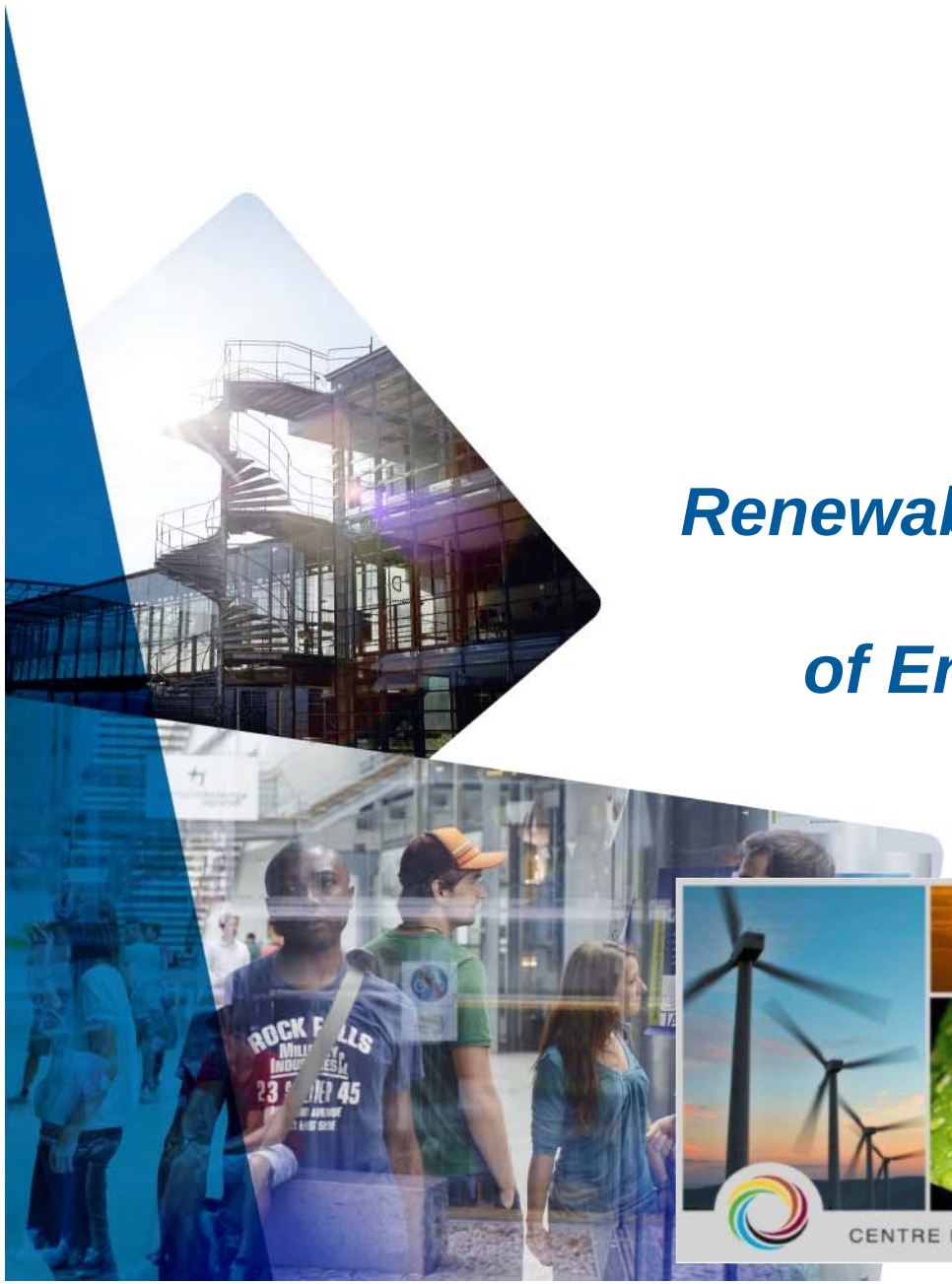
Technische Hochschule Ingolstadt
Institute of new Energy Systems



Renewable Energies in Germany – Status and Development of Energy Markets and Politics

Prof Wilfried Zörner Ph.D. 19.08.2015

Outline

Institute of new Energy Systems

I. Ingolstadt Technical University & Institute of New Energy Systems

II. Renewable Energies in Germany

III. Contact

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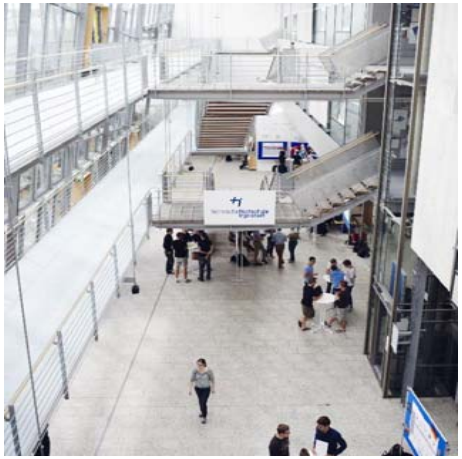
Technische Hochschule Ingolstadt

Overview



Established:	1994
Students:	~ 5.500
Professors:	110
Faculties:	3
Degrees:	Bachelor, Master
Staff Admin:	169
Staff Research:	65

- **THI Business School:**
  4 Bachelor´s / 7 Master´s degree programmes
- **Faculty of Electrical Engineering and Computer Sciences:**
  4 Bachelor´s / 5 Master´s degree programmes
- **Faculty of Mechanical Engineering:**
  6 Bachelor´s / 3 Master´s degree programmes
  ⇨ *B.Eng. programme (in German)*
  Renewable Energy Technologies

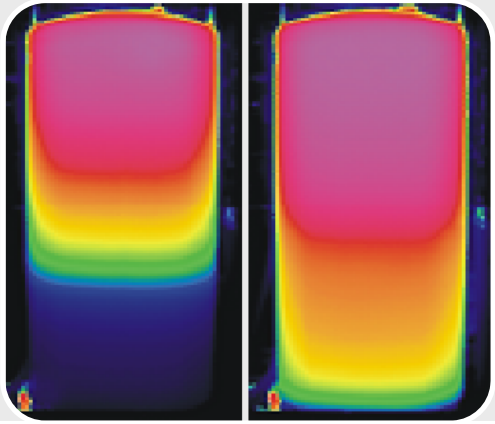
Institute of new Energy Systems (InES)

Overview

Established:	2001
Research Staff:	18
Professors:	4
Current Research Projects:	12
Current Research Grants:	€ 3.5m
Publications:	> 120
Co-operation Partners:	> 30

Institute of new Energy Systems (InES)

Fields of Research



Bioenergy Technology

- ***Wood-Fired Power Stations***
  - → Flexible Operation on Demand (Electricity/Heat)
  - → Closed Loop Supply of Industrial Parks
- ***Biogas Research***
  - → Ecological and Economic Plant Optimisation
  - → Controllable Electricity Production
  - → Biogas Upgrading

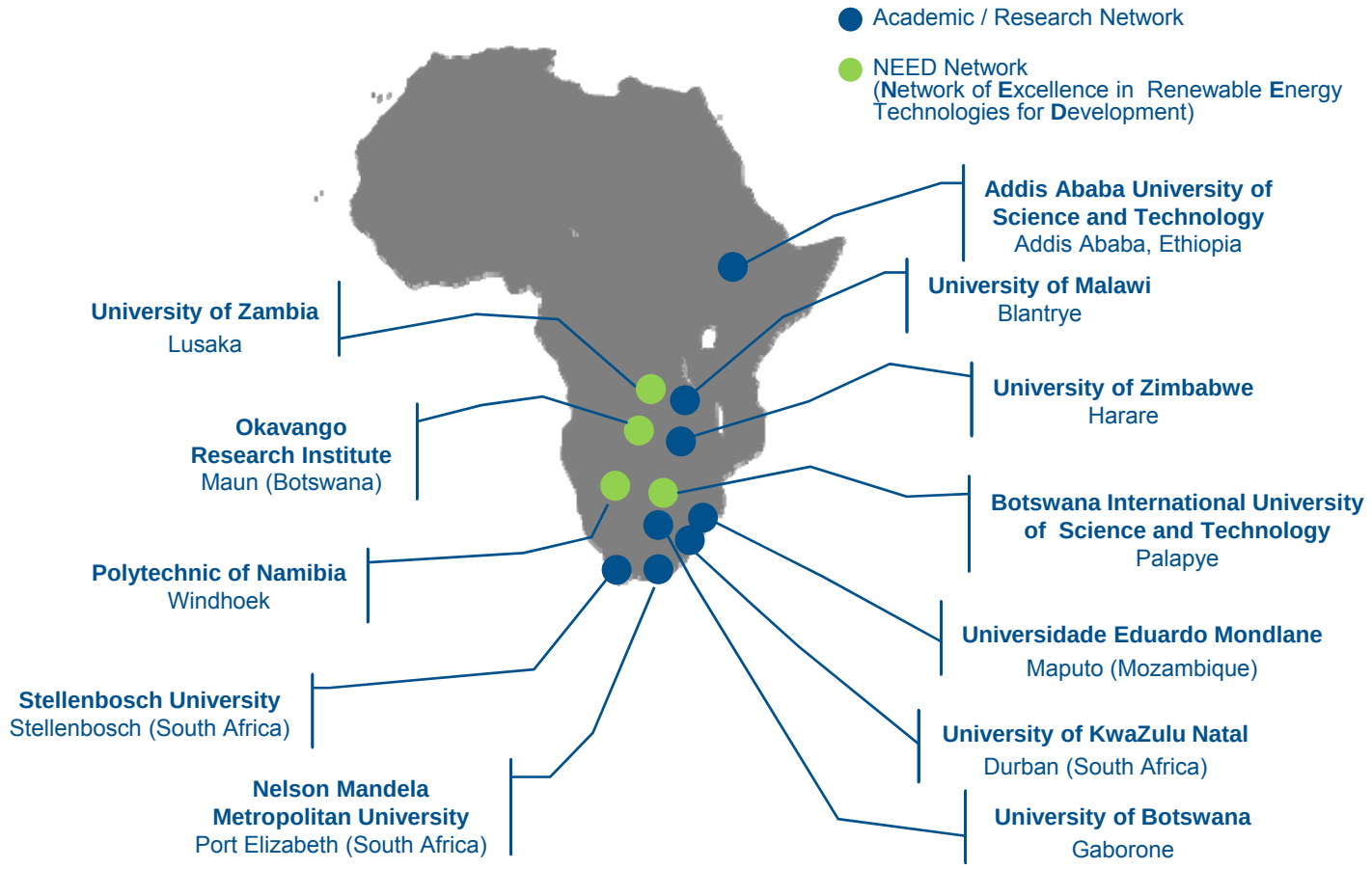
Energy Systems Technology

- Local / Regional Energy Concepts
- Local / District Heating Systems
- Combined Heat and Power and Cooling Systems
- Energy Efficiency in Industry
- Electricity Grid Integration
- Energy Storage Technologies

Solar Energy Technology

- Photovoltaics
  On-grid and Off-grid
- Solar Heating and Cooling
- ***Solar-Thermal Collector Research***
  - → Conceptual and Design Optimisation
  - → New Materials and Production Processes
  - → Solar Collector Testing

- Co-operative research and higher education projects with science and business centres in Africa



Institute of new Energy Systems (InES)

NEED: Network of Excellence in Renewable Energy Technologies for Development

Overview NEED Project	
Location	Zambia, Namibia and Botswana
Duration	36 months
Total Project Budget	€ 1.2 m
Start	01 March 2014

University of Zambia

Network of Energy Excellence for Development

- Challenges
  - Development and application of renewable energy technologies (RET) in Southern African countries still undermined
  - Despite ambitious renewable energy plans in BW, NAM and Z and numerous activities in the past, there is still a lack of knowledge and skilled workforce
  - Although the potential of renewable energies has been recognised, governments remain resistant – mainly small-scale research and enterprises have developed
- Overall Objective
  - Inter-link policy makers, research institutes and stakeholders of the private sector to promote innovation in RET

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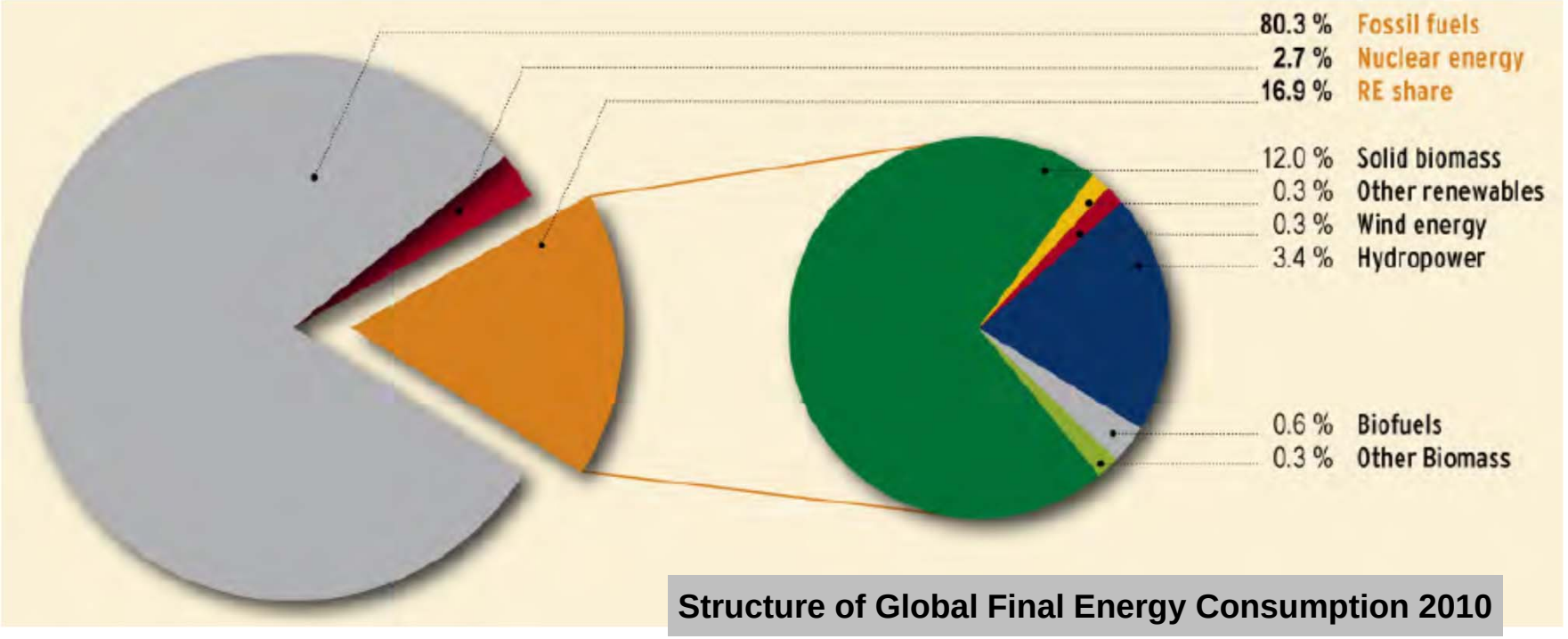
Renewable Energies in Germany (1)

Global Use of Renewable Energies (1)



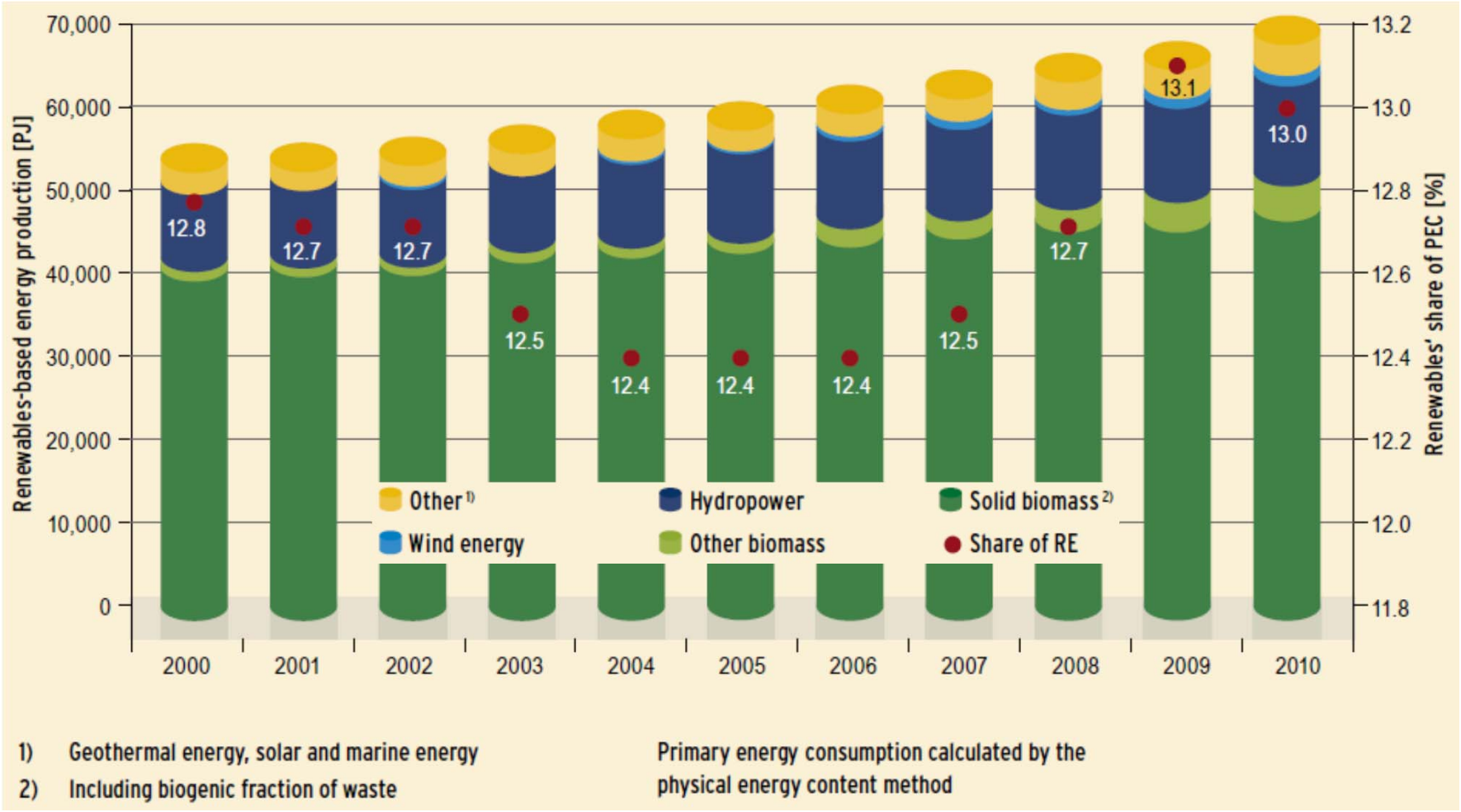
Structure of Global Final Energy Consumption 2010

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Ed.) (2013) *Renewable Energy Sources in Figures – National and International Development*. Berlin, July 2013, p 76

Renewable Energies in Germany (2)

Global Use of Renewable Energies (2)

Development of Global Renewables-Based Primary Energy Production and the Renewables Share of Primary Energy Consumption



Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Ed.) (2013) *Renewable Energy Sources in Figures – National and International Development*. Berlin, July 2013, p 78

Renewable Energies in Germany (3)

Global Use of Renewable Energies (3)

Institute of new Energy Systems

Top Ten Investors in the Renewable Energy Sector

Rank	Country	2011 EE-Investment [1]	2010 EE-Investment [1]
		[bn USD]	
1	USA	48.0	33.7
2	China	45.5	45.0
3	Germany	30.6	32.1
4	Italy	28.0	20.2
5	Rest of EU	11.1	15.2
6	India	10.2	6.6
7	Unit. Kingdom	9.4	7.0
8	Japan	8.6	7.0
9	Spain	8.6	6.9
10	Brazil	8.0	6.9

1) Private-sector investment

Top Ten Countries/Regions Related to Installed Renewable Energy Capacity 2011

Country	Total renewables-based power capacity	Capacity per capita	Total renewables-based power capacity
	excluding hydropower		including hydropower
	[GW]	[kW/inhabitant]	[GW]
China	70	0.05	282
USA	68	0.22	147
Germany	61	0.75	65
Spain	28	0.60	48
Italy	22	0.37	40
India	20	0.02	62
Japan	11	0.09	39
EU	**174**	**0.35**	**294**
World	**390**	**0.06**	**1,360**

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Ed.) (2012) *Renewable Energy Sources in Figures – National and International Development*. Berlin, July 2012, p 90

Renewable Energies in Germany (4)

Germany´s Situation at a Glance (1)

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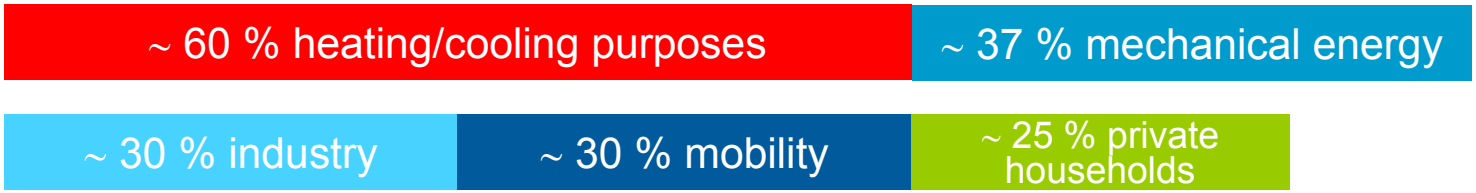
Energy (rough 2013 figures)

- Total final energy consumption: 2,575 TWh – of which



- Total electricity consumption: 630 TWh – of which

- Energy import rate: 71 % – equivalent to ~ ZAR 1,100 bn (2008; + 53 % against 2005)

Natural Resources

- Bio-energy: densely populated, very limited area of cultivable land
- Solar energy: low irradiation (~ 950…1,100 kWh/m²·a)
- Wind energy: densely populated, short coastline

Renewable Energies in Germany (5)

Germany´s Situation at a Glance (2)

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Politics

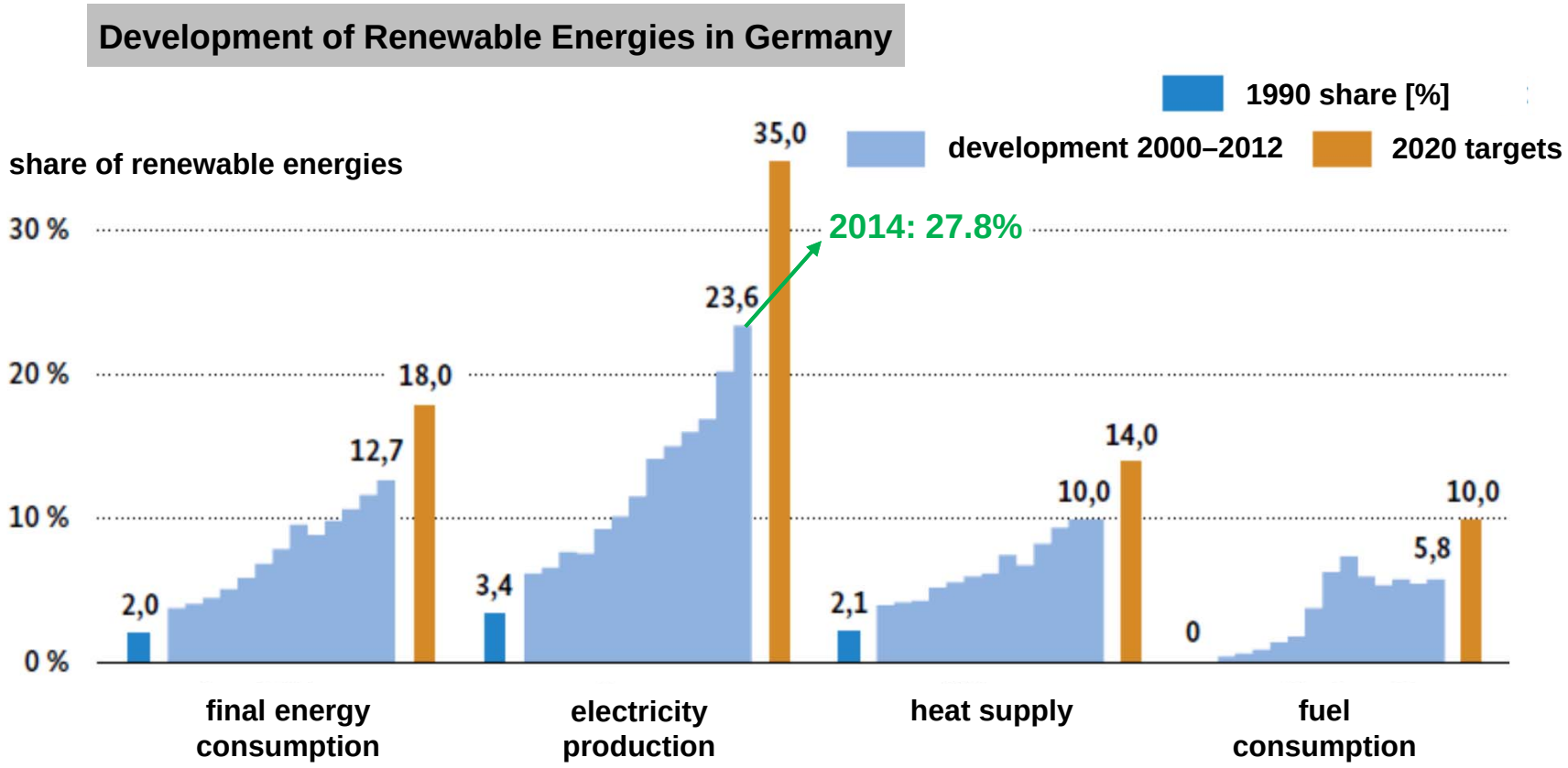
- Part of European Framework for Climate and Energy (→ partly more ambitious than EU!):
  - climate protection: reduction of CO_2 emissions by 40 % (2020) compared to 1990
  - share of renewable energies of final energy consumption: 18 % (2020), 30 % (2030)
  - share of renewable energies of electricity production: 35 % (2020), 50 % (2030)
- Nuclear phase-out:
  - 8 power stations in 2011 (8.8 GW_{el}), 9 power stations by 2022 (12.7 GW_{el})
  - search for nuclear waste repository still ongoing (→ limited options)
  - Decommissioning of power plants to be taken over by operators (≥ ZAR 500 bn!)
- Current government: pro-business

Economy

- Energy markets (electricity, gas, oil, heat): completely liberalized
  (→ 4 big private electricity producers with 85 % share of production)
- German economy: still growing despite global crisis

Renewable Energies in Germany (6)

Development of Renewables in Germany

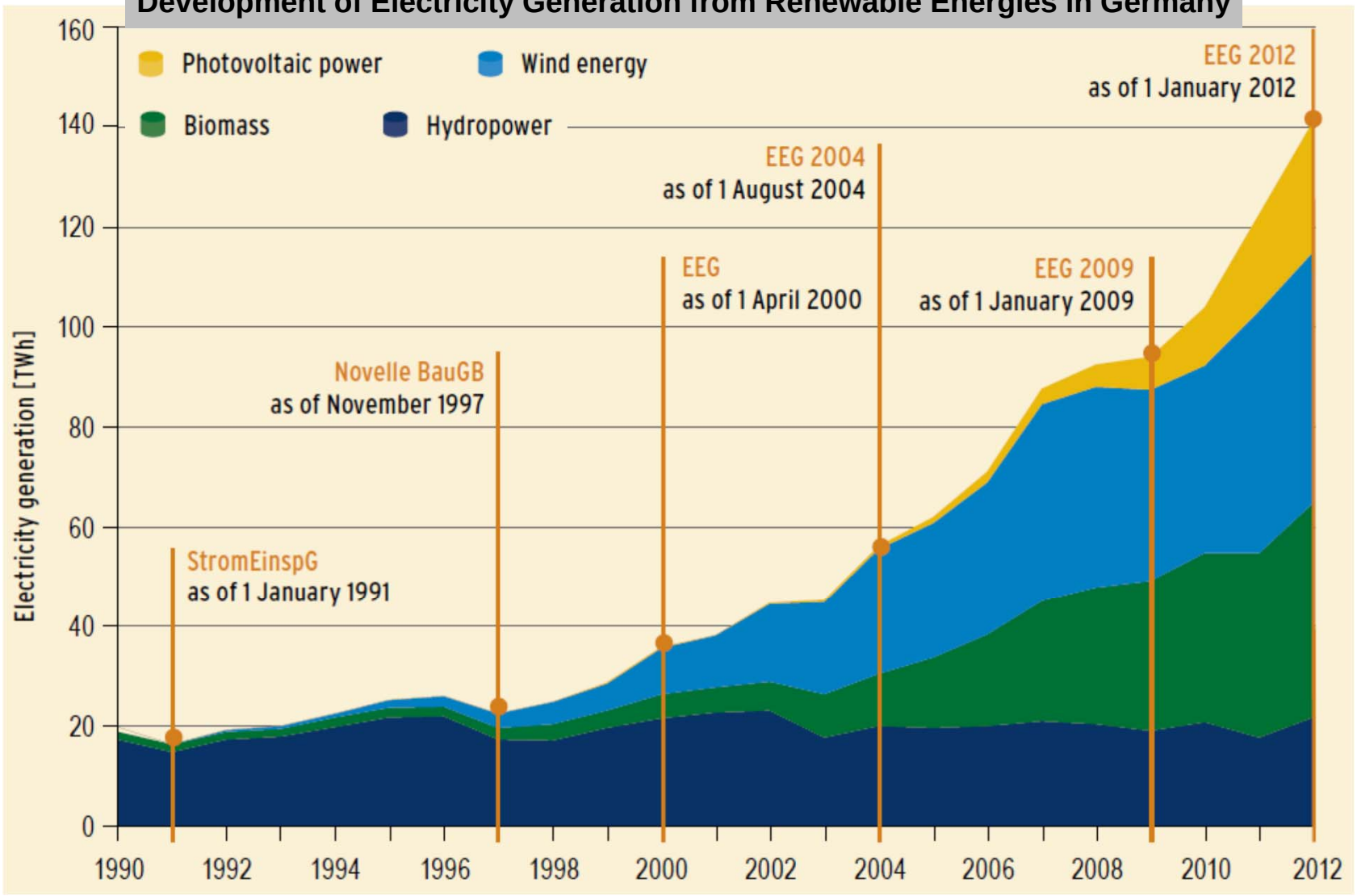


Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Ed.) (2014) *Klimaschutz in Zahlen – Fakten, Trends und Impulse deutscher Klimaschutzpolitik*. Berlin, June 2014, p 37

Renewable Energies in Germany (7)

Development of Renewable Electricity Generation in Germany (1)

Development of Electricity Generation from Renewable Energies in Germany

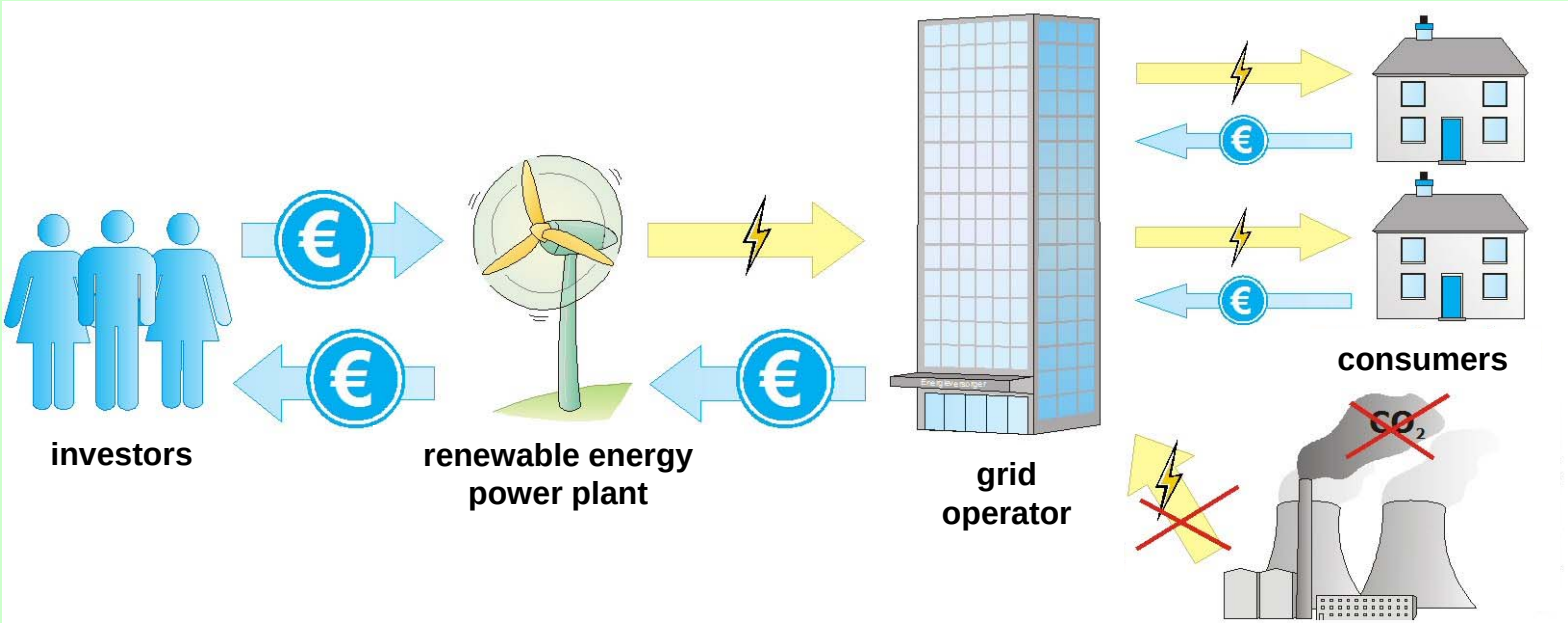


Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Ed.) (2013) *Erneuerbare Energien in Zahlen – Nationale und internationale Entwicklung*. Berlin, July 2013, p 15

Act on Granting Priority to Renewable Energy Sources

(Renewable Energy Sources Act - EEG)

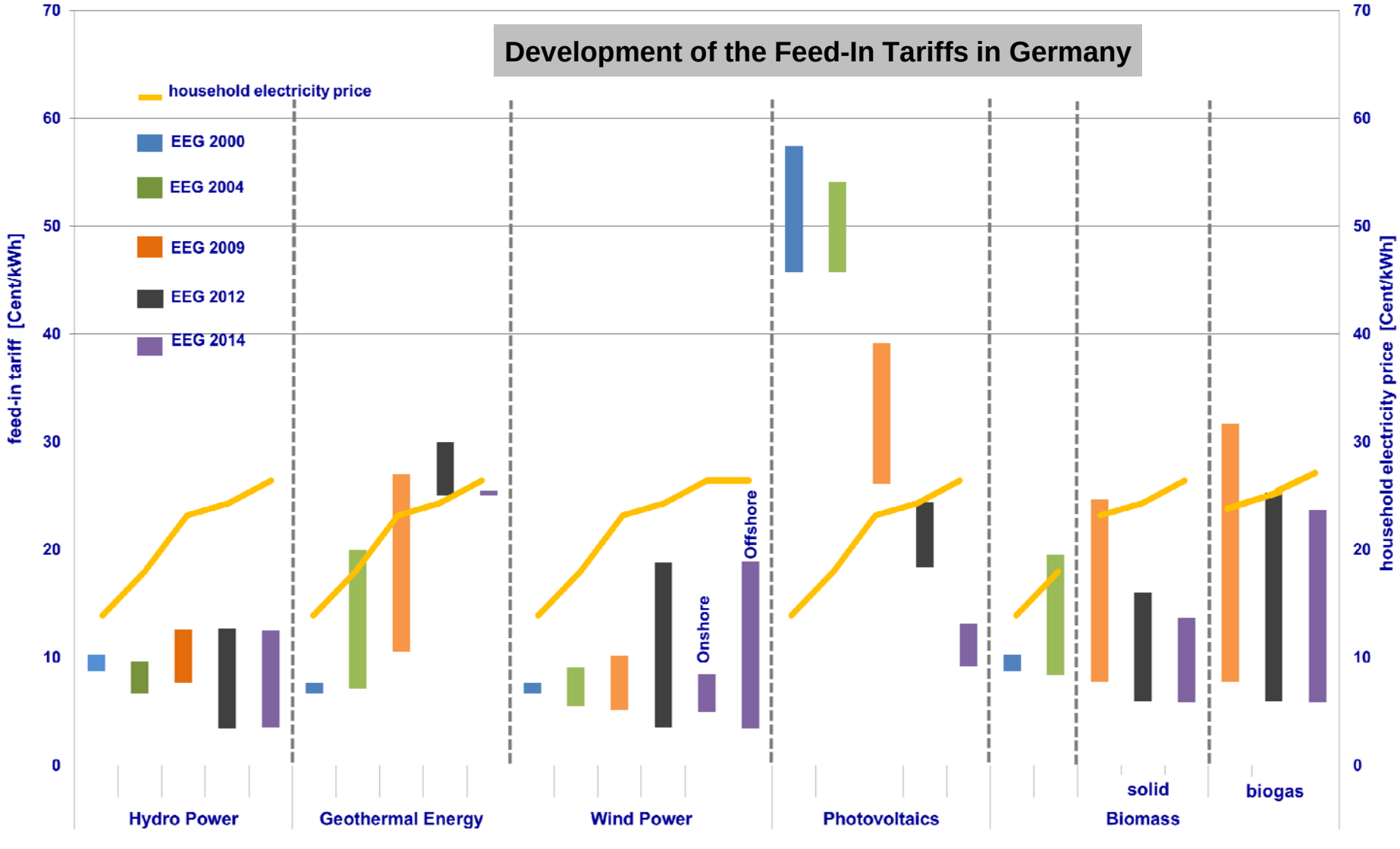
Target: Accelerated market launch of technologies for electricity production from renewable energy sources, i.e. wind energy, solar energy, biomass, geothermal energy, hydro power, also landfill and sewer gas



Quaschning V. (2009) *Regenerative Energiesysteme*. 6. edition, Hanser Verlag, München, p 364

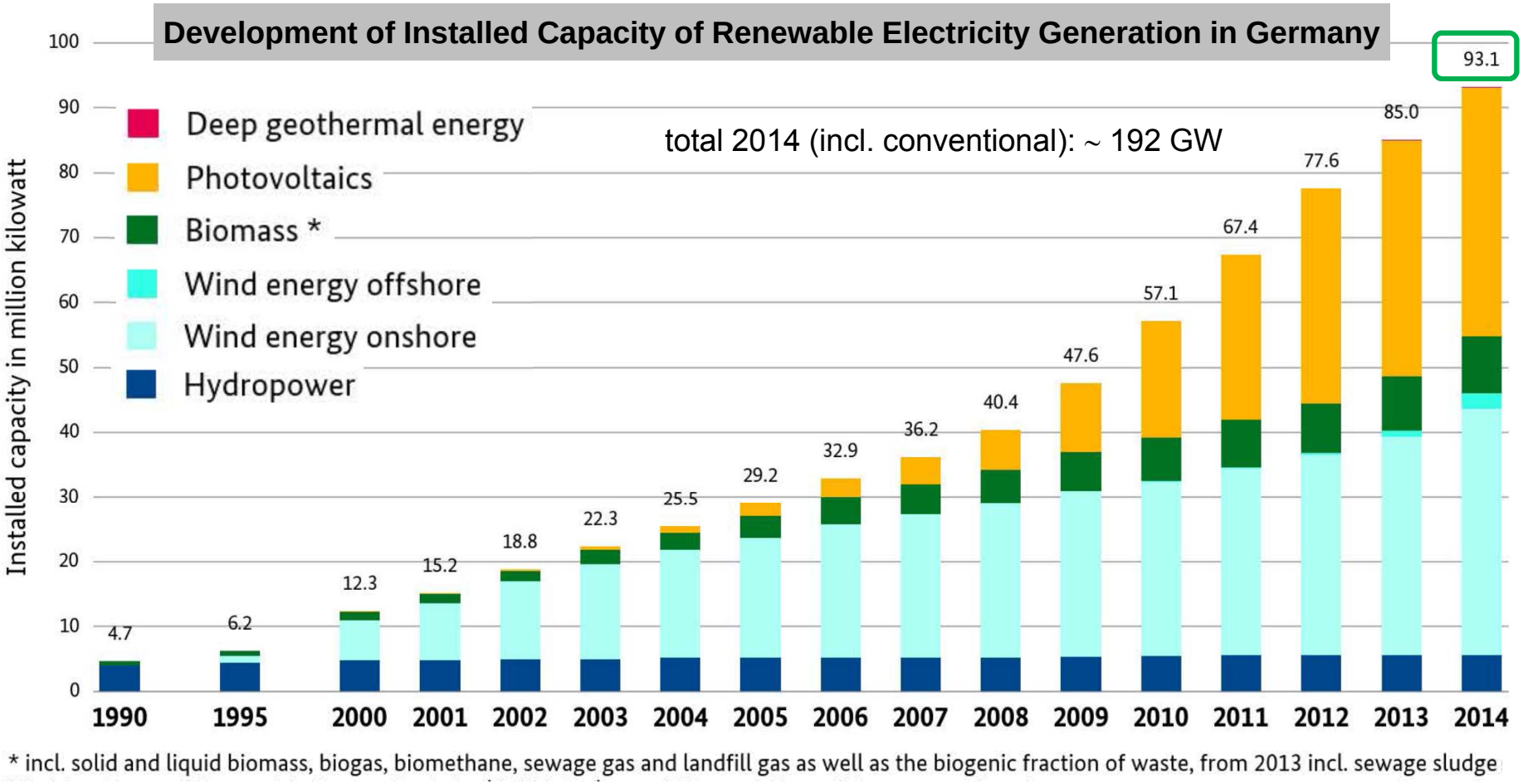
Renewable Energies in Germany (9)

Development of Renewable Electricity Generation in Germany (3)



Renewable Energies in Germany (10)

Development of Renewable Electricity Generation in Germany (4)

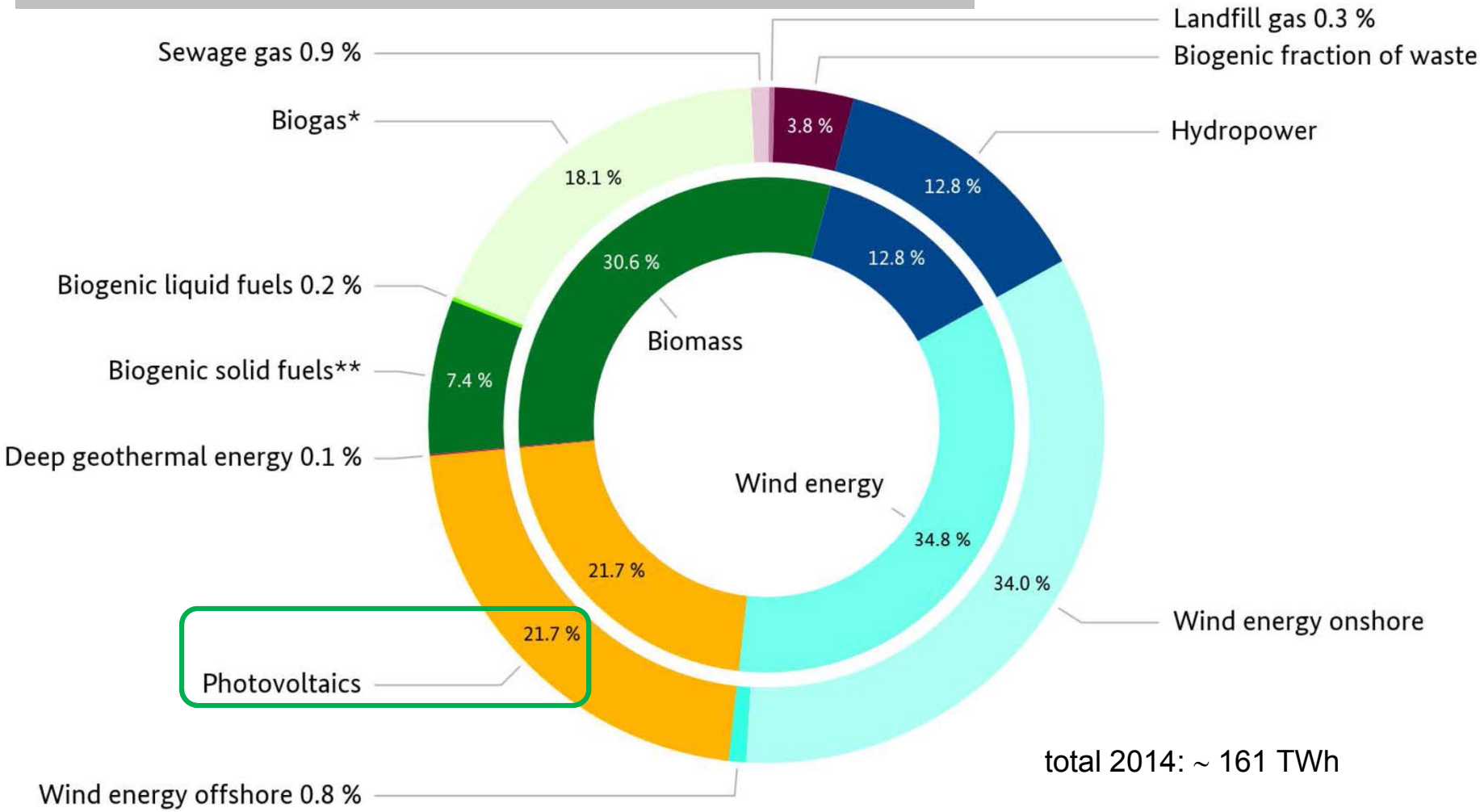


Bundesministerium für Wirtschaft und Energie (Ed.) (2015) *Development of Renewable Energy Sources in Germany 2014*. Berlin, February 2015, p 19

Renewable Energies in Germany (11)

Development of Renewable Electricity Generation in Germany (5)

Electricity Generation from Renewable Energies in Germany 2014

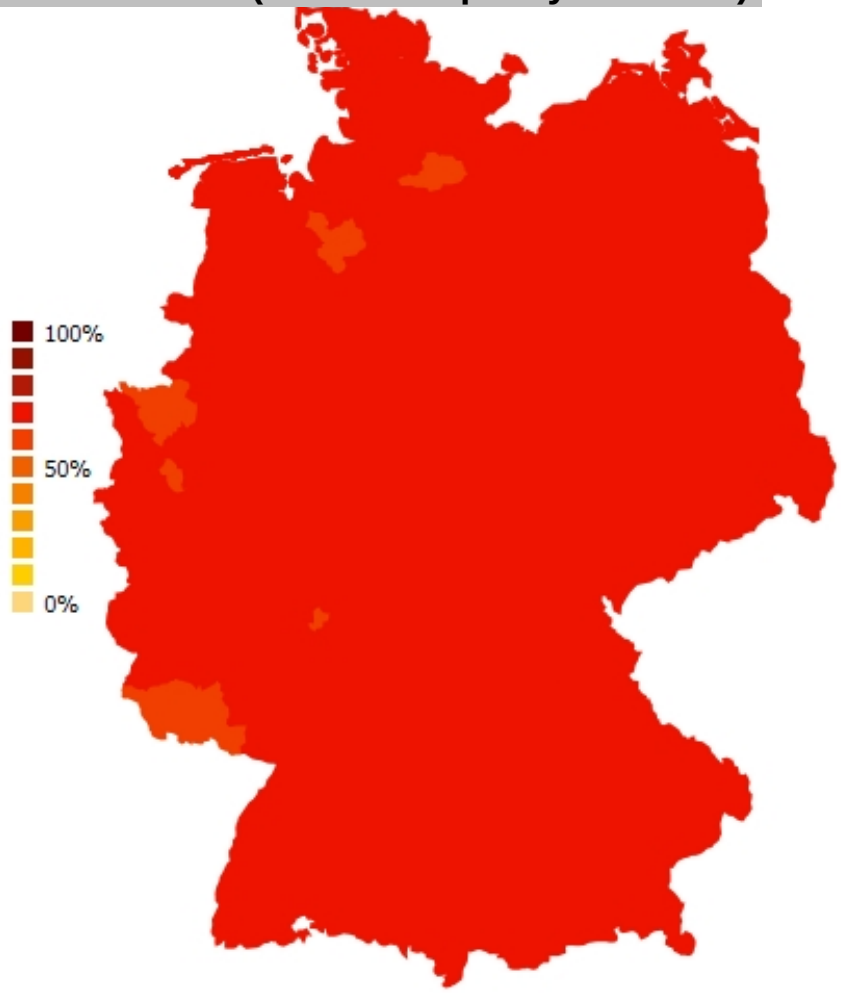


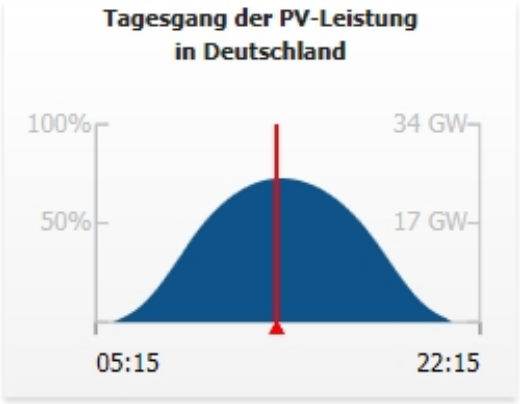
Bundesministerium für Wirtschaft und Energie (Ed.) (2015) *Development of Renewable Energy Sources in Germany 2014*. Berlin, February 2015, p 19

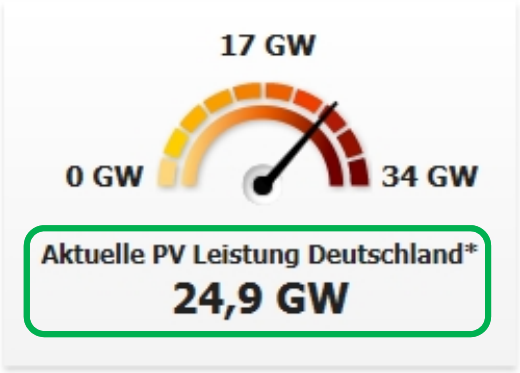
Renewable Energies in Germany (12)

Development of Renewable Electricity Generation in Germany (6)

Photovoltaic Electricity Generation in Germany on July21st 2013 at 13h15 (total PV Capacity: ~ 34 GW)







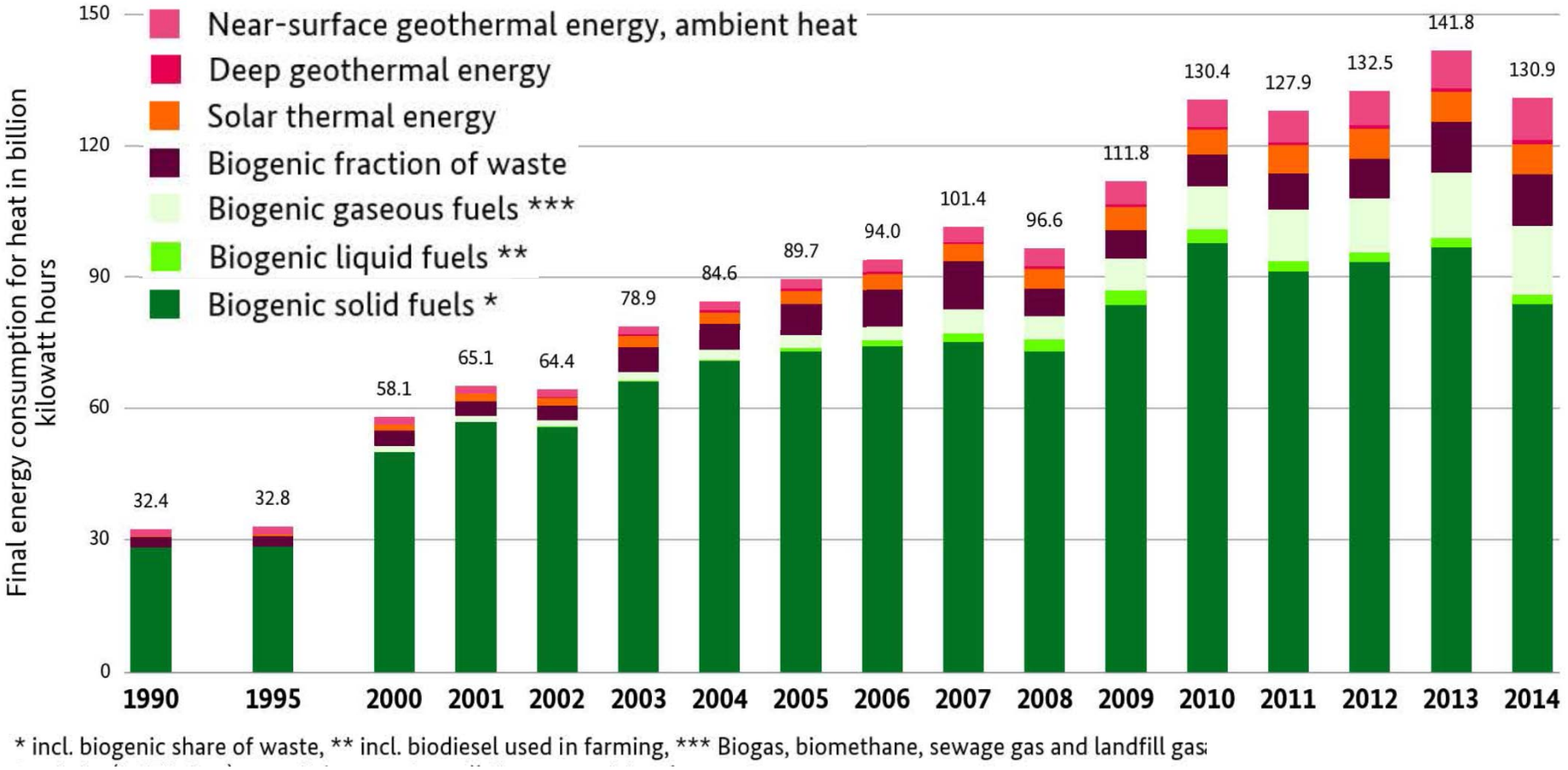
*Hochgerechnete Leistung aller lt. Bundesnetzagentur am Stichtag 30.06.2013 installierten PV-Anlagen mit insgesamt 34,24 GW Nennleistung.

SMA Solar Technology AG (n.d.) *Das leistet Photovoltaik in Deutschland* [WWW] available from: http://www.sma.de [accessed: 16.08.2015]

Renewable Energies in Germany (13)

Development of Renewable Heat Generation in Germany (1)

Development of Heat Consumption from Renewable Energy Sources in Germany

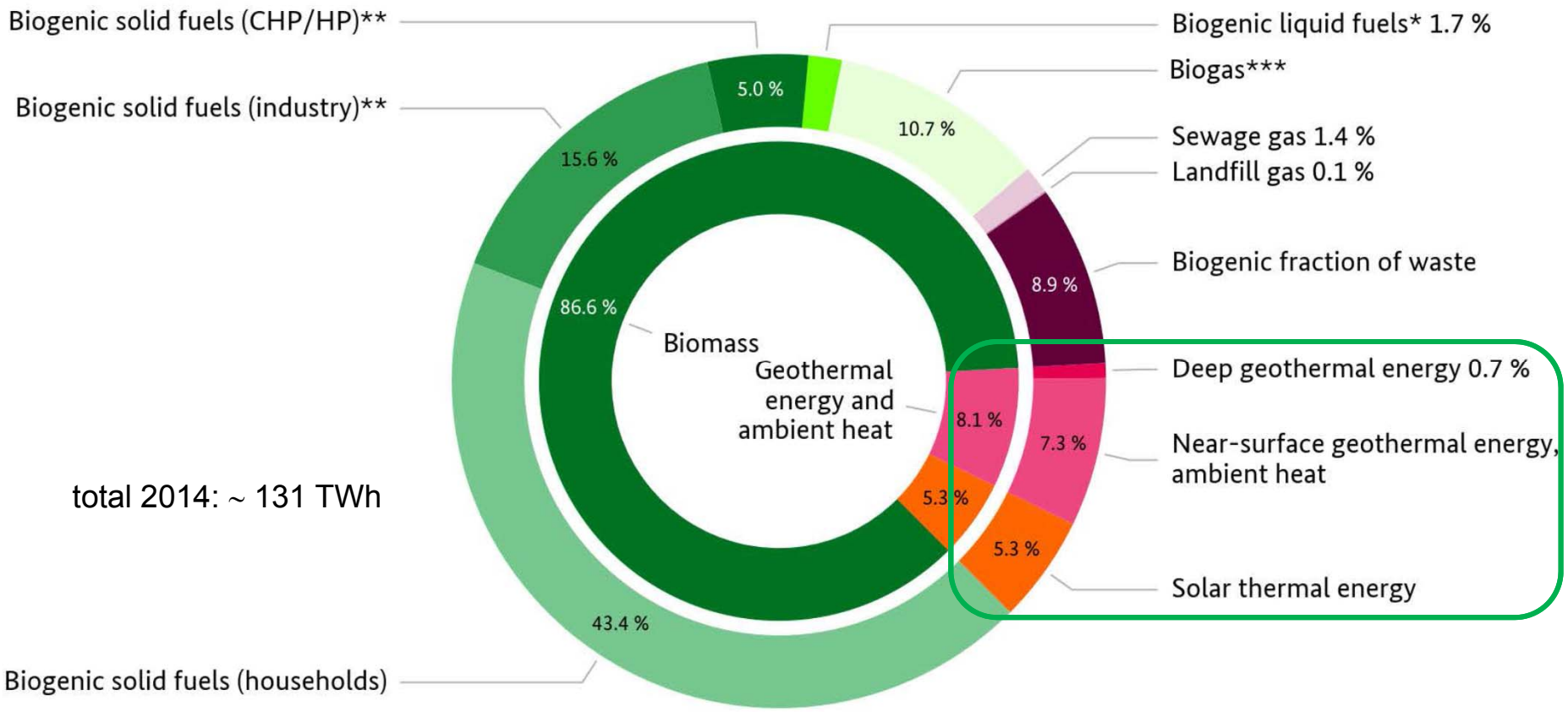


Bundesministerium für Wirtschaft und Energie (Ed.) (2015) *Development of Renewable Energy Sources in Germany 2014*. Berlin, February 2015, p 21

Renewable Energies in Germany (14)

Development of Renewable Heat Generation in Germany (2)

Renewables-Based Heat Consumption in Germany 2014



total 2014: ~ 131 TWh

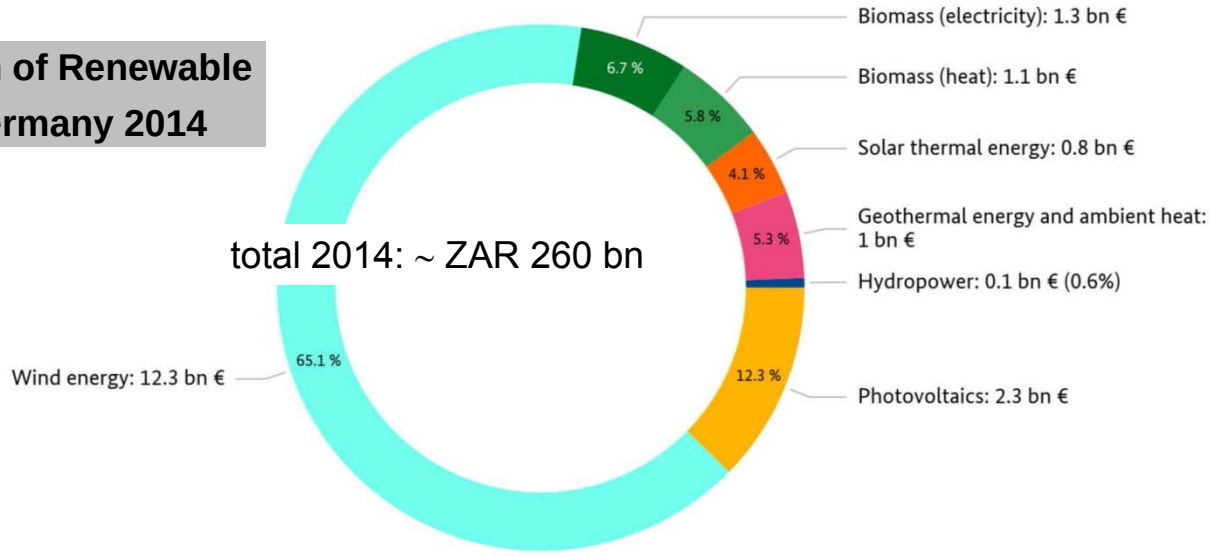
* incl. biodiesel used in farming, ** incl. biogenic share of waste, *** biogas, biomethane, sewage gas and landfill gas

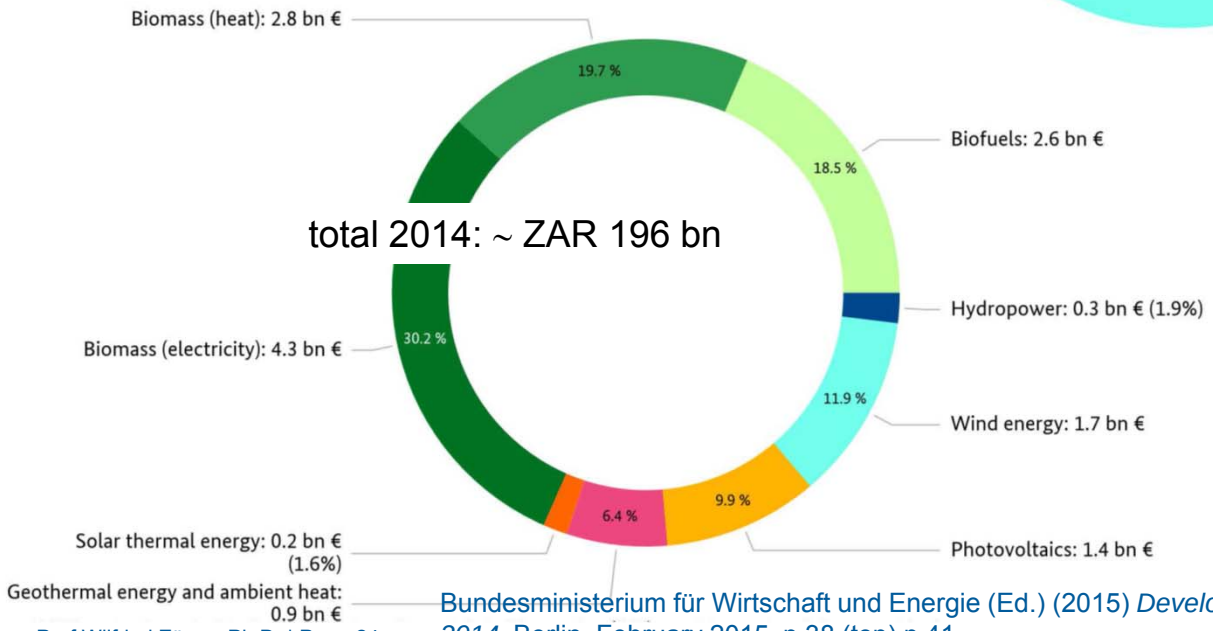
Bundesministerium für Wirtschaft und Energie (Ed.) (2015) *Development of Renewable Energy Sources in Germany 2014*. Berlin, February 2015, p 19

Renewable Energies in Germany (15)

Economic Dimension of Renewables in Germany (1)

Investments in Construction of Renewable Energy Installations in Germany 2014





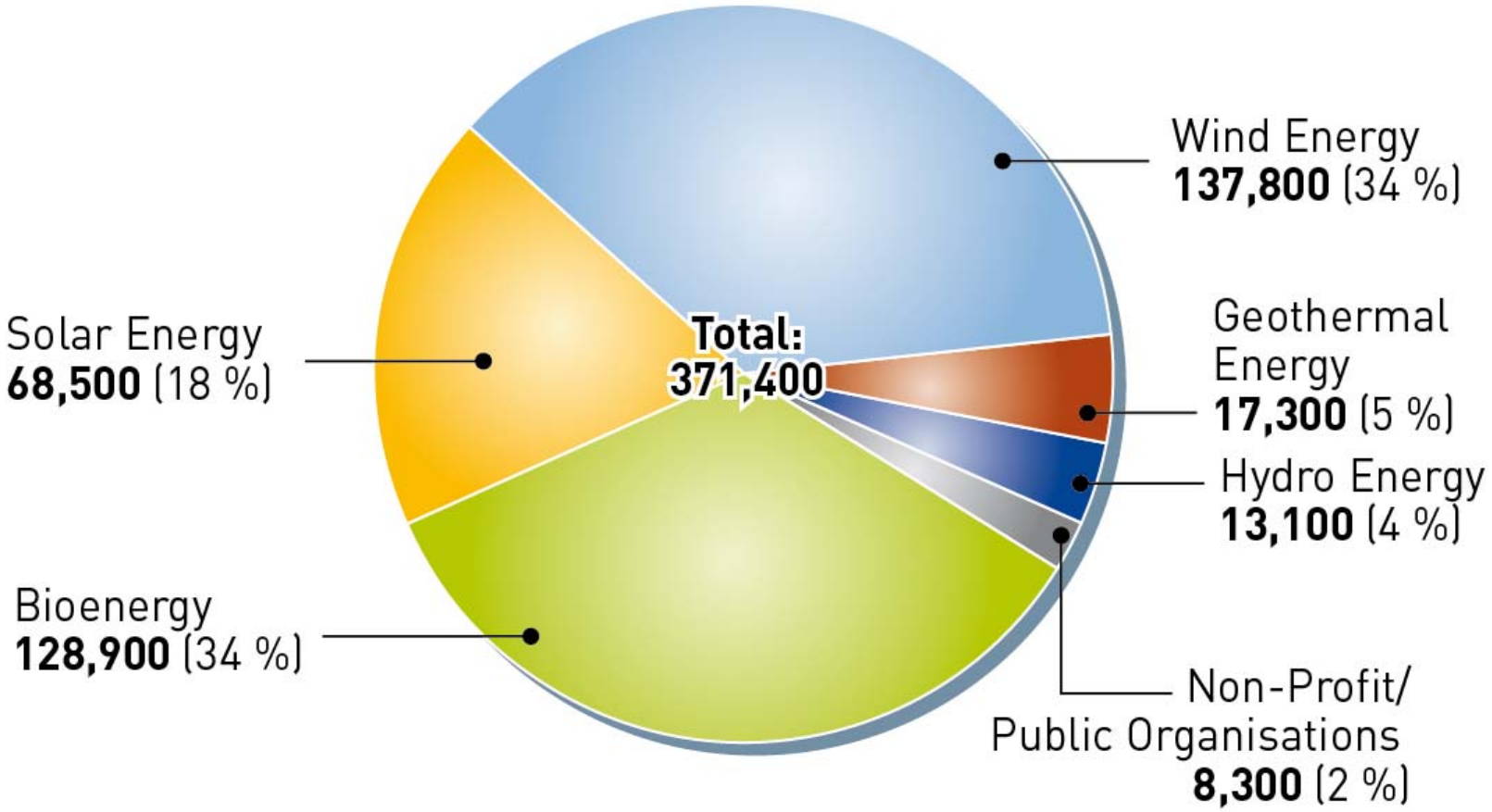
Turnover from the Operation of Renewable Energy Installations in Germany 2014

Bundesministerium für Wirtschaft und Energie (Ed.) (2015) *Development of Renewable Energy Sources in Germany 2014*. Berlin, February 2015, p 38 (top) p 41

Renewable Energies in Germany (16)

Economic Dimension of Renewables in Germany (2)

Employees in Different Renewable Energy Sectors in Germany 2013



Agentur für Erneuerbare Energien (2015) *Good Reasons – Job Engine* [WWW] available from: http://www.unendlich-viel-energie.de [accessed: 16.08.2015]

Renewable Energies in Germany (17)

Roots of Success of Renewables in Germany

Institute of new Energy Systems

Population

- Very sensitive regarding environmental and health issues
  - Green Party elected into government end of 1990s
  - government forced to abandon nuclear power after Fukushima disaster

→ Transition from Nuclear / Fossil-Based to Renewable Electricity Production → 'Energiewende'

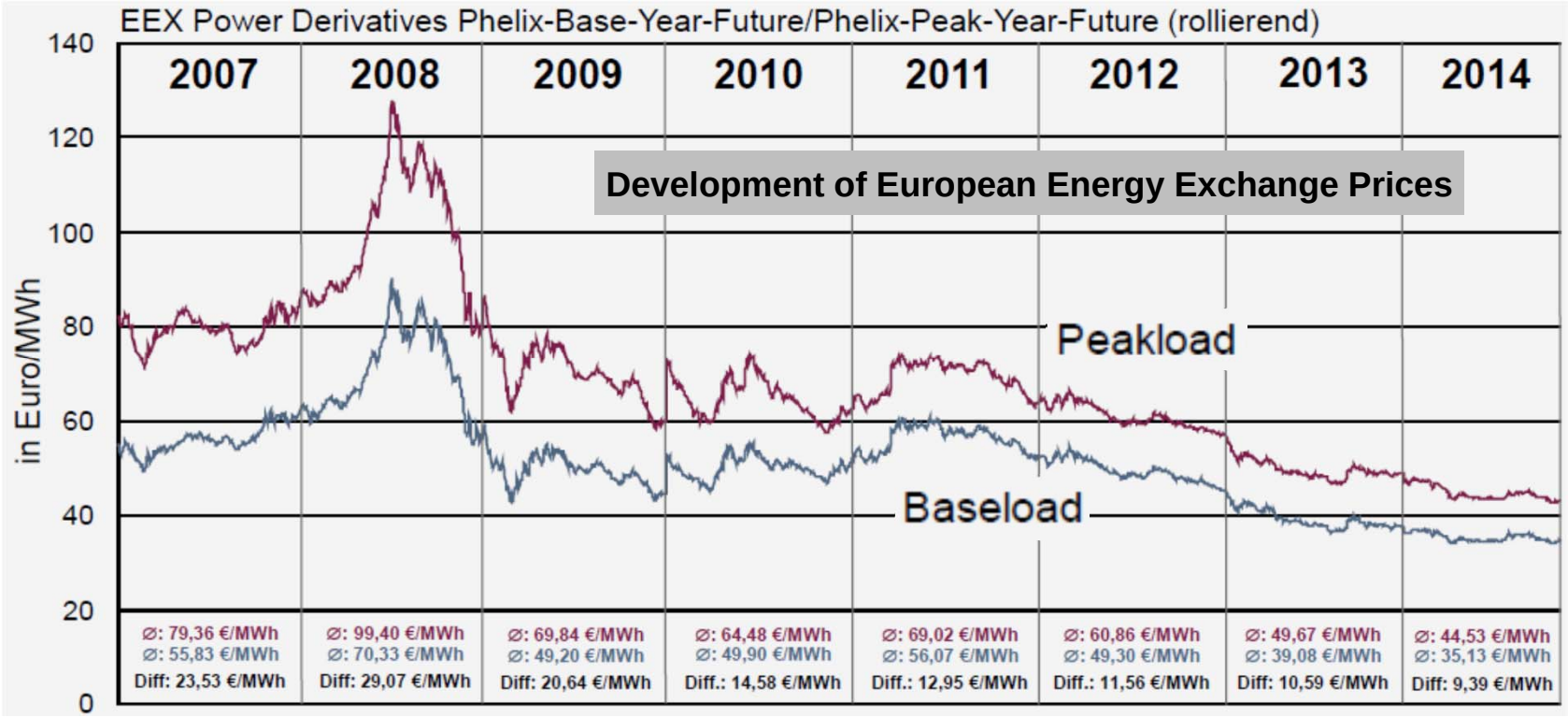
- Despite high cost, 92 % support the increased use of renewable energies (2014)!

Government

- Very consequently implemented liberalisation of German energy markets end of 1990s (→ electricity and gas, production and distribution)
- Generated 'Renewable Energy Sources Act' (end of 1990s), not based on tax financed subsidies but distribution of extra cost between all electricity consumers
- Generated financial support programme to enable private investments in renewable power generation

Massive Over-Capacities in Electricity Production

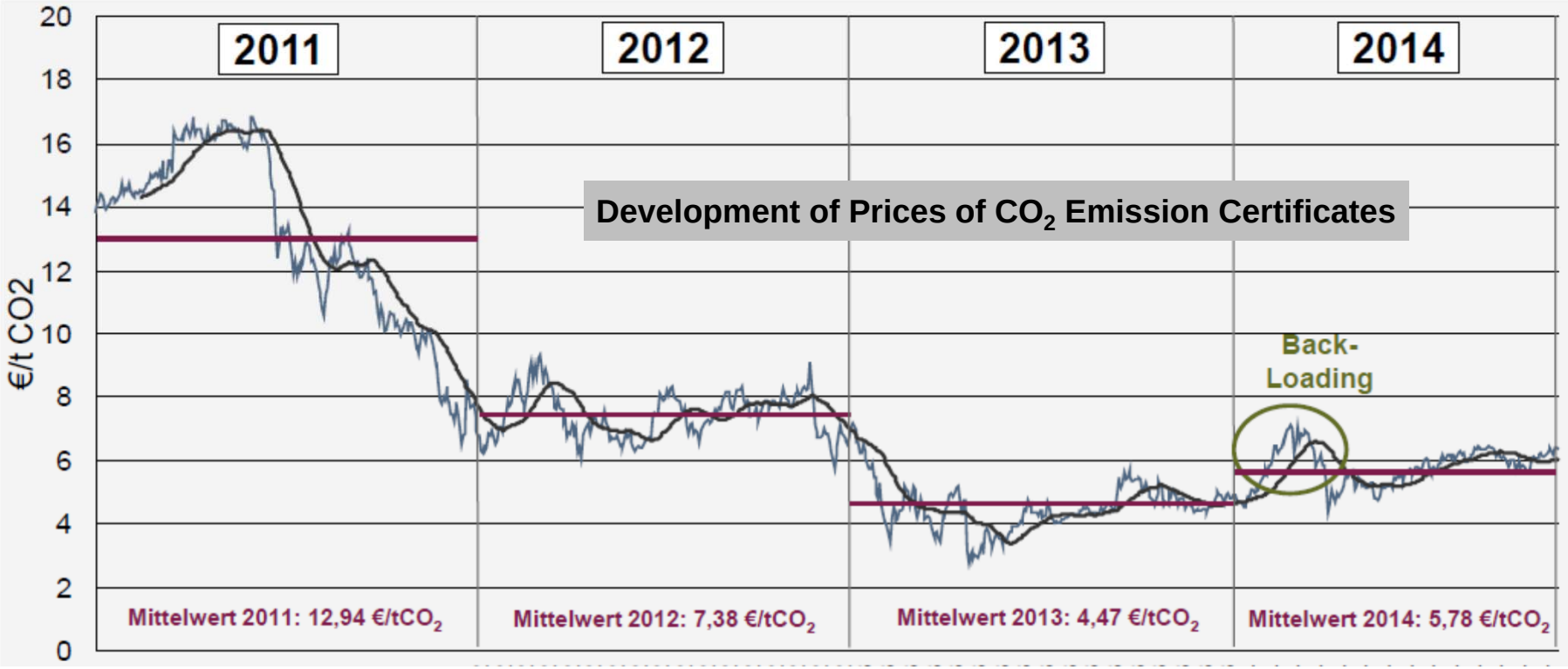
- Additional installation of renewable-based power stations, however,
  no reduction of conventional electricity generation ⇨ EEX prices drop dramatically



Kuhlmann A. (2014) *Entwicklung des Kraftwerksparks in Deutschland und Bayern*. Energiedialog Bayern AG 4 „Versorgungssicherheit - Strombedarf, gesicherte Leistung, dezentrale vs. zentrale Versorgungsstrukturen“, München, 21.11.2014, p 5

Massive Over-Capacities in Electricity Production (cont.)

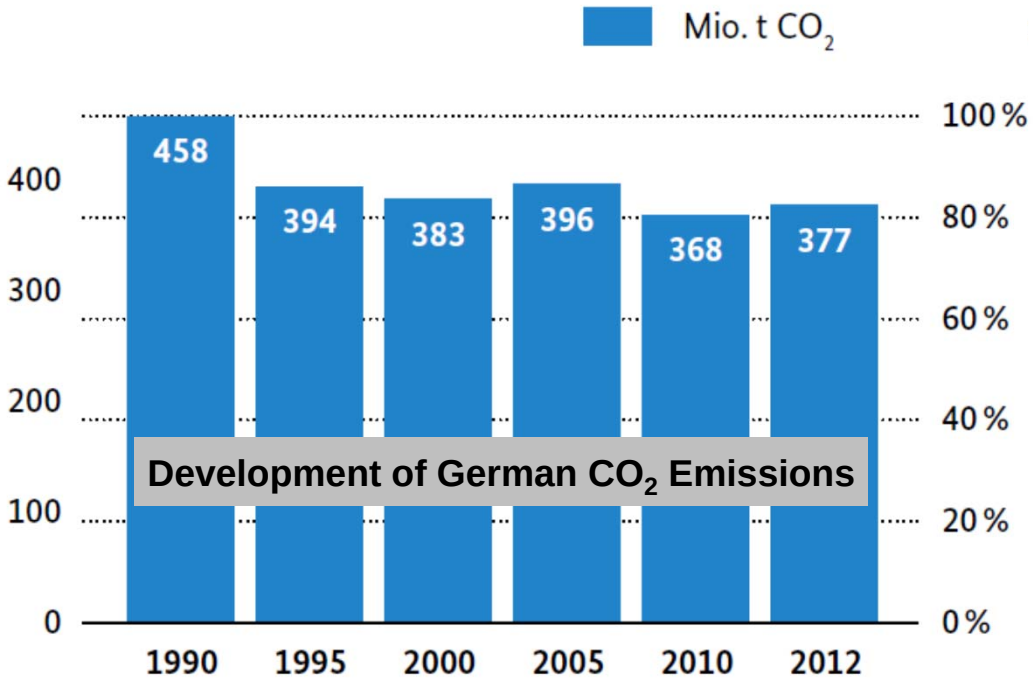
- Low emission certificate prices support coal firing
  - ⇨ high-efficient natural gas power stations pushed out of the market



Kuhlmann A. (2014) *Entwicklung des Kraftwerksparks in Deutschland und Bayern*. Energiedialog Bayern AG 4 „Versorgungssicherheit - Strombedarf, gesicherte Leistung, dezentrale vs. zentrale Versorgungsstrukturen“, München, 21.11.2014, p 4

Massive Over-Capacities in Electricity Production (cont.)

- (Highly profitable) coal firing threatens German goals of CO_2 emission reduction!
  - ⇨ Ministry of Energy announces 'National Action Programme for Energy Efficiency'
  - ⇨ Ministry of Energy announces extra duty on 'old' soft coal fired power plants (→ 18-20 €/t CO_2, beyond applicable power plant individual allowance)
  - ⇨ massive resistance from plant operators, industry and German states with extensive soft coal industry
- Germany massively increases electricity exports (→ mainly coal)



Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Ed.) (2014) *Klimaschutz in Zahlen – Fakten, Trends und Impulse deutscher Klimaschutzpolitik*. Berlin, June 2014, p 23

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(International) Integration of Conventional and Renewable Electricity Generation

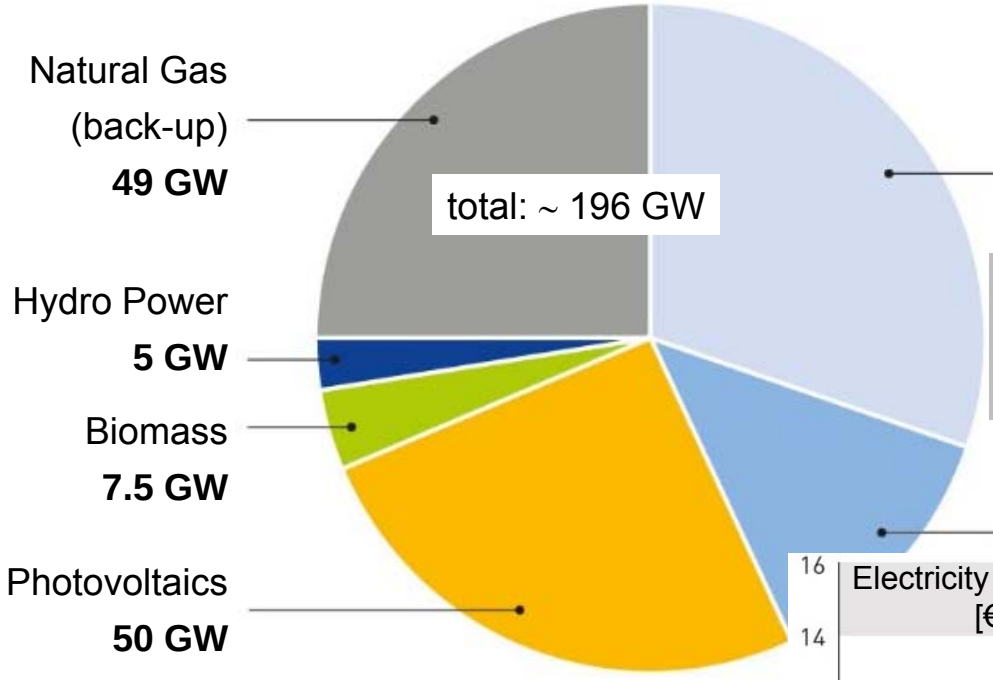
- Integration of conventional and renewable electricity generation neglected
  ⇨ more emphasis must be put on integration, including modifications of electricity grid(s)
- Integration of power, heat and mobility complex, hence completely neglected
  ⇨ Integration bears enormous potential, more research urgently needed
- Energiewende still only German project – no coherent political strategy within EU
  ⇨ European perspective of electricity generation and transmission urgently needed

(National) Government Policies

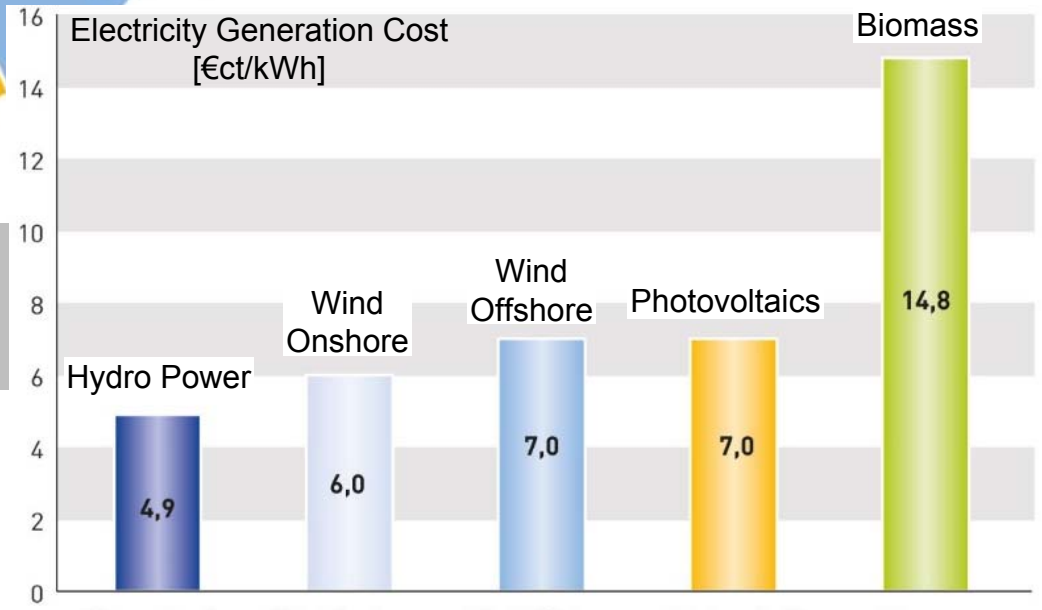
- Single-sided focus on renewable electricity generation, even though heat is predominant in Germany (→ 'heat EEG' only for new buildings!) ⇨ wider perspective necessary
- 'Big 4' heavily under economic pressure ⇨ fundamental changes in energy markets need to be accepted, even against resistance of the established stakeholders
- Energy policy needs a long-term perspective ⇨ wide social consensus indispensable

Renewable Energies in Germany (22)

Lessons Learnt and the Future (2)



Future Electricity Generation Capacities in Germany to Achieve 80 % Coverage by Renewable-Based Sources (2050)



Future Electricity Generation Cost in Germany to Achieve 80 % Coverage by Renewable-Based Sources (2050)

Agentur für Erneuerbare Energien (n.d.) *Künftige Kosten der Stromerzeugung* [WWW] available from: http://www.unendlich-viel-energie.de [accessed: 16.08.2015]

Renewable Energies in Germany (23)

Lessons Learnt and the Future (3)

Germany has just started transition from a nuclear / fossil-based to a renewable-based society

There still is a long way to go – all stakeholders of the society need to be involved to make it a success story

‚The energy business as we all know it, becomes a bygone chapter of industrial history.‘

‚As we realise today, the changes of the past were only the prelude of much more fundamental changes – a revolution of the energy world, that started to overthrow everything that has been certain for more than a hundred years.‘

‚Where and how we produce energy, how it is being transported – all of that dramatically changes just now.‘

Johannes Teyssen, CEO of E.ON SE, Düsseldorf (Germany), on the occasion of E.ON´s annual stockholders meeting 2015

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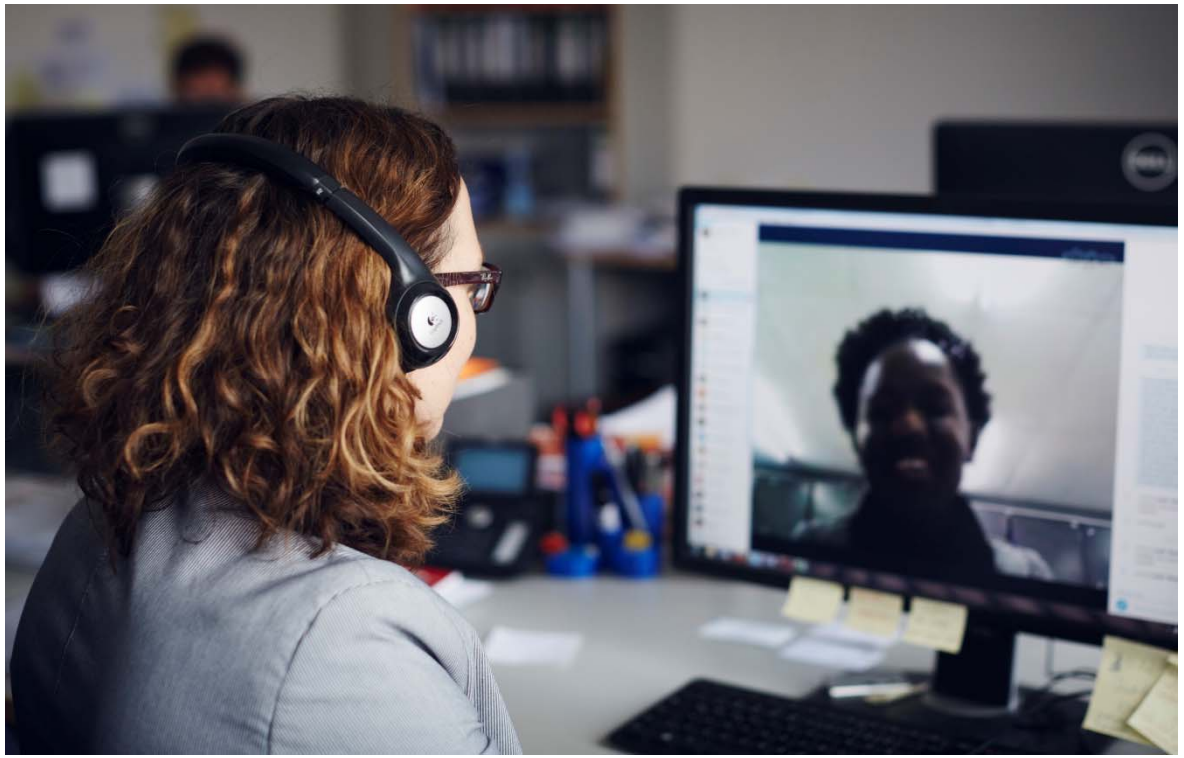

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www.thi.de/go/energy
www.need-project.org

Institute of new Energy Systems

Many thanks for your kind attention !

Any questions ?