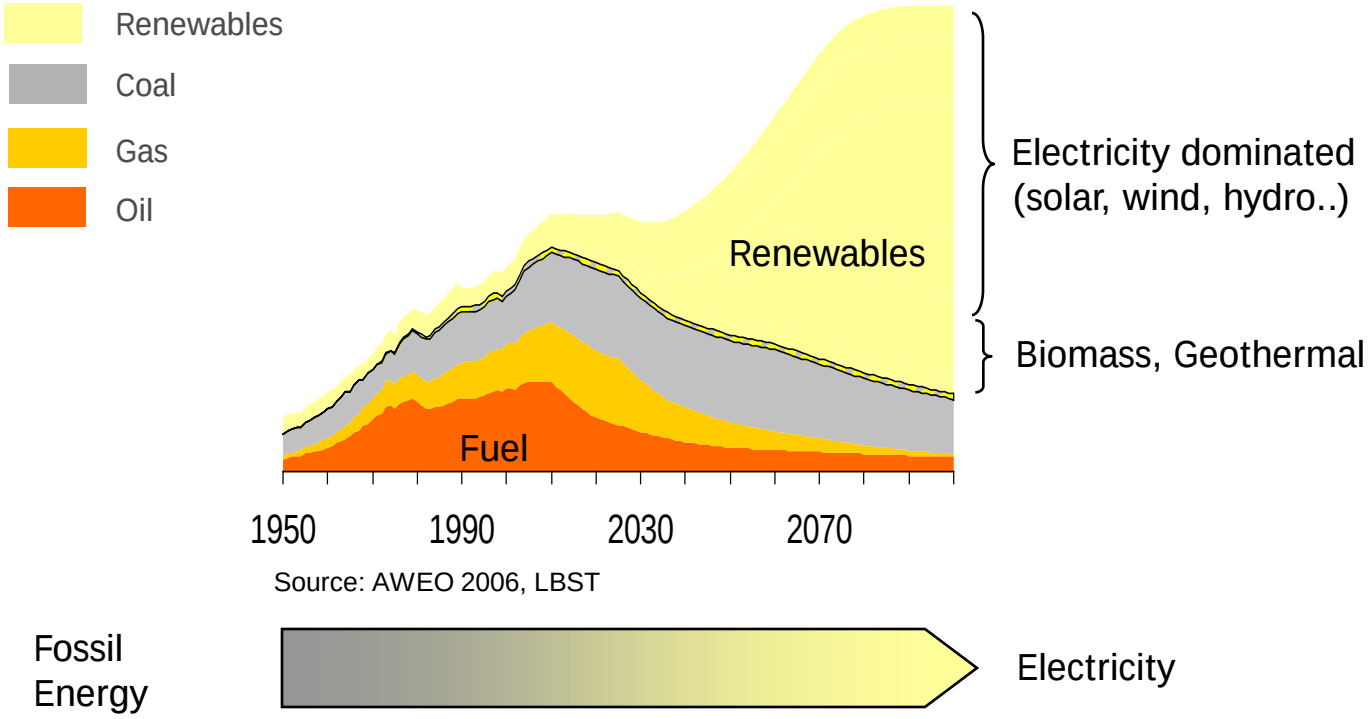
Statement 2: The future is electricity dominated



Renewable electricity has different characteristics than fossil fuels:

- Not easy to store
- Direct coupling between production and consumption

Technological Consequencen

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- Electricity dominates the energy infrastructure
- The smoothing of fluctuations becomes system relevant
- Fuels can only produced with huge losses

During Transition Phase

⇒Over capacities in base load
⇒Full load hours of conventional power plants declines
⇒Coupling between electricity, heat and fuels

⇒The transport sector will change fundamentally

Ways of adaption

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- Demand side management:
  Adapt conventional power plants to wether forecasts
  Adapt consumption via price signals (small metering)
  (E-cars, heat pumps, air conditioning/refrigeration)

- Interregional Compensation of Fluctuations
  (Grid extension at regional, national and european level)

- Storage
  Short time: compressed air, hydro power, Batteries
  Long time: hydro power, chem. storage (H_2 or Methane)

- Coupling with transport sector
  E-mobility (Public transport, individual transport)
  CNG-cars
  Fuel cell cars or trucks (hydrogen)

Storage / fuels (synthetic Methane from CO_2 and H_2)

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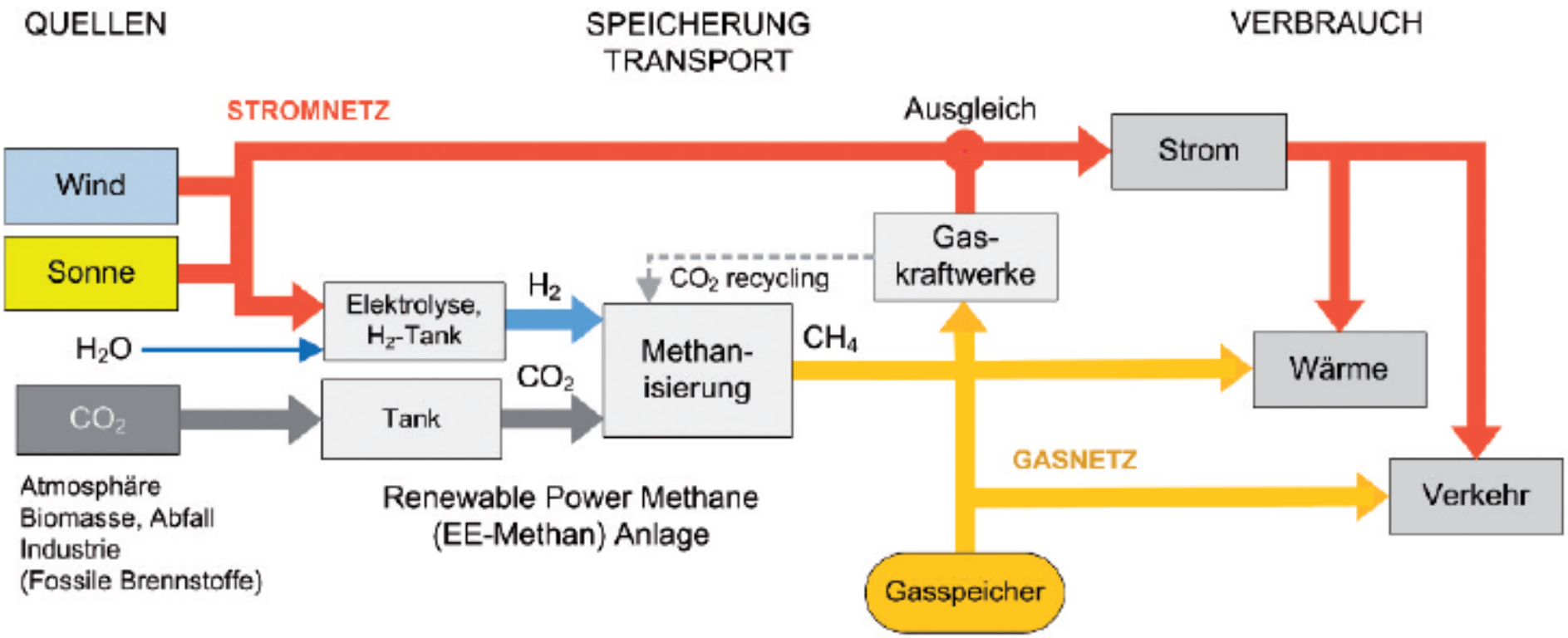

Quelle: Fraunhofer IWES (Sterner) und ZSW (Specht)

Source: FVEE 2010

Storage / fuels (Hydrogen - H_2)

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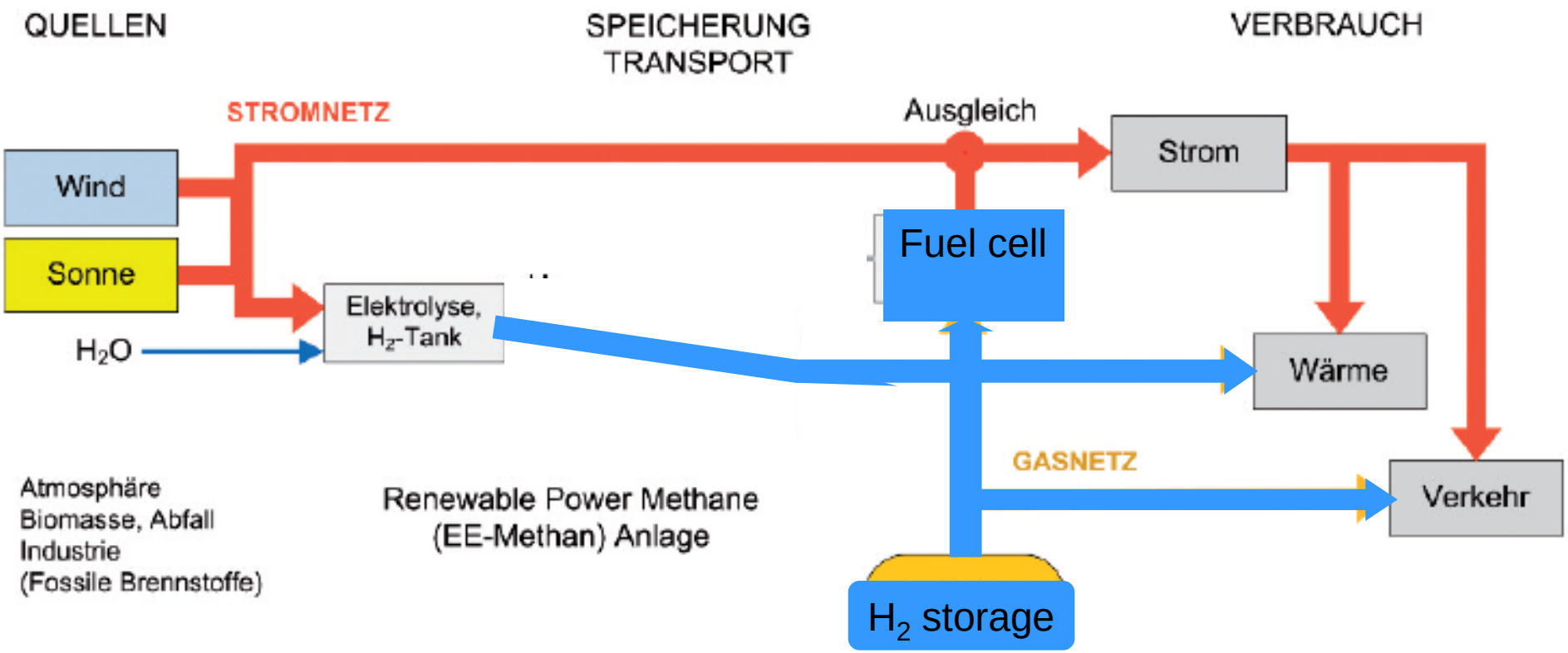

Source: Based on FVEE 2010

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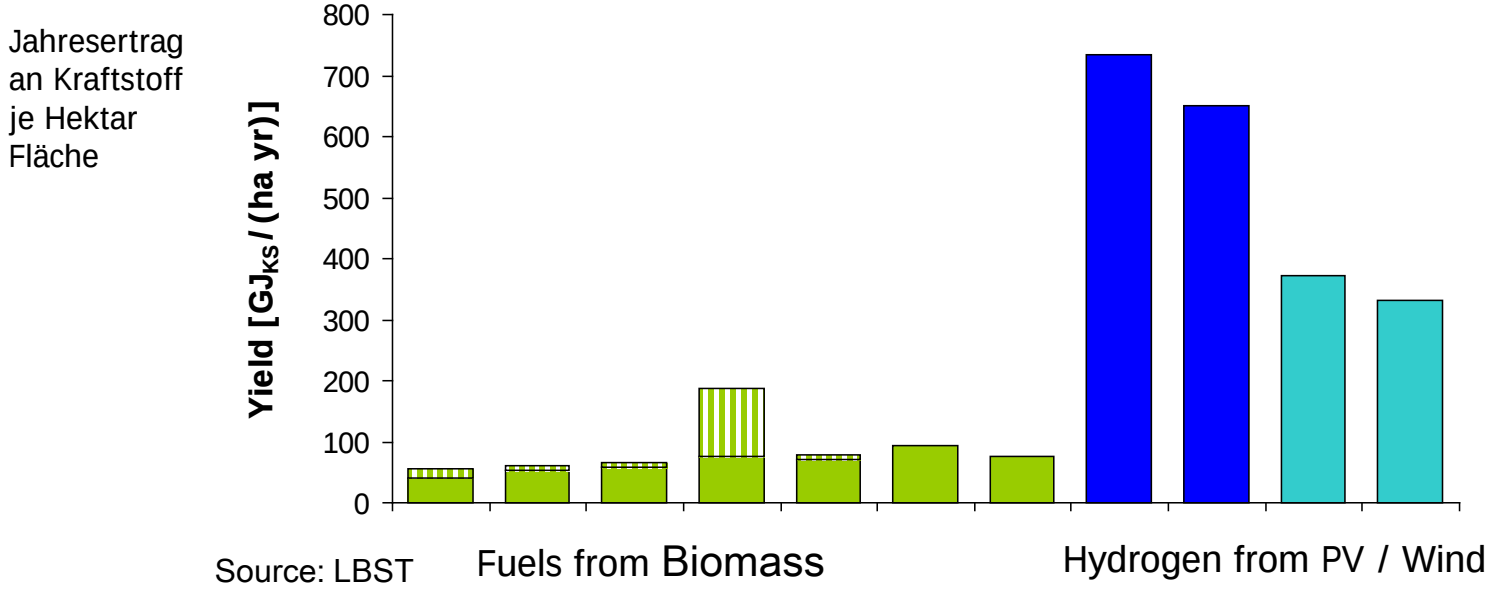
Statement 3: Biomass is not an option for the transport sector
- The agricultural area is restricted



- Competition between Food, Construction Materials, different energetic uses
- Climate change (Reduction of agricultural area)
- Demand for water (humans, food production, Industry, Energy crops)
- Fertilizer use is energy and resource consuming (e.g. Phosphorous)

=> **Biomass predominantly in statonary applications** (CHP)
only at regional level in transport sector
[e.g. Brazil, Indonesia]

Energy density of mobile Storage systems

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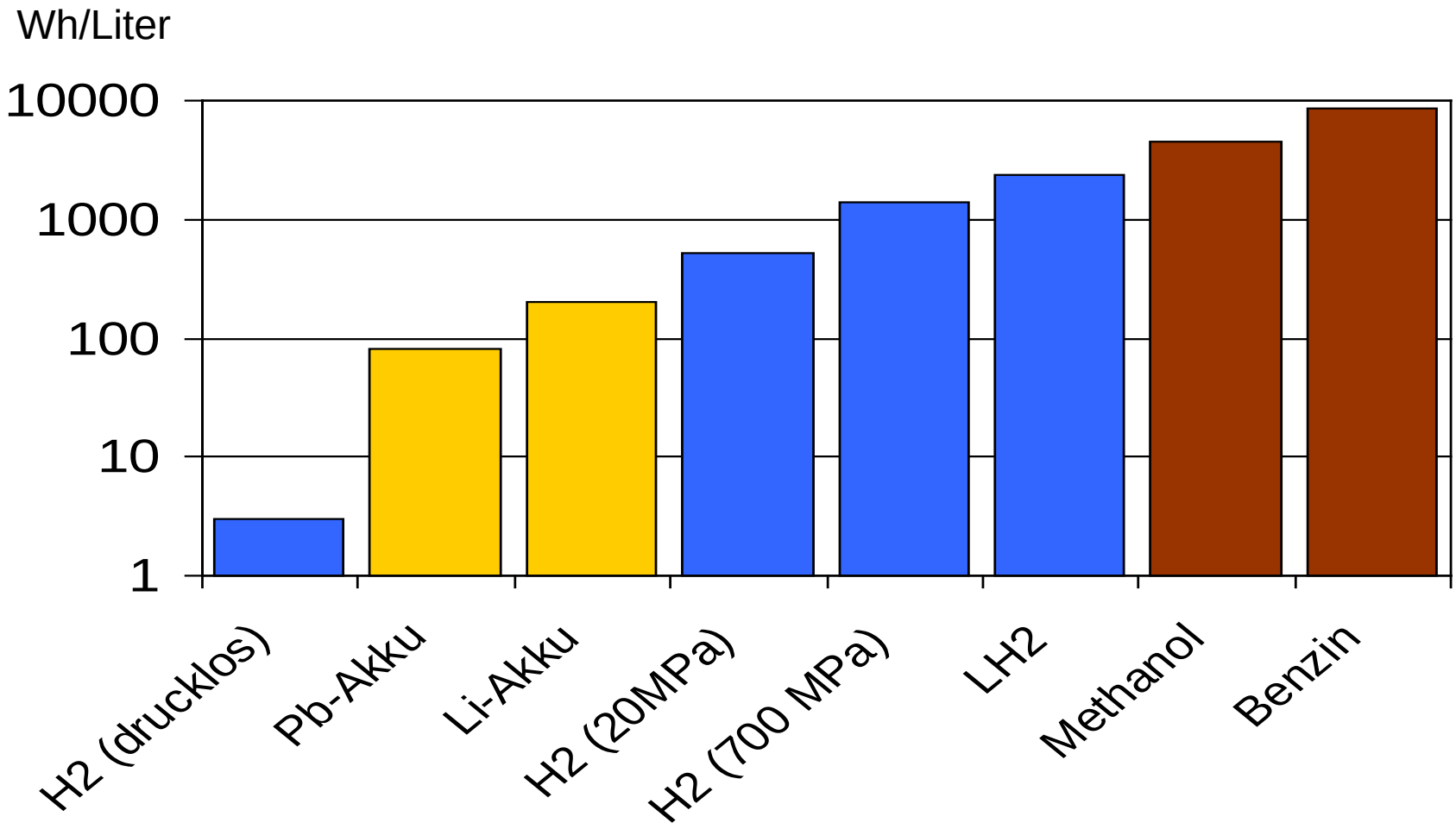

source: LBST

Energy density of mobile Storage systems

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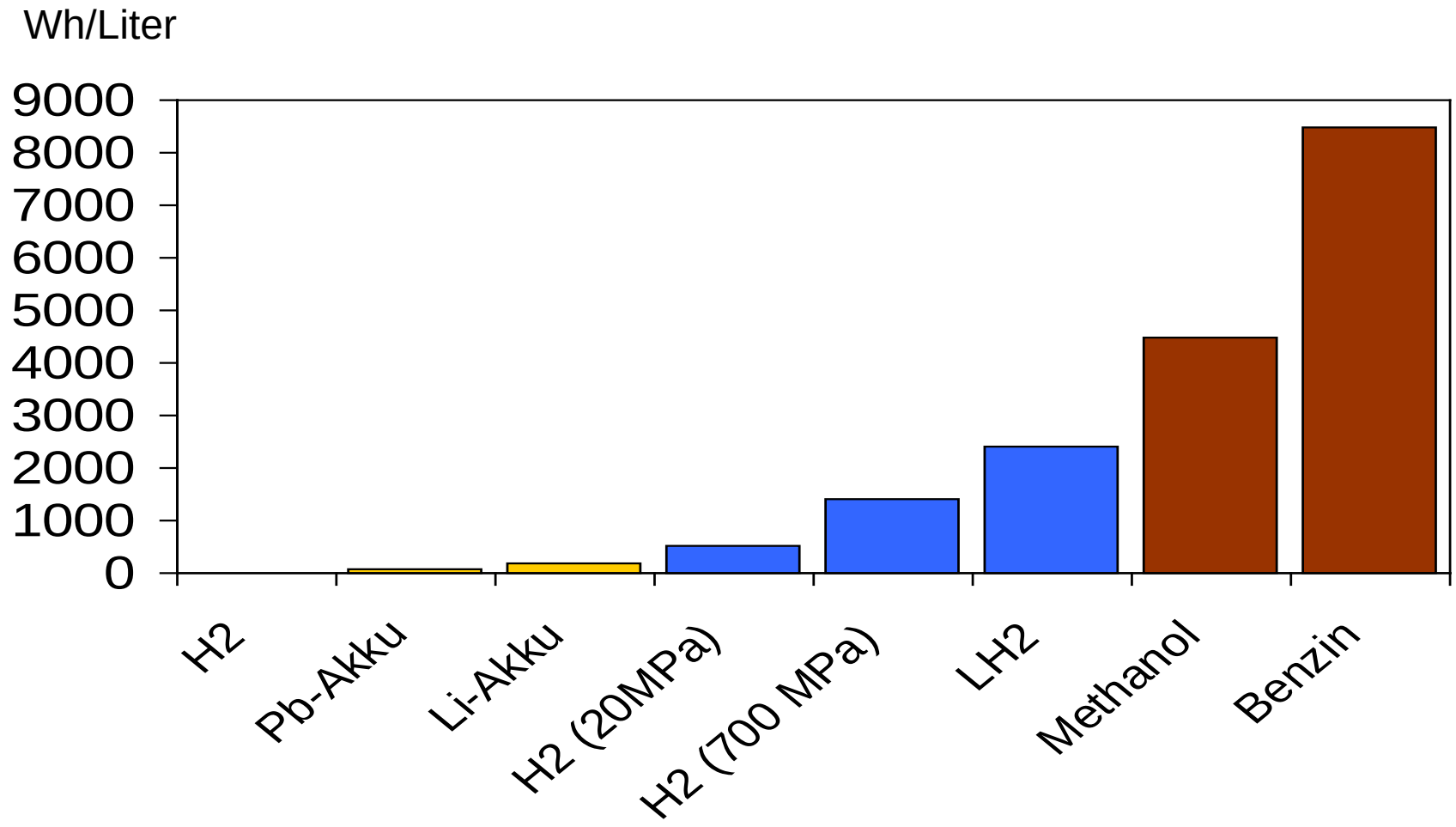

Source: LBST

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Statement 4: The transport sector goes electric

Tendencies: Internal combustion engine
Hybrid car
Plug-in Hybrid car

?

Fuel cell car

Electric car

Options:

Short Distance: Walking, Cycle, Pedelec, E-car
Medium Distance: Pedelec, Scooter, E-car, Public Urban Transport
Long Distance: Hydrogen Fuel Cell Car, CNG-Car, Biofuels (?)

Railways: Electricity, Hydrogen Fuel Cells ?
Ships: Wind, LH2, Biofuels, LNG ???
Aircraft: Kerosene, Biofuels, LH2, LNG ???

EU White Paper Roadmap to a Single European Transport Area
Towards a competitive and resource efficient transport system

28th March 2011

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Ten goals, among them:

- achieve essentially CO_2-free city logistics in major urban centres by 2030

- 30% of road freight over 300 km should shift to other modes by 2030
  To meet this goal will also require appropriate infrastructure to be developed

- By 2050, complete a European high-speed rail network

- By 2050, connect all core network airports to the rail network..,
  … ensurethat all core seaports are sufficiently connected to the rail freight
  and, where possible, inland water way system

…“growing out of oil“ will not be possible relying on a single technological solution

…. Urban Mobility Plans should be fully aligned
with Integrated Urban Development Plans

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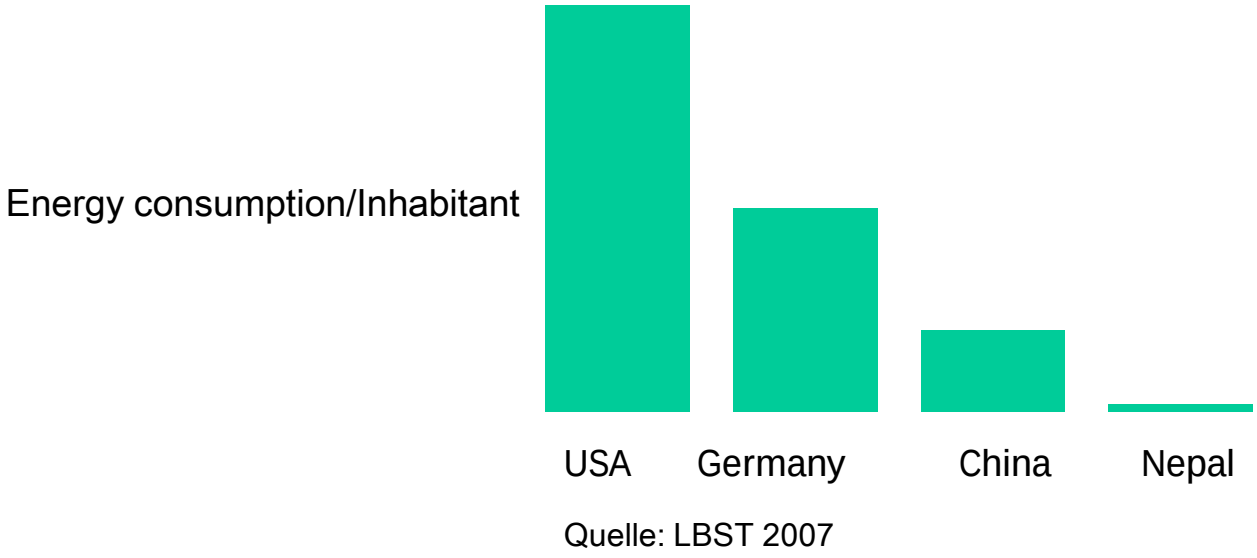
Statement 5: Industrialised nations must change their Living standard

The energy intense life style of industrialised nations is not an option for all people worldwide



Quelle: LBST 2007

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- World Energy Supply 2009
- Driving forces of Future Energy Trends
- Statements on Future Energy Supply
- General Consequences

Consequences of Peak Oil (regional):

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- Structural change (BAU is not an option):

  Challenge: Energy will become rare and expensive

  Change of economic structures:
  Transition into post fossil world

  Change of our relation to local, regional and distant activities
  Rising importance of local and regional

  Chance for new business
  Sustainable Innovations become important

  => Influence on political and social Structures?

Consequences of Peak Oil (regional):

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- Change of regional balances

  oil exporting regions
  oil importing regions

- Further conditions

  Climate Change
  Growing Population
  Food sector / Agricultura potential
  Financial crises
  Geopolitical Changes (BRIC)

- Geopolitical Factors

  Political tension („access“ to resources)
  Social tension (social imbalances)

Open questions

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Will there be shortages/ extreme price increases?
-Social conflicts (e.g. food prices)

Is there the potential for sustainable growth? Can this compensate for the Economic downturn in conventional sectors?

Will Peak Oil weaken the world economy?

What are the geopolitical consequences?

What is a robust strategy?

Will there be a sustainable transition into the post fossil world?

Summary

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- Probably, world oil production is at peak
- No other conventional fuel can substitute the missing oil

⇨ Peak oil will trigger a structural change

⇨ Today‘s economic structures are not adapted to these new conditions

⇨ The transport sector faces the largest challenge

⇨ A new balance between local, regional and distant levels must be found
(regionale Kreisläufe werden aufgewertet)
(regional cycles are revalued)

⇨ We must hurry up to find a sustainable way of living

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Thank You !

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