

## Energy alternatives for future (A case of renewable energy development in Germany – past success and future challenges)

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17 a 19 de setembro de 2019

## Outline

- Brief introduction about myself and our University
- Status quo of the current global energy supply
- Case of Germany – past success and future challenges

## My professional path to date

- **2002** Bachelor in Mechanical Engineering, Pulchowk Campus, Tribhuvan University, Nepal
- **2002-2005** Project engineer in renewable energy sector in Nepal
- **2007 (MSc) and 2010 PhD** – Renewable energy, Germany
- **2007-2010** Research stays, work (from some weeks to several months in Thailand, Indonesia, Afghanistan)
- **2010-2013** Researcher at the Institute for Energy and Climate Research in Research Centre Jülich, Germany and Centre for Renewable Energy (ZEE), University of Freiburg, Germany
- **Since 2013** Professor for Renewable Energy Systems at TH Köln – University of Applied Sciences, Germany

## Cologne University of Applied Sciences - some figures

- 25000 students, thereof 3500 international
- Annually about 5000 new students
- 11 faculties, 48 institutes
- > 90 study programs (51 Bachelor and 45 Master programs)
- About 1600 employees, thereof about 416 professors and 600 academic staffs
- > 17 Mio. Euro research grants and external fund (annual)
- > 200 Partner universities and international contacts



## ITT

- ITT - Institute for Technology and Resources Management in the Tropics and Subtropics
- Founded in 1978
- First International Master Programme in the state of NRW
- International cooperation, mainly in tropical South
- 3 international master programs and three derivatives

## ITT's master programmes

### • REM



#### Renewable Energy Management (REM)

- Energy Efficiency
- Photovoltaics and Solar Thermal Systems
- Wind Energy and Hydropower
- Decentralized Energy Systems

<http://www.rem-master.info>

### • NRM



#### Natural Resources Management and Development (NRM)

- Land Use Systems
- Ecological and Social Risks
- Food Security
- Resources Efficient Buildings and Quarters

<http://www.nrm-master.info>

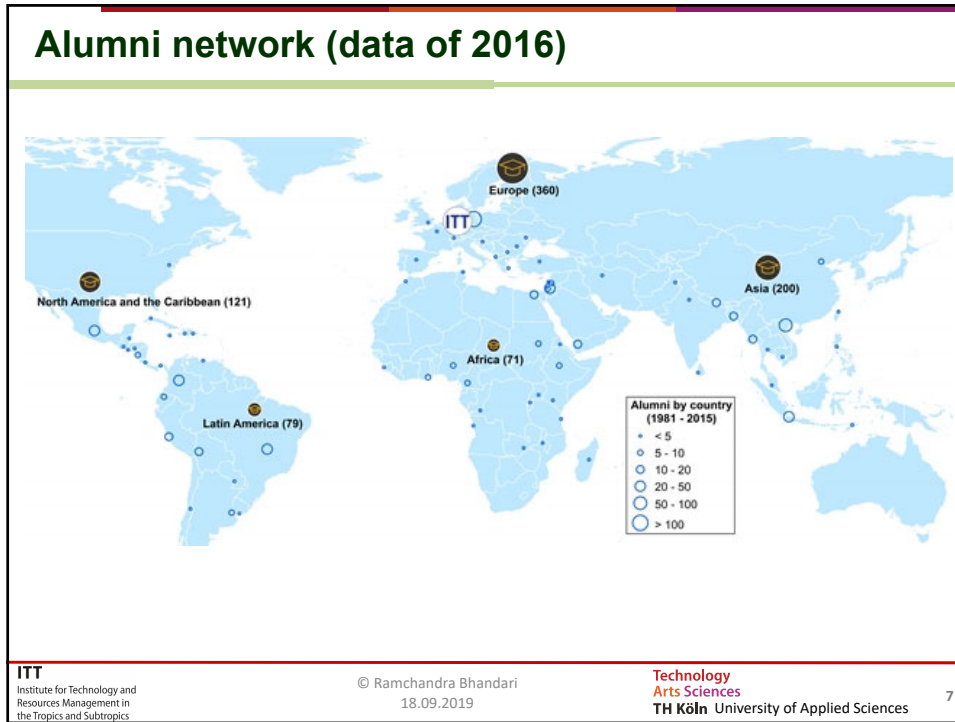
### • IWRM



#### Integrated Water Resources Management (IWRM)

- Watershed Management
- Water Economics and Governance
- Sanitation and Public Health
- Water System Analysis

<http://www.iwrn-master.info>



## Cologne Institute for Renewable Energy (CIRE)

**Cologne Institute for Renewable Energy**

16 Professors, basically all fields of renewable energy covered, except high temperature solar thermal and wind energy

◀ **Institute**

▼ **Cologne Institute for Renewable Energy**

- Fachgebiete
- Forschung
- Labore
- Newsletter
- Fachschaft
- Personen

**Cologne Institute for Renewable Energy**

Das Cologne Institute for Renewable Energy (CIRE) ist ein Zusammenschluss von Professoren und Wissenschaftler innerhalb der Fachbereiche Maschinenbau, Elektrotechnik und Ressourcenmanagement.

Das CIRE verbindet Lehre und Forschung interdisziplinär. Das Institut widmet sich der Technologie und der Implementierung von erneuerbaren Energien. Es bietet ein Bachelor- und ein Masterprogramm an und unterstützt zwei weitere Bachelor- und ein weiteres Masterprogramm.

Der Schwerpunkt der Forschung liegt auf innovativen Komponenten und Systemen zur Nutzung erneuerbarer Energien mit dem Ziel einer vollständigen Versorgung mit erneuerbaren Energien.

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## Cologne Institute for Renewable Energy (CIRE)

- The CIRE has been established to bundle the expertise on Renewable Energy from different branches of the Renewable Energy industry, faculties and institutes:
  - Mechanical and electrical engineering
  - Resource management
  - Energy management, policy and economics
  - Building technology and management
- CIRE is offering study courses focussed on technology and management of renewable energy resources
- Among the members, there are 15 Professors



### Bachelor Study Course Renewable Energies

7 semesters incl. 1 semester industry internship  
and 1 semester bachelor thesis  
German language

Degree: Bachelor of Engineering

### Master Study Course Renewable Energies

3 semesters incl. 1 semester master thesis  
German language

Degree: Master of Science

### Master Study Course Renewable Energy Management

## Laboratories at CIRE - examples

- Biogas technology
- Measurement of mechanical and chemical properties of biomass
- Biomass pelletizing
- Biomass boilers and heating systems
- Light technology, optical analytics and spectroscopy
- Solar energy systems (PV, thermal)
- Combustion engines (CHPs)
- Hydropower and fluid machines
- Fundamental training with wind energy, fuel cells and energy storage
- Computational fluid dynamics
- Test rigs for electrical components
- Hybrid systems for green mobility and electro-mobility

# Renewable energy development in Germany – past success and future challenges

## Three pillars of German energy transition

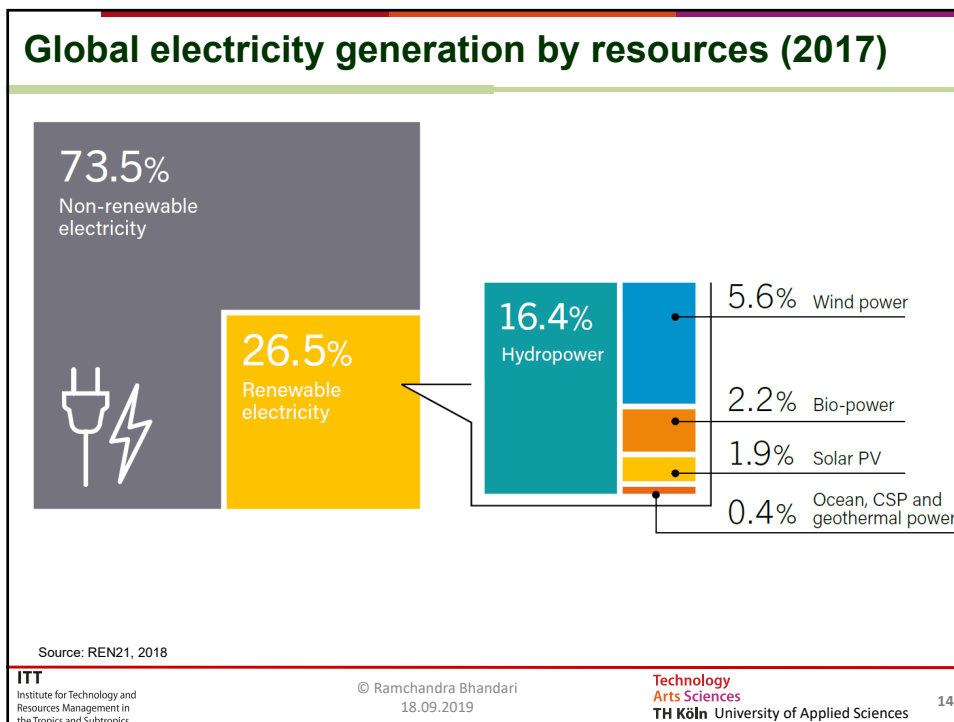
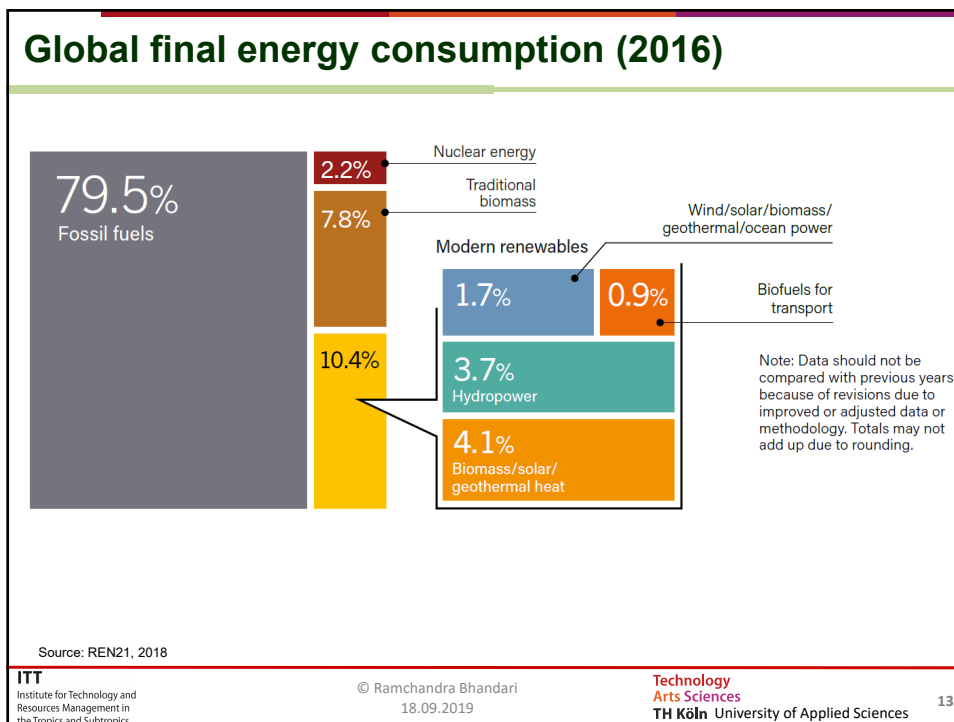
- Phase out of nuclear energy
- Expansion of renewable energy
- Increase in energy efficiency

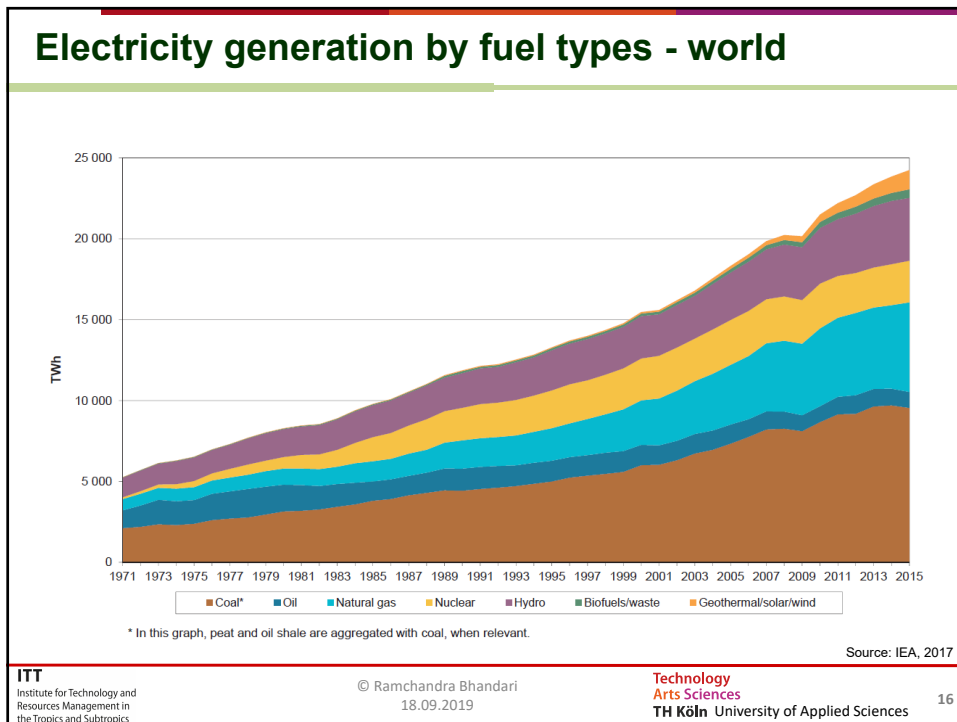
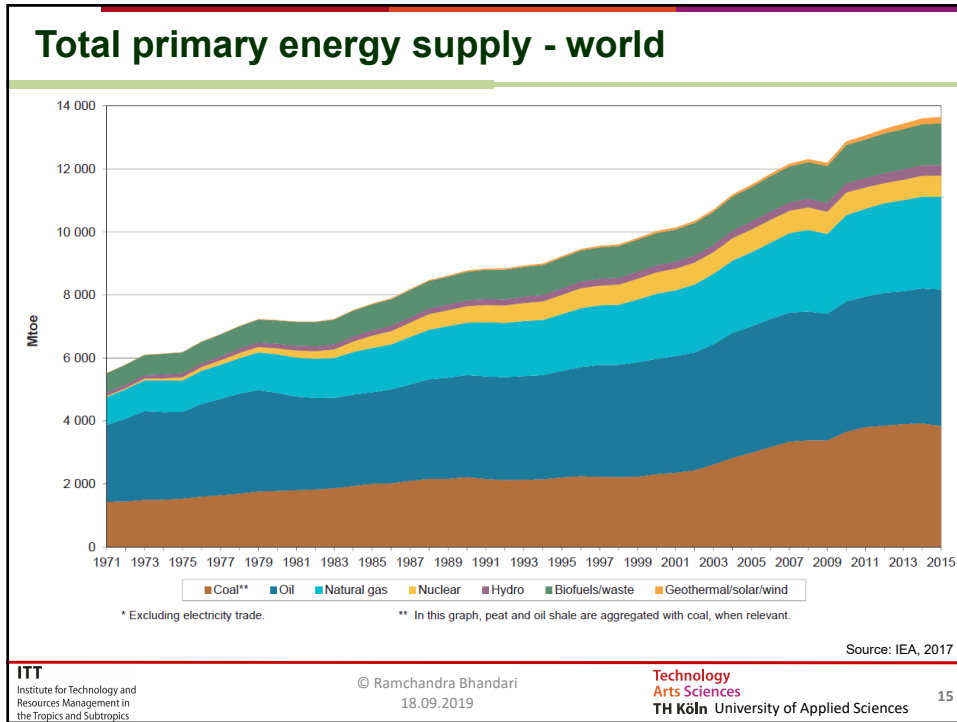
Energiewende!

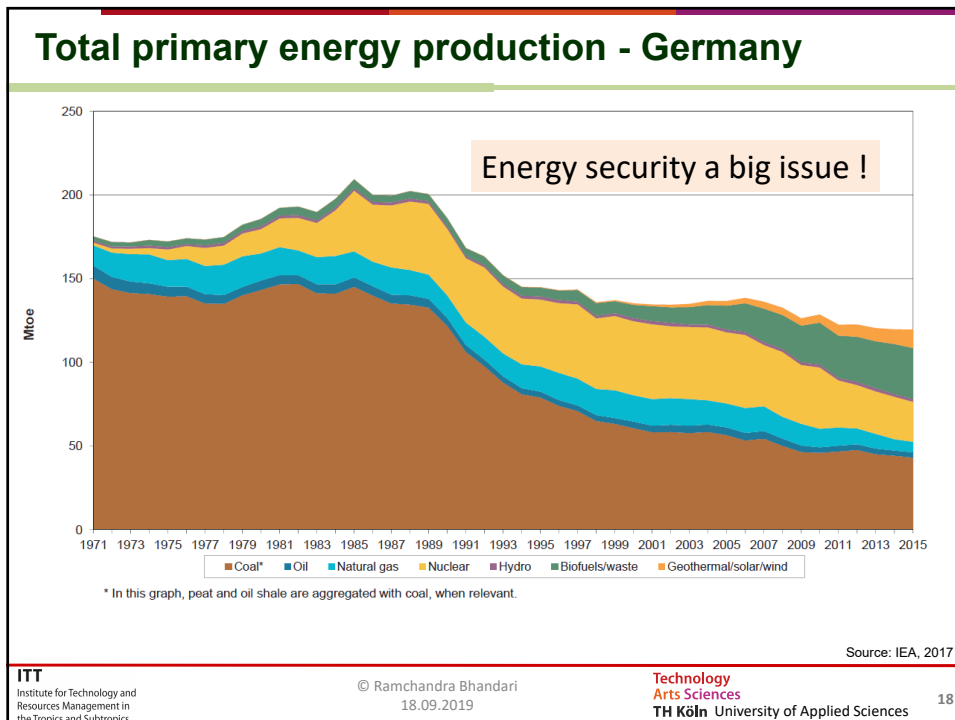
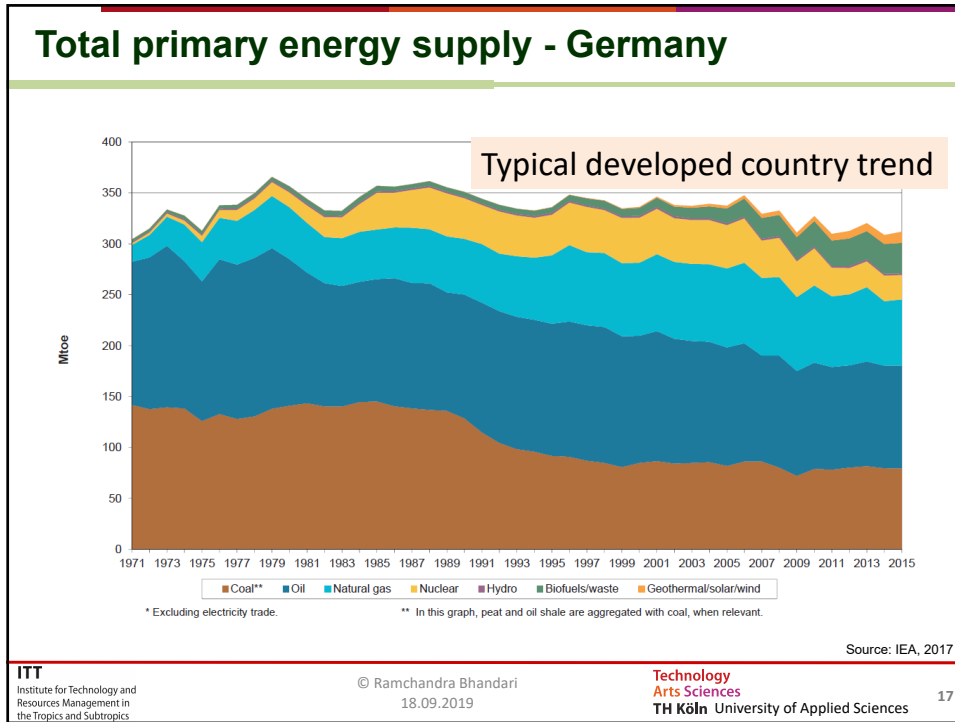
### Aim

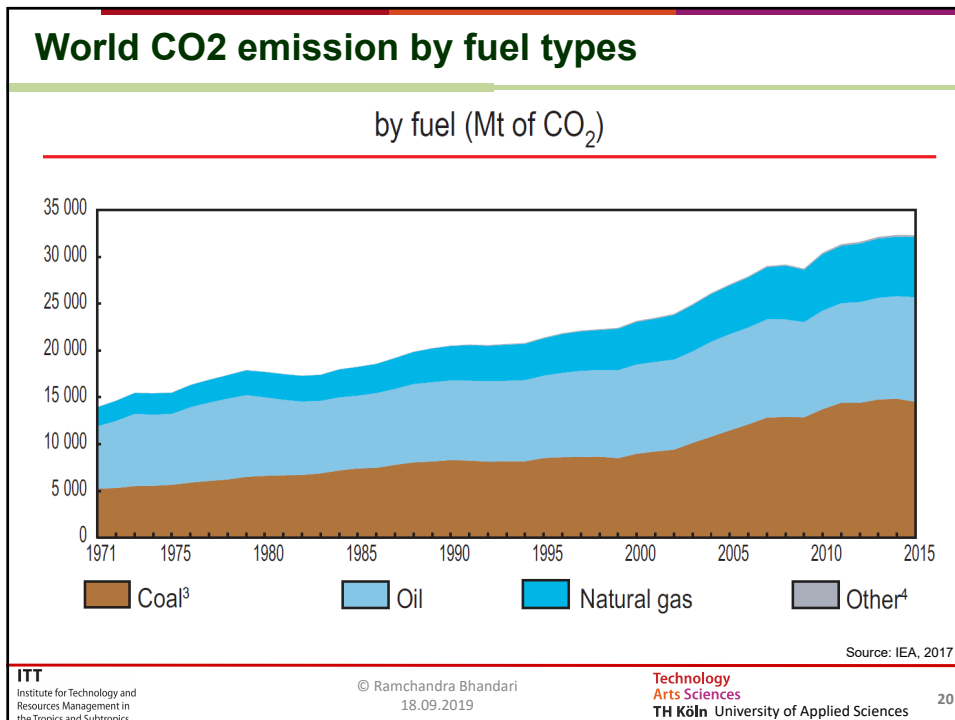
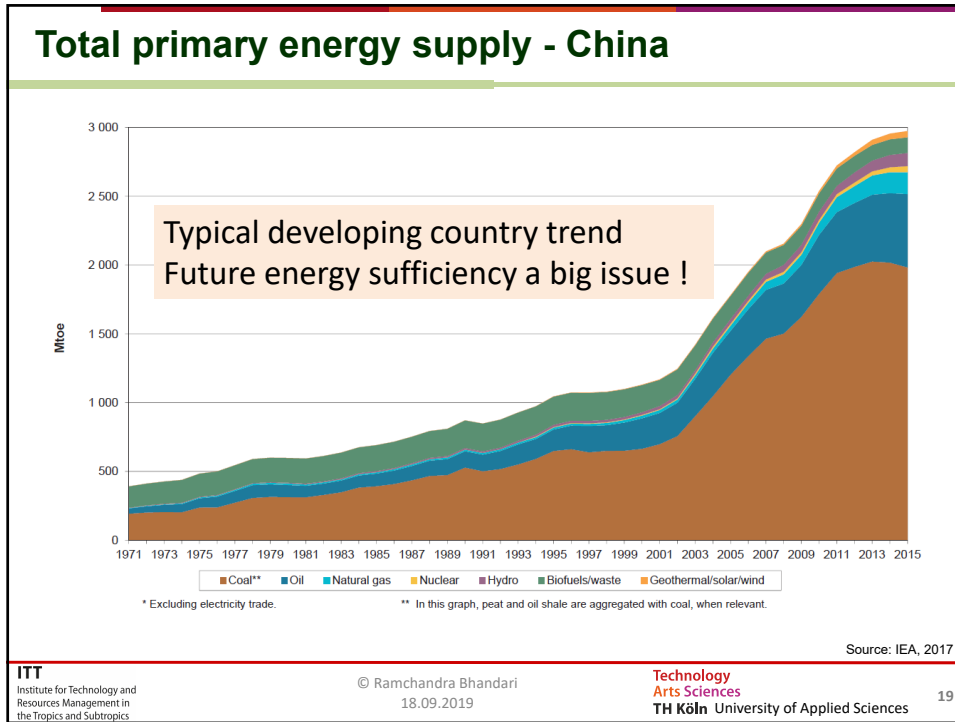
- Energy security
- Combating climate change
- Economics (innovation, technological development)

.. But the road there is not an easy one...









Current global energy supply is heavily dominated - also in Germany - by fossil fuels, and it is responsible for greenhouse gas emissions

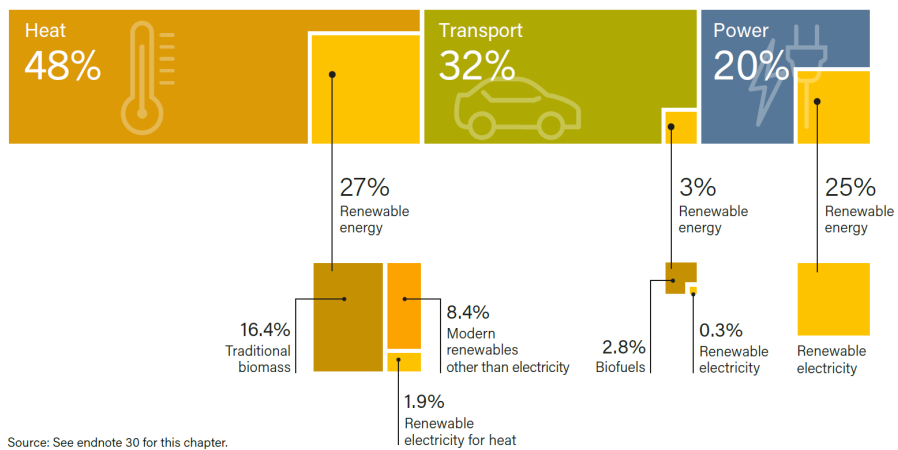
Can renewables play a greater role to solve the problems of energy scarcity, energy economics and energy related emissions?

## The energy challenges

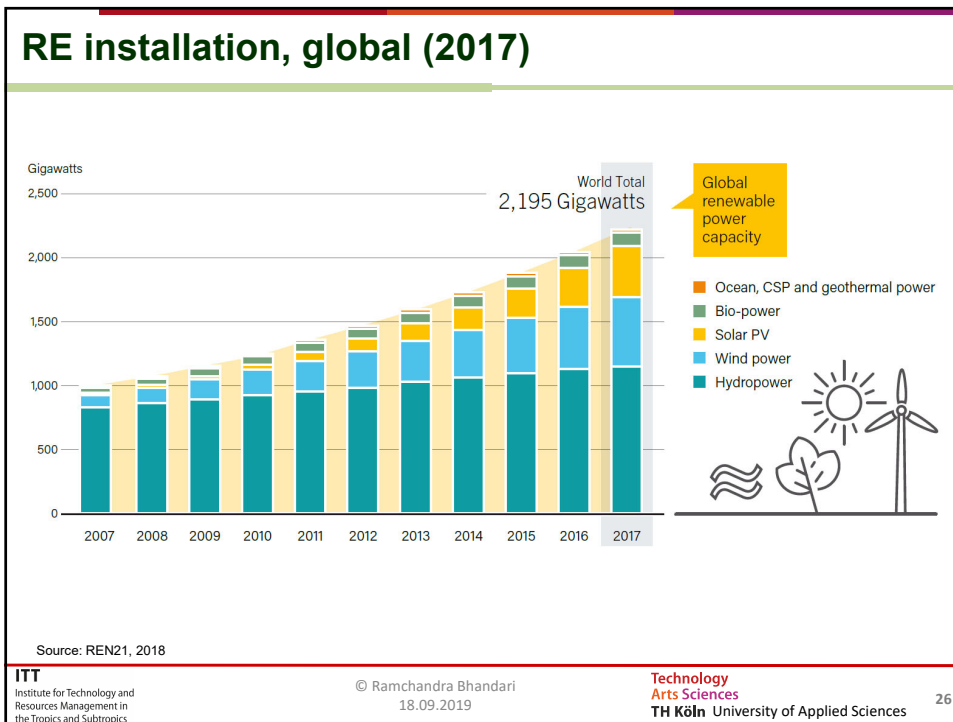
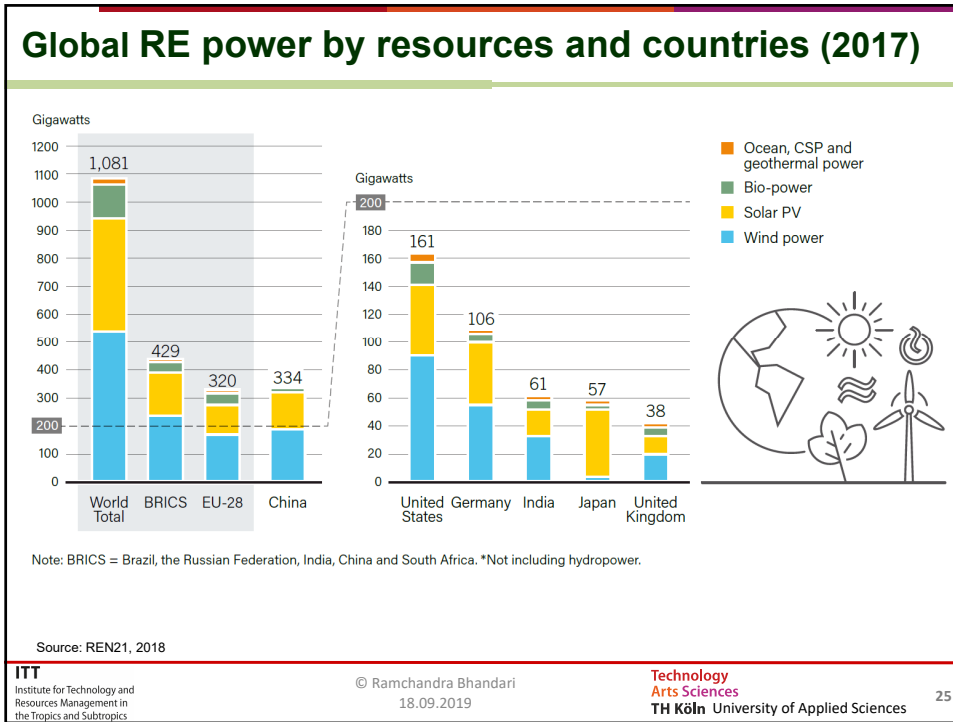
- If we have to change our energy technologies over a relatively short period of time, where are the best alternatives?
- How should we invest in developing better alternatives?
- What are the drivers that will encourage timely development and market penetration of these technologies?

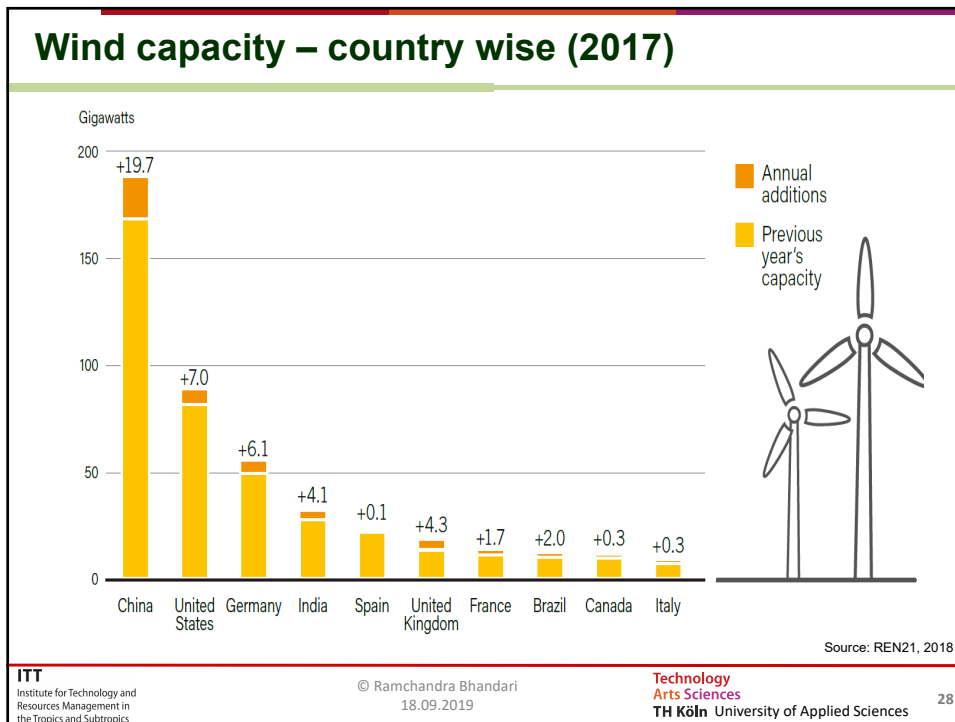
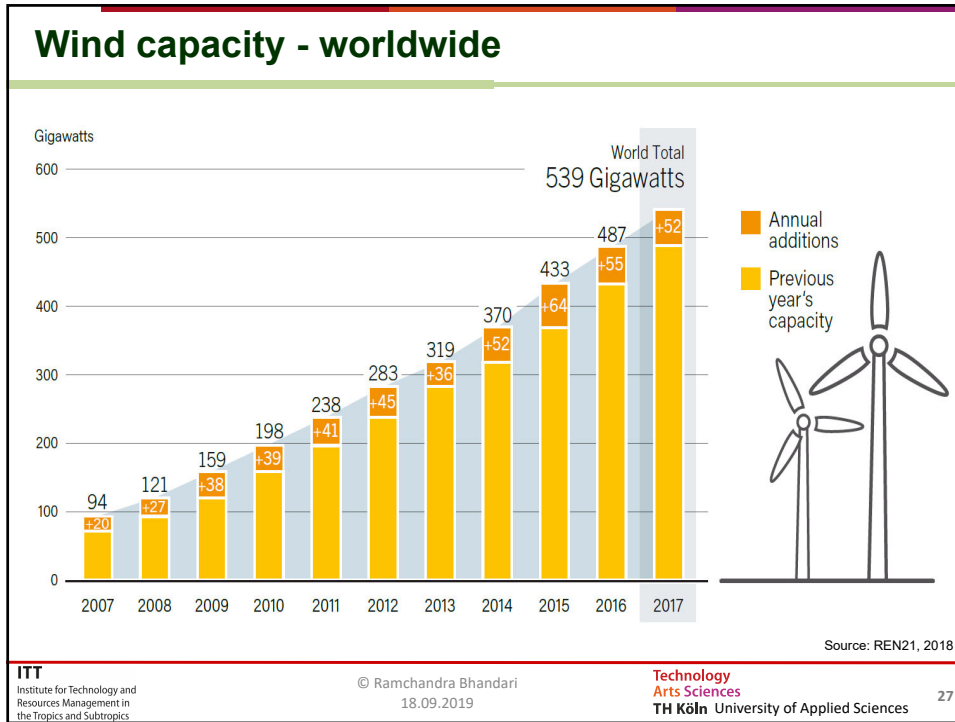
## A closer look to „only“ renewables – what has been so far achieved, globally

### Sectoral renewable share in final energy (2015)



Source: REN21, 2018





## Hydropower

Producers	TWh	% of world total
People's Rep. of China	1 193	28.6
Canada	387	9.3
Brazil	381	9.1
United States	292	7.0
Russian Federation	187	4.5
Norway	144	3.5
India	138	3.3
Japan	85	2.0
Venezuela	68	1.6
Turkey	67	1.6
Rest of the world	1 228	29.5
<b>World</b>	<b>4 170</b>	<b>100.0</b>

2016 data

Net installed capacity	GW
People's Rep. of China	344
United States	103
Brazil	97
Canada	80
Russian Federation	51
Japan	50
India	45
Norway	32
Turkey	27
France	26
Rest of the world	302
<b>World</b>	<b>1 157</b>

2016 data  
Sources: International Energy Agency, United Nations

Country (top ten producers)	% of hydro in total domestic electricity generation
Norway	96.2
Brazil	65.8
Venezuela	60.1
Canada	58.0
Turkey	24.5
People's Rep. of China	19.2
Russian Federation	17.1
India	9.3
Japan	8.0
United States	6.8
Rest of the world	14.9
<b>World</b>	<b>16.6</b>

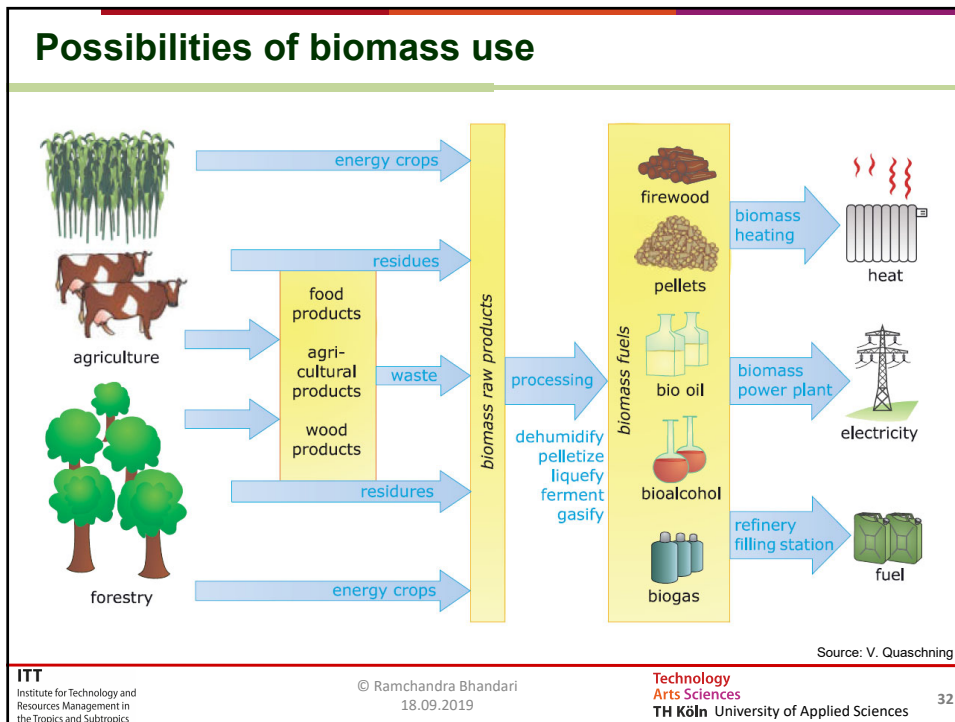
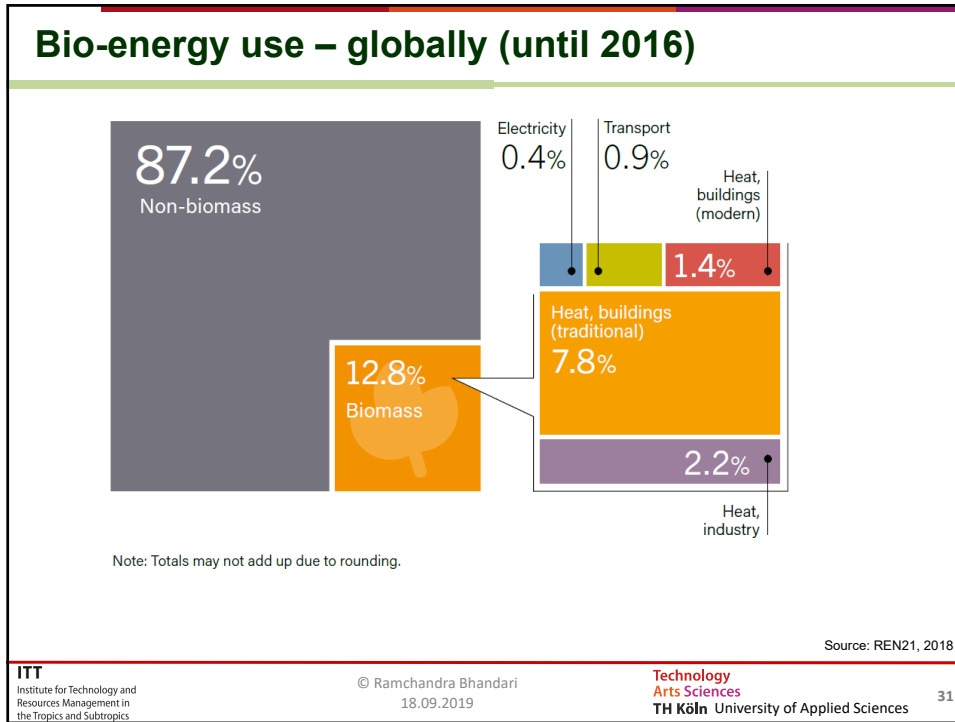
2016 data

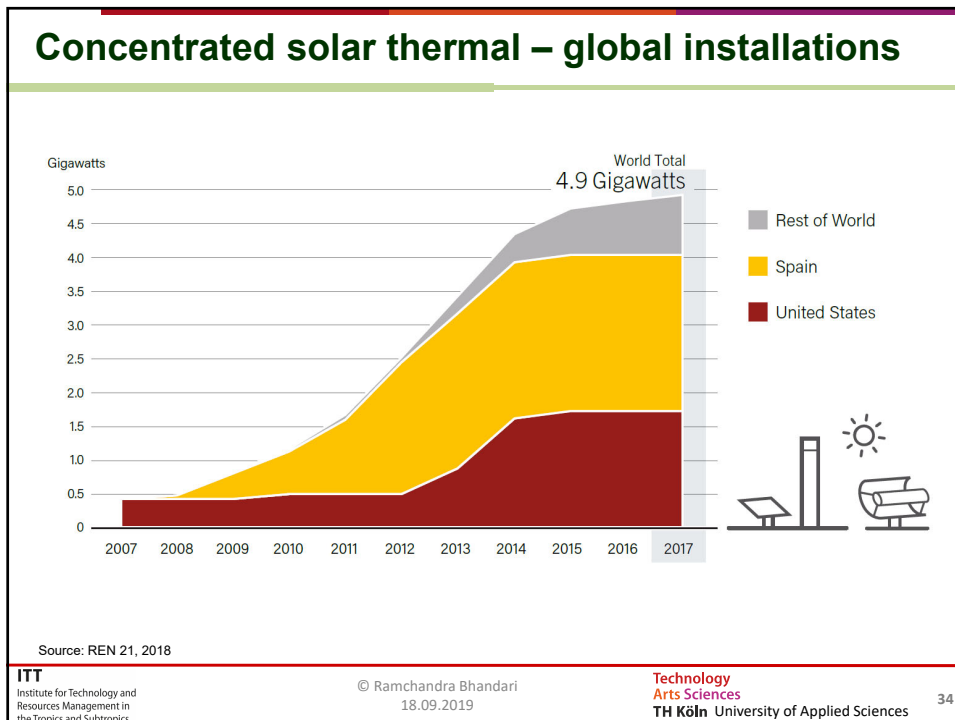
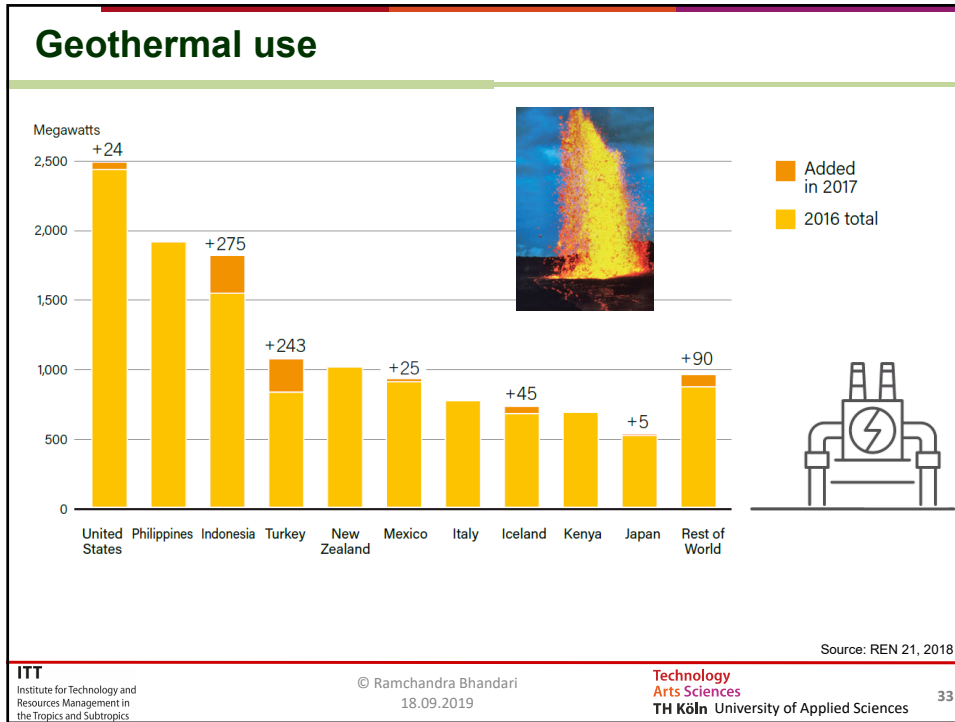
WEO, 2018

## Three Gorges Project

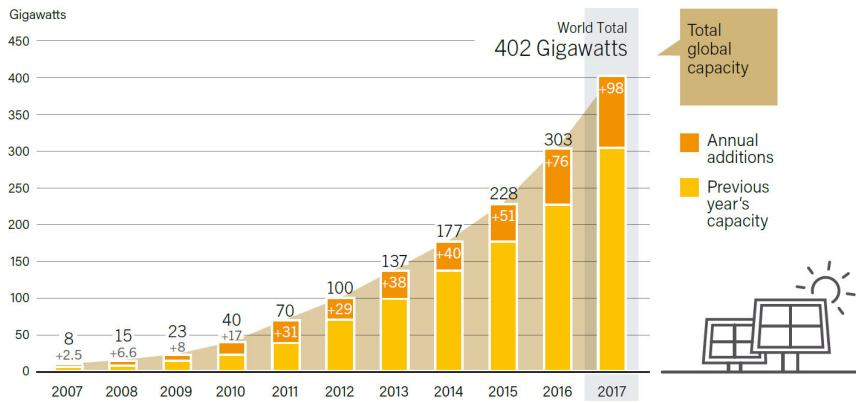
- Built on the Yangtze river
- Dam to provide **22.5 GW** of power
- Currently the world's largest hydroelectric dam





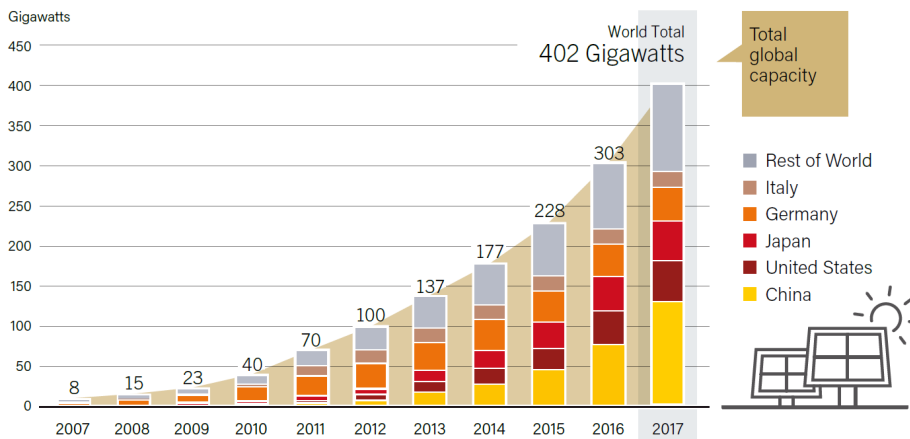


## Cumulative PV installations – global figures



Source: REN 21, 2018

## PV installation - countrywise



Note: Data are provided in direct current (DC).

Source: REN 21, 2018

## Germany's status quo

## Renewable energy targets in Germany (initial...)

### Renewable energy: Goals of the German government

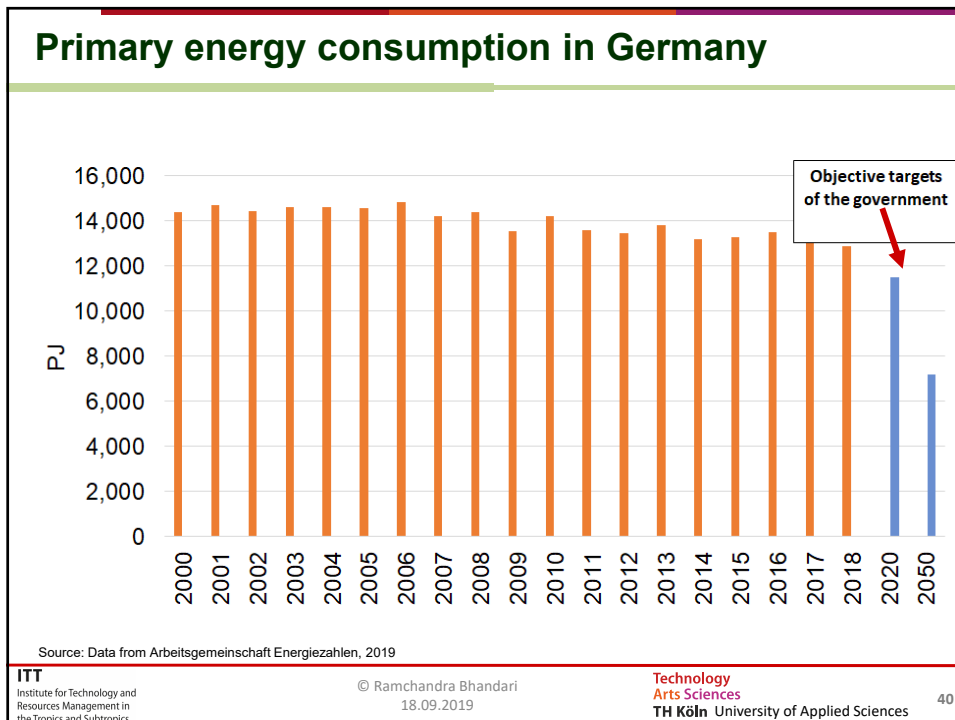
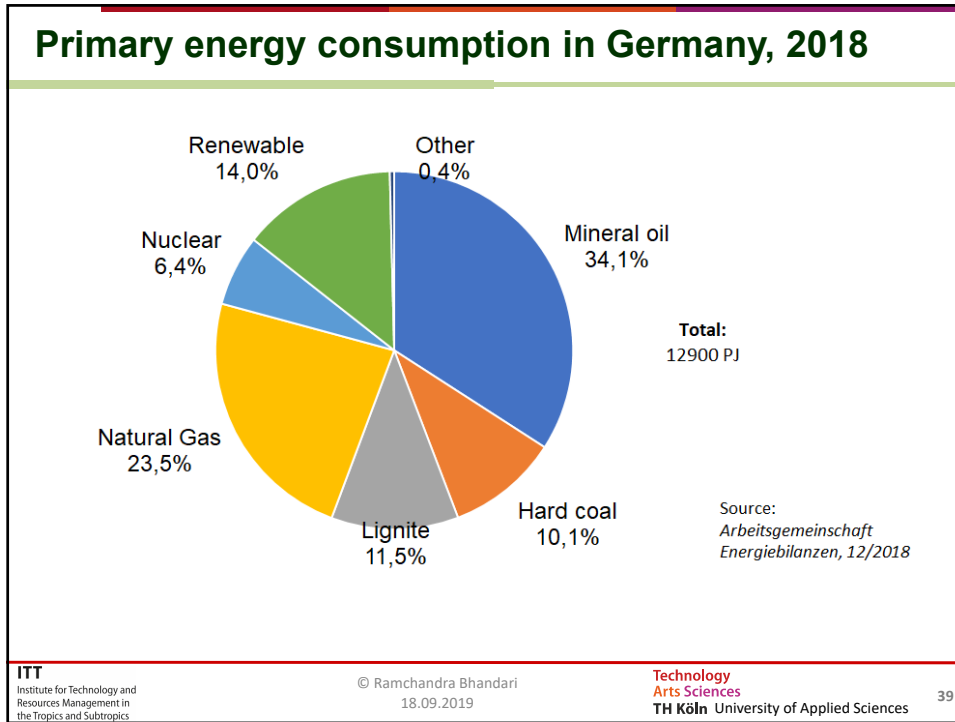
Renewables-based share of electricity consumption		Renewables-based share of gross final energy consumption	
by not later than	[%]		[%]
2020	at least 35	2020	18
2030	at least 50	2030	30
2040	at least 65	2040	45
2050	at least 80	2050	60

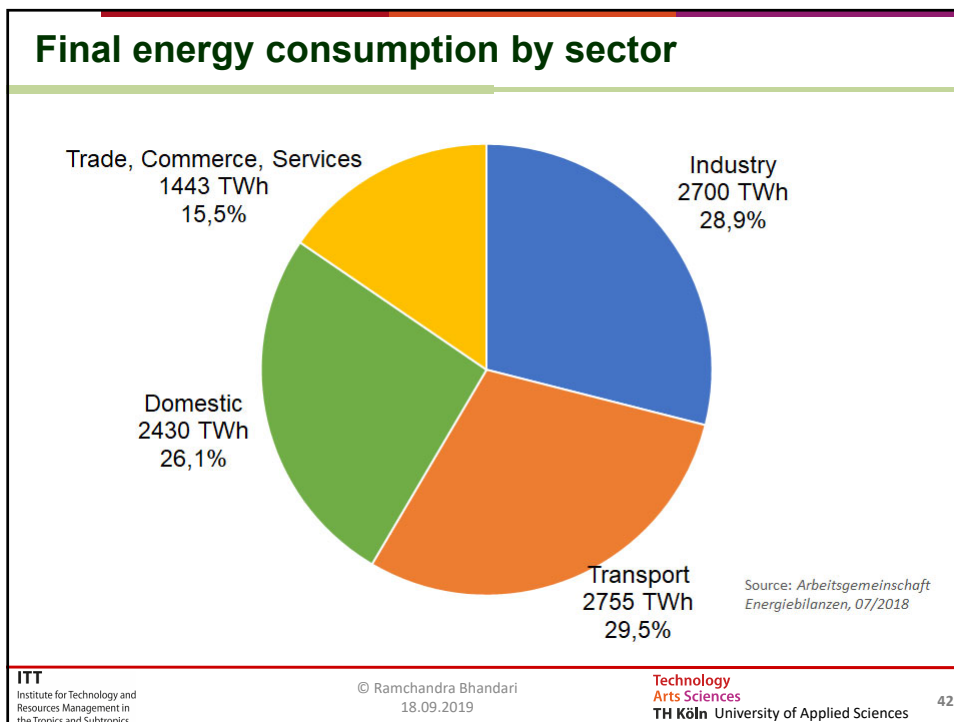
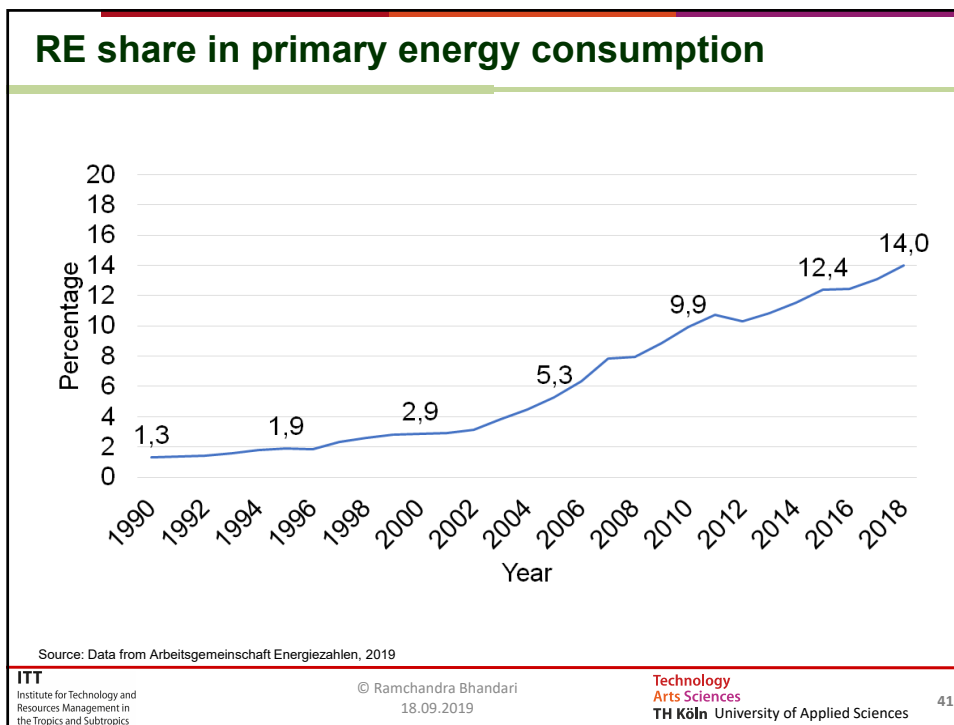
By 2020 the renewables' share of total heat supply is to be raised to 14 percent and the renewables' share of final energy consumption in the transport sector to 10 percent.

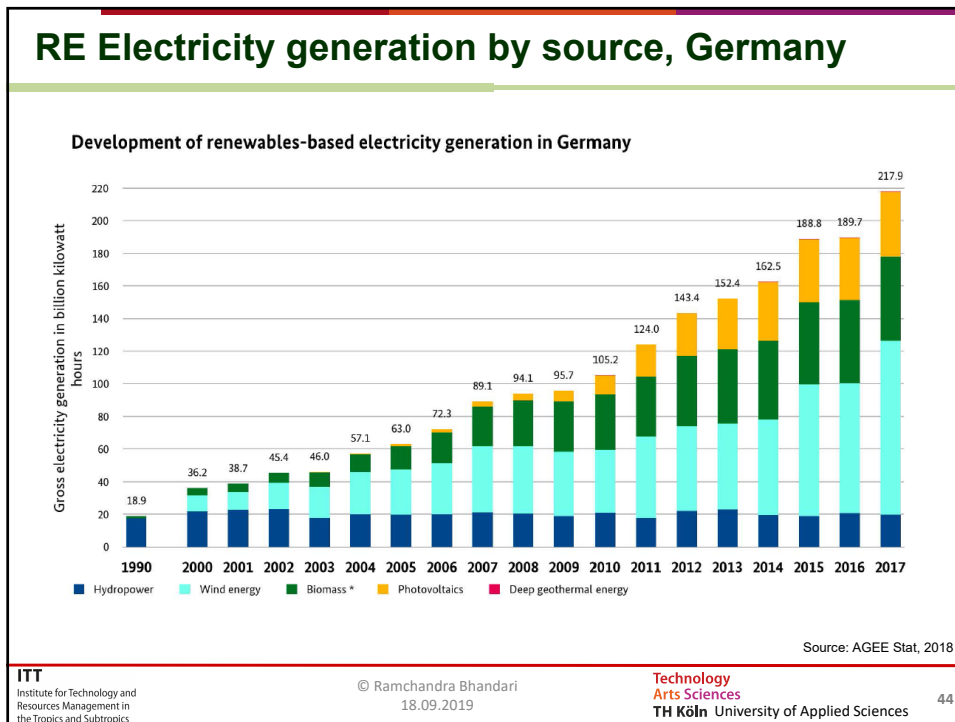
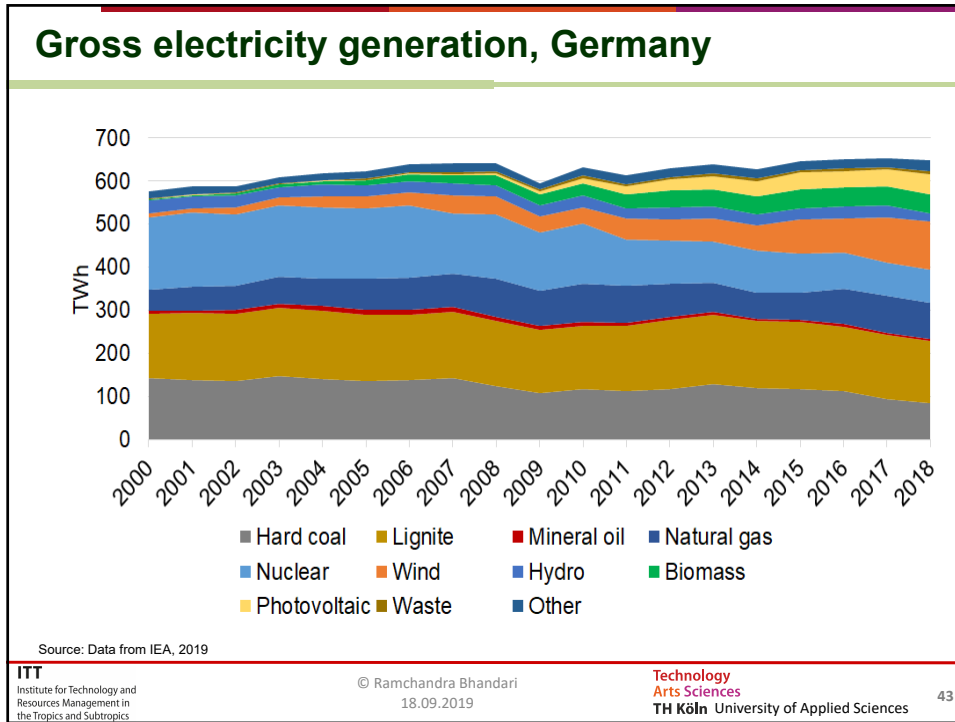
These targets will also help to achieve a 40-percent reduction in greenhouse gas emissions in Germany by 2020 (compared to 1990)

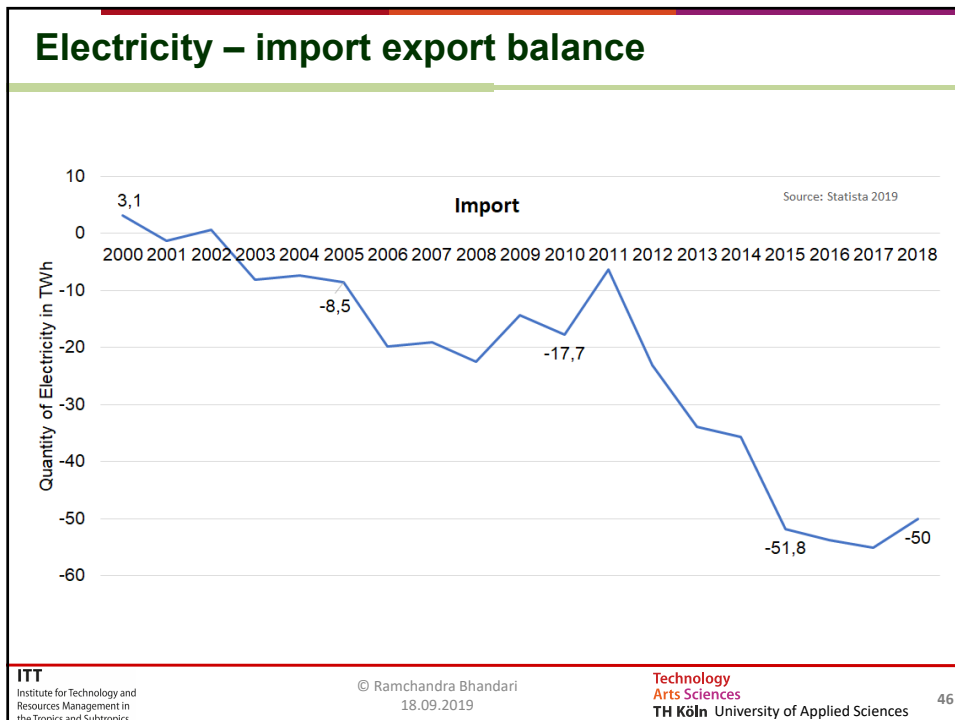
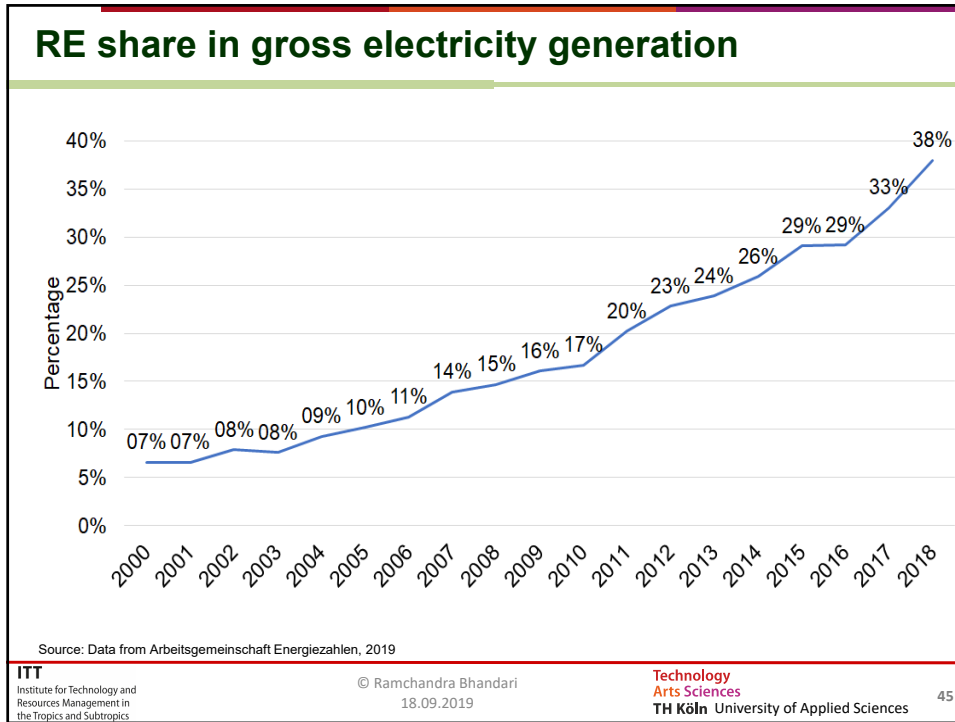
and a reduction of between 80 and 95 percent by 2050. At the same time, electricity consumption is to be reduced by 10 percent by 2020 and 25 percent by 2050, and primary energy consumption will be cut by 20 percent by 2020 and 50 percent by 2050.

Source: BMU, 2011

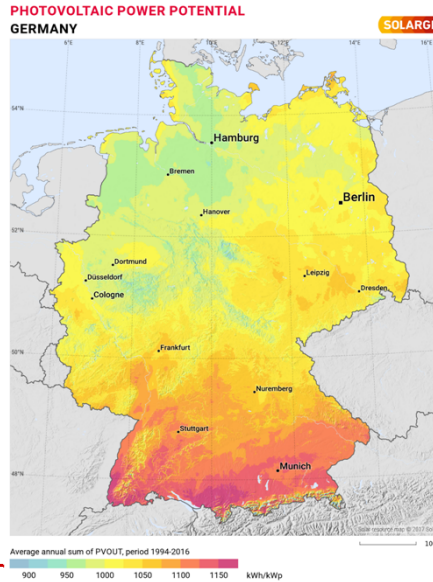








## Solar PV potential in Germany

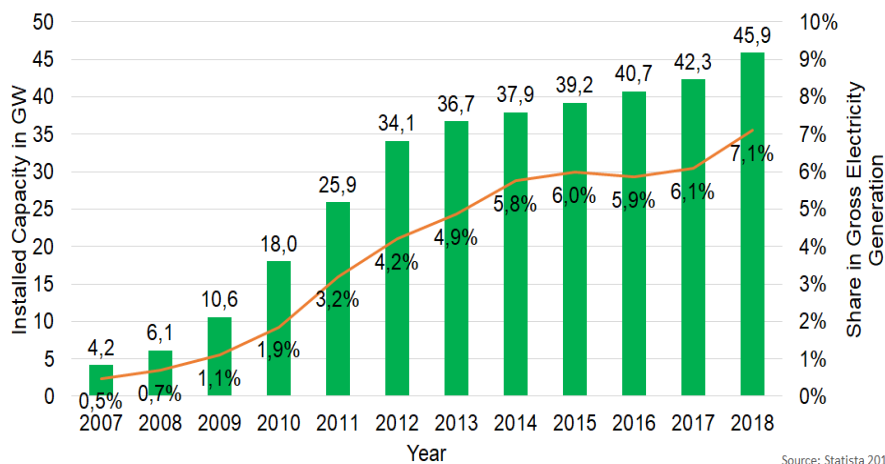


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## Installed PV capacity



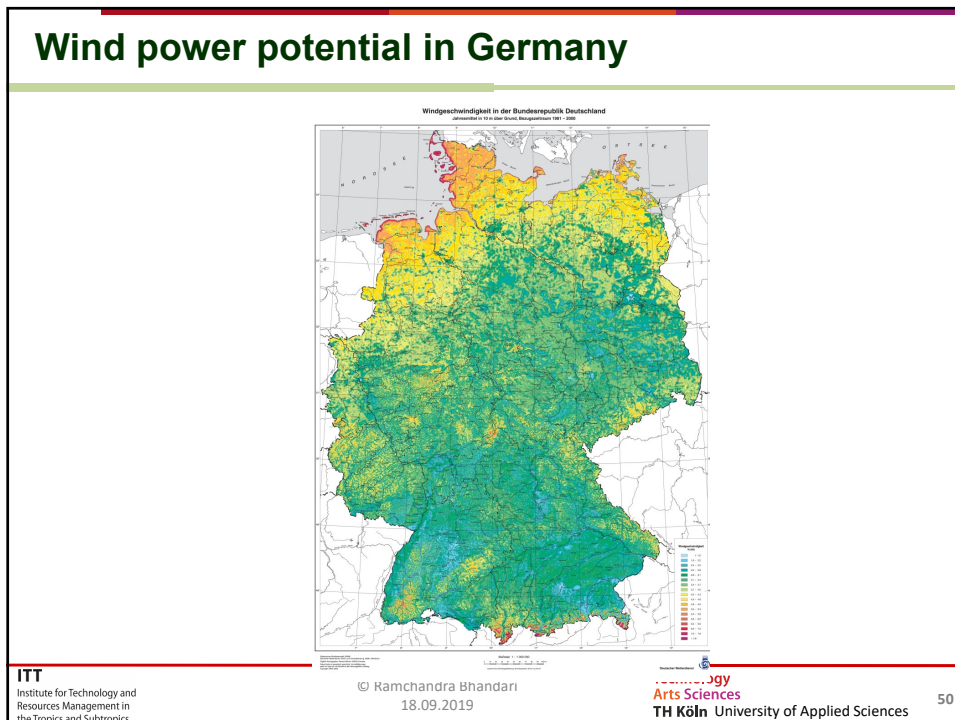
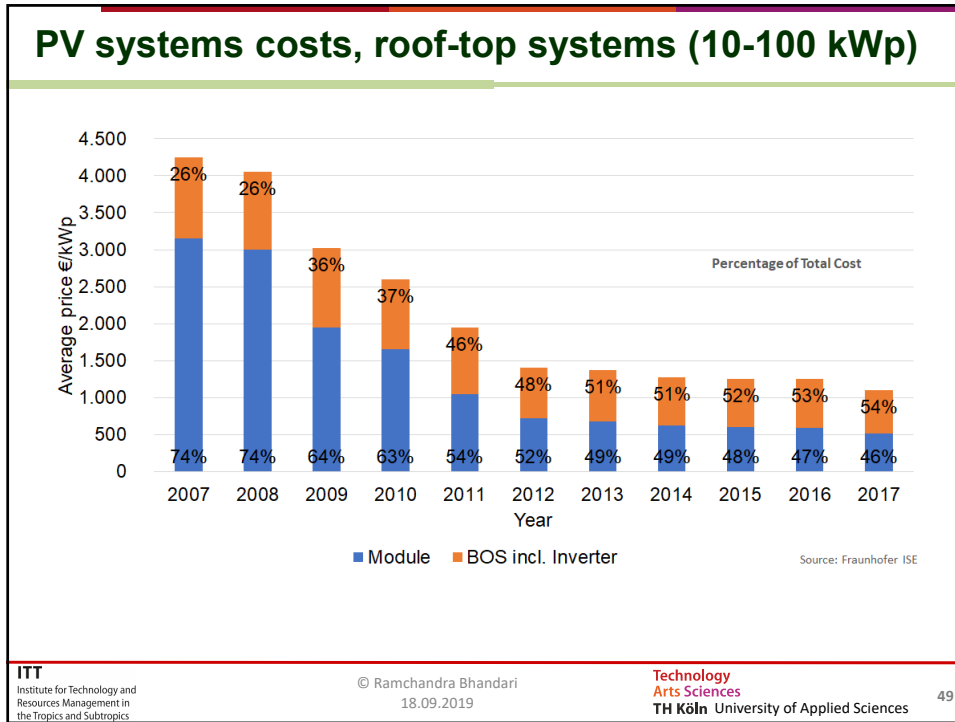
Source: Statista 2019

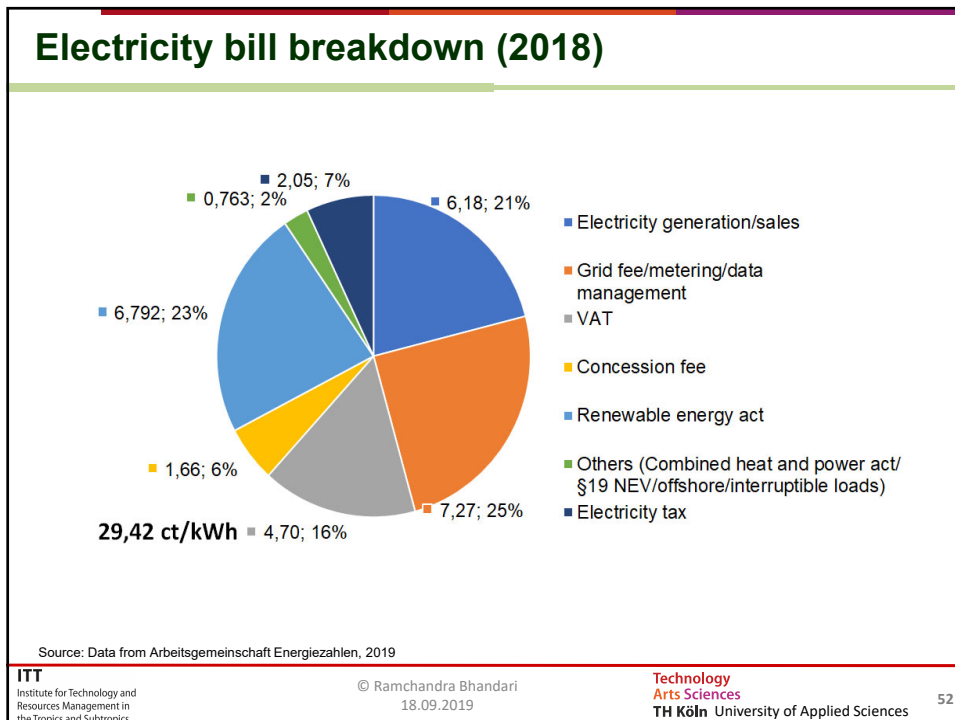
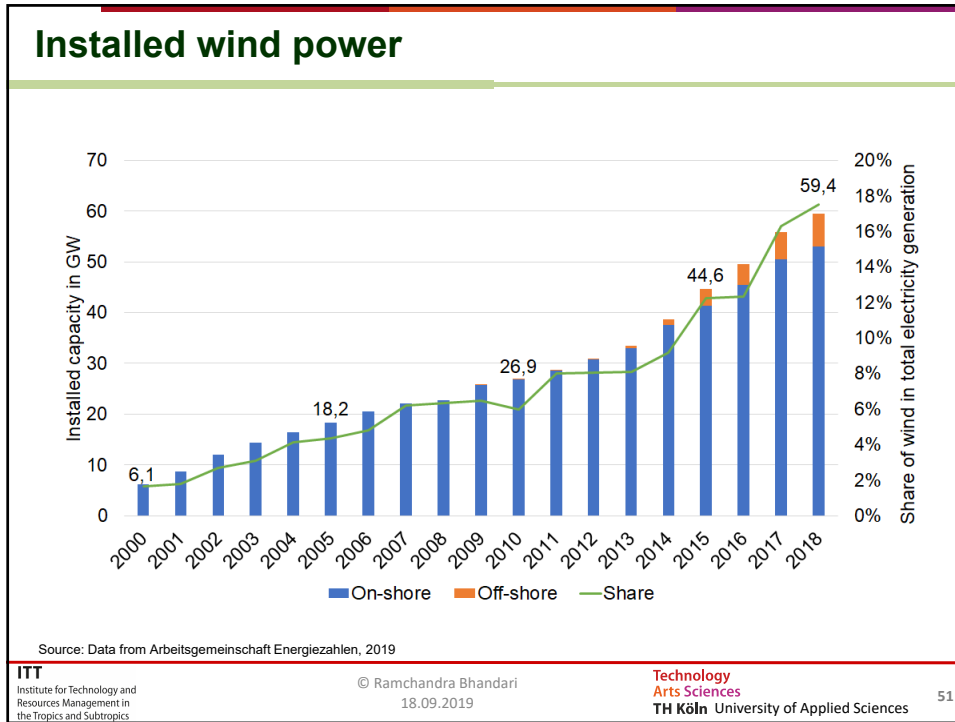
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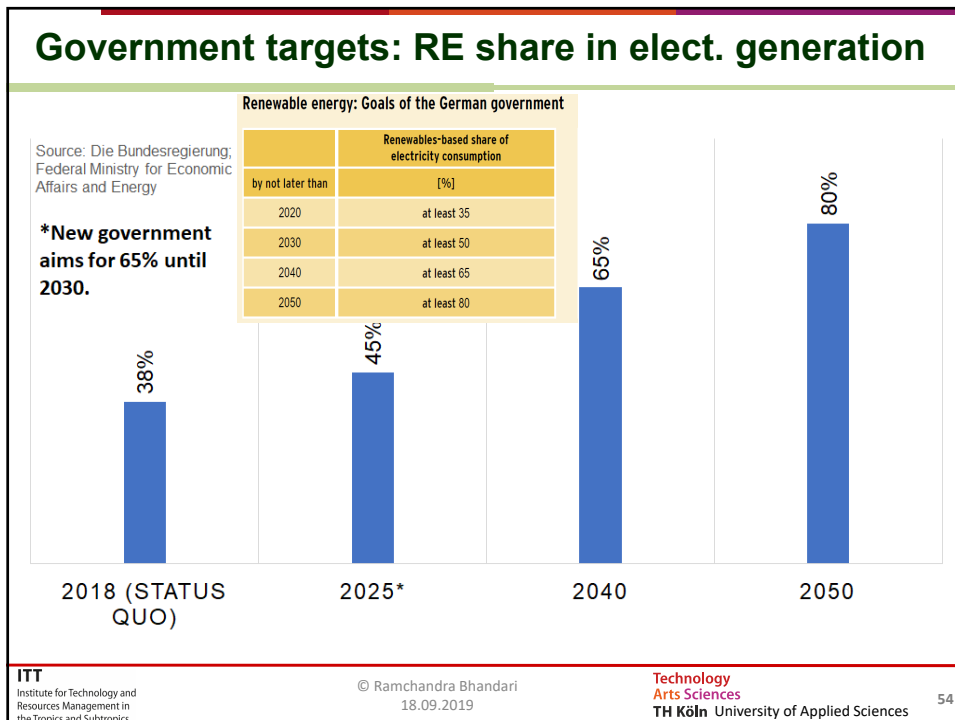
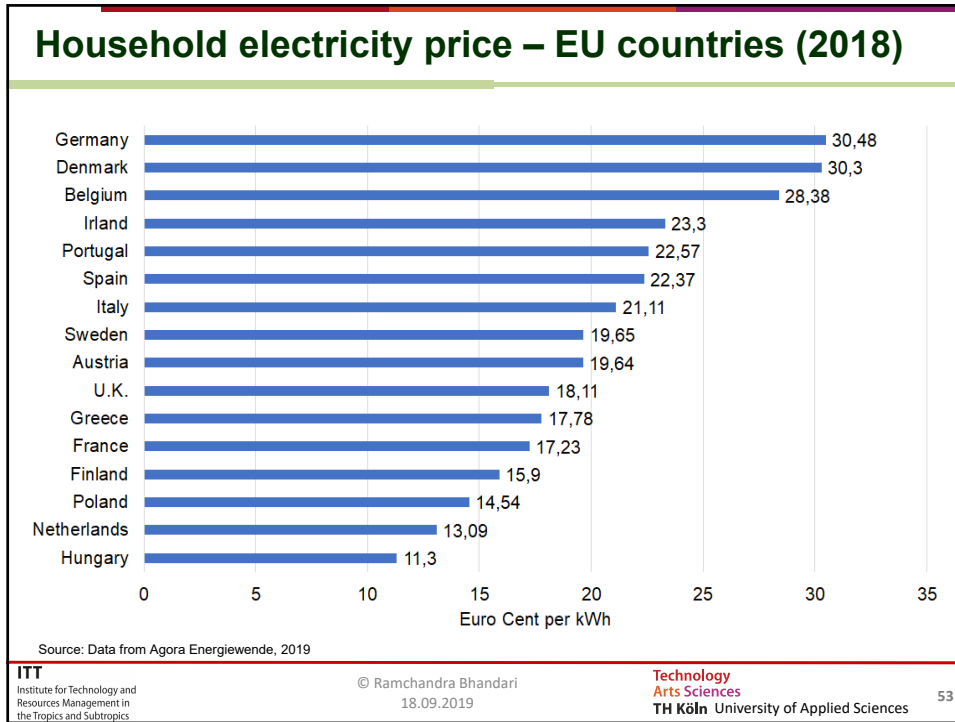
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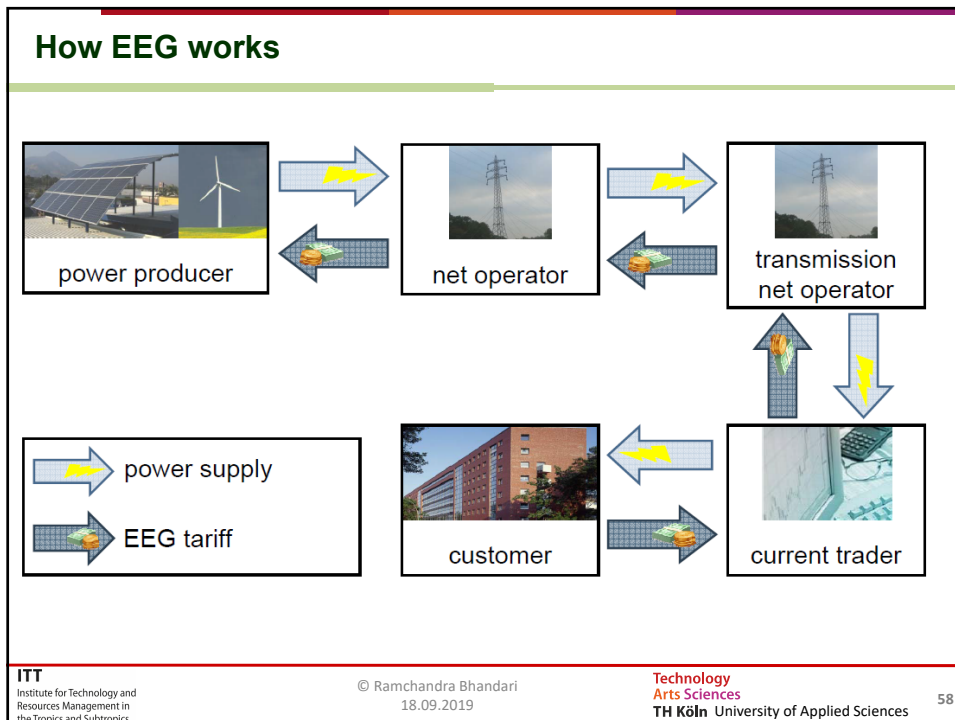
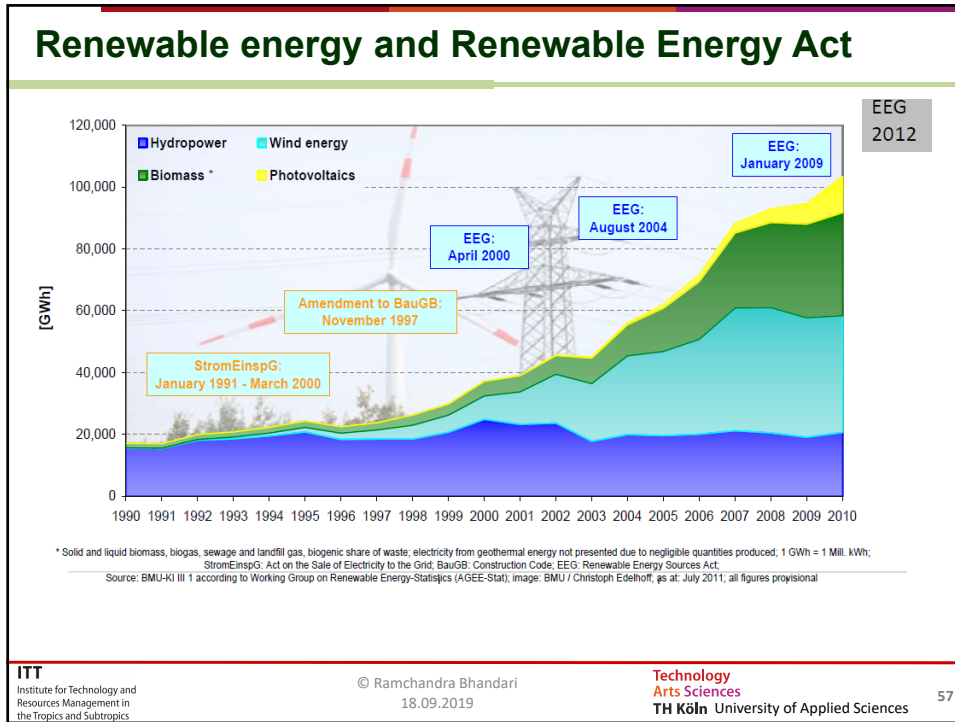


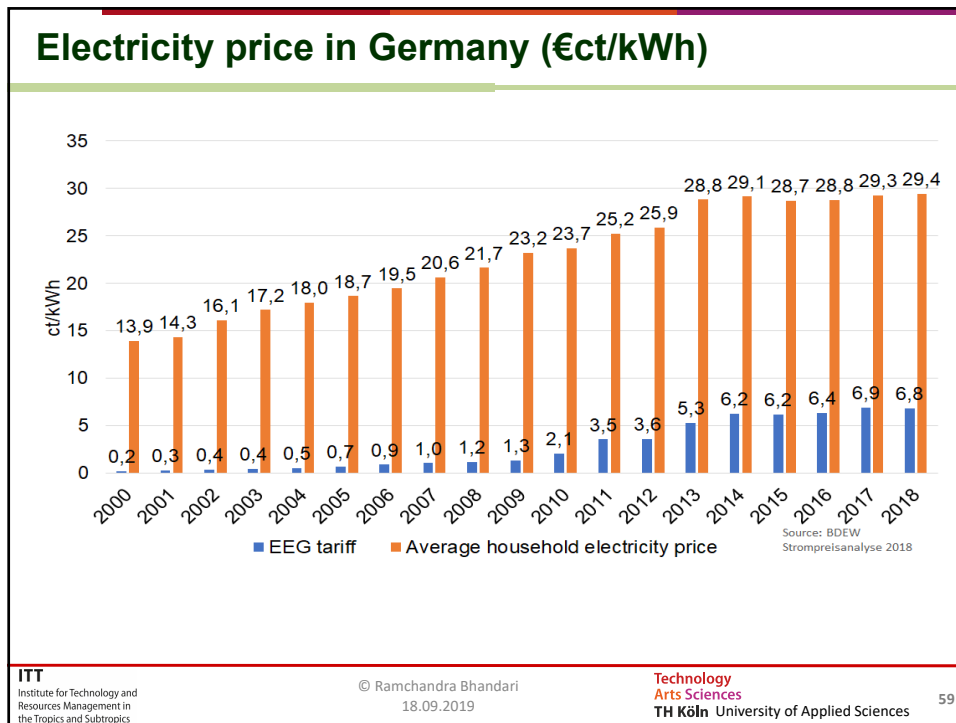


## What is the the reason behind?

## The impulse was ... Renewable Energy Act ...

- 1991 „Feed-in Law“
- 2000 Renewable Energy Act
- 2004 Renewable Energy Act - First amendment
- 1.1.2009 Renewable Energy Act - Second amendment
- 2011 Preparation of Third amendment
- 1.1.2012 Renewable Energy Act - Third amendment
- Reform – 2014 / 2016 / 2017





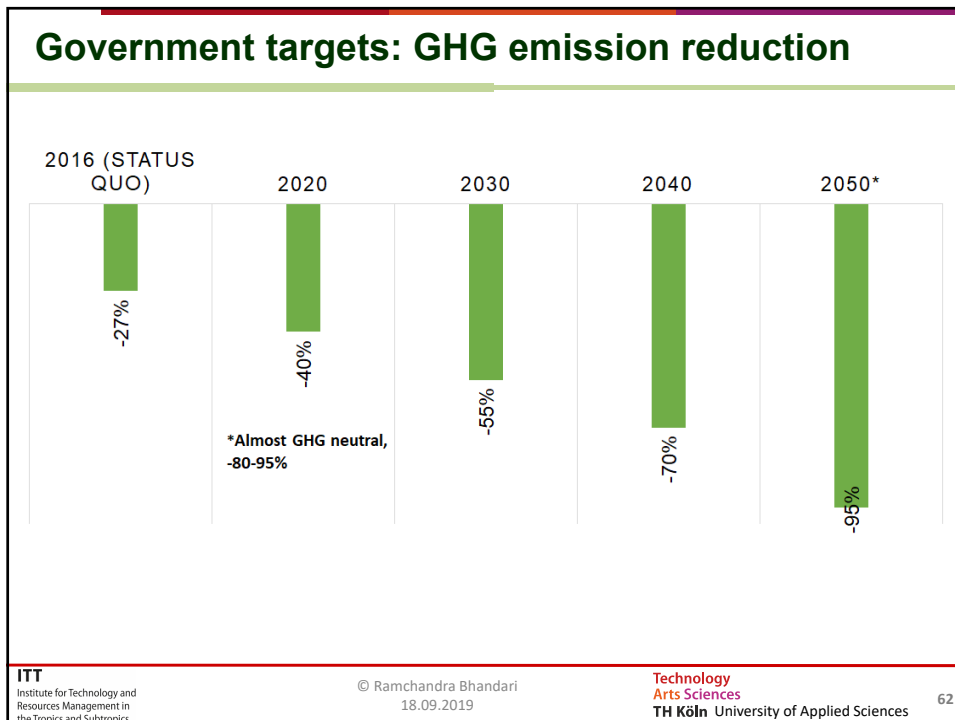
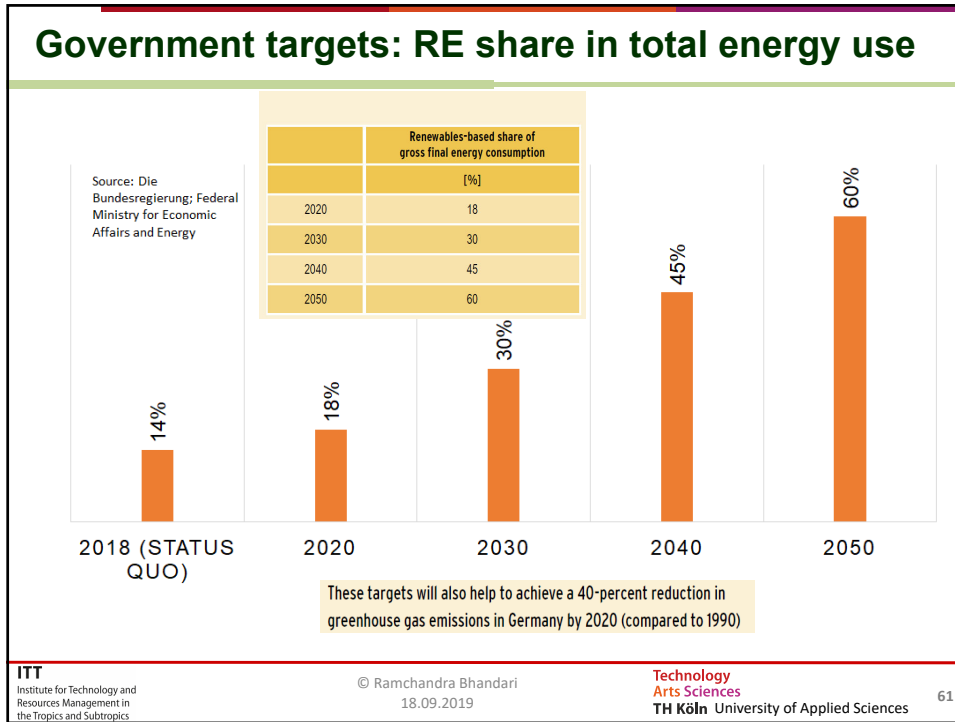
## Challenges and further „revolutions“

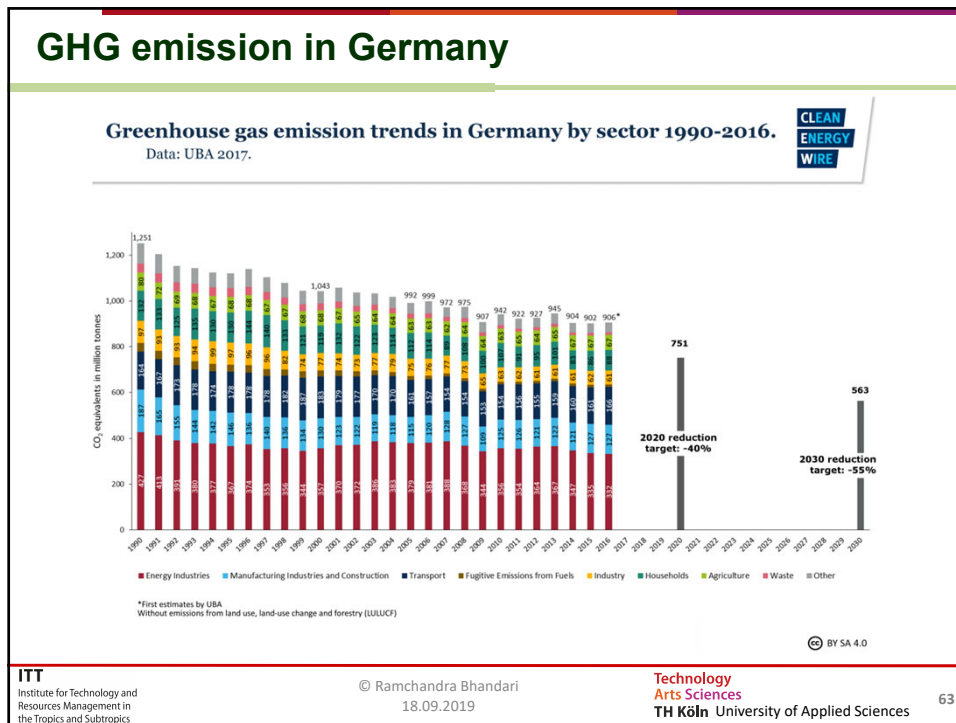
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## Nuclear phase out

- After the reactor accident in Fukushima in Japan on 11 March 2011, the Federal Government decided (on 14 March 2011) to shut down all German nuclear power plants by the end of 2022 at the latest.
- Since then, the Atomic Energy Act has set a shutdown date for each nuclear power plant.
- Regardless of the shutdown date, the authorization to operate a nuclear power plant expires when the assigned electric volume has been produced.

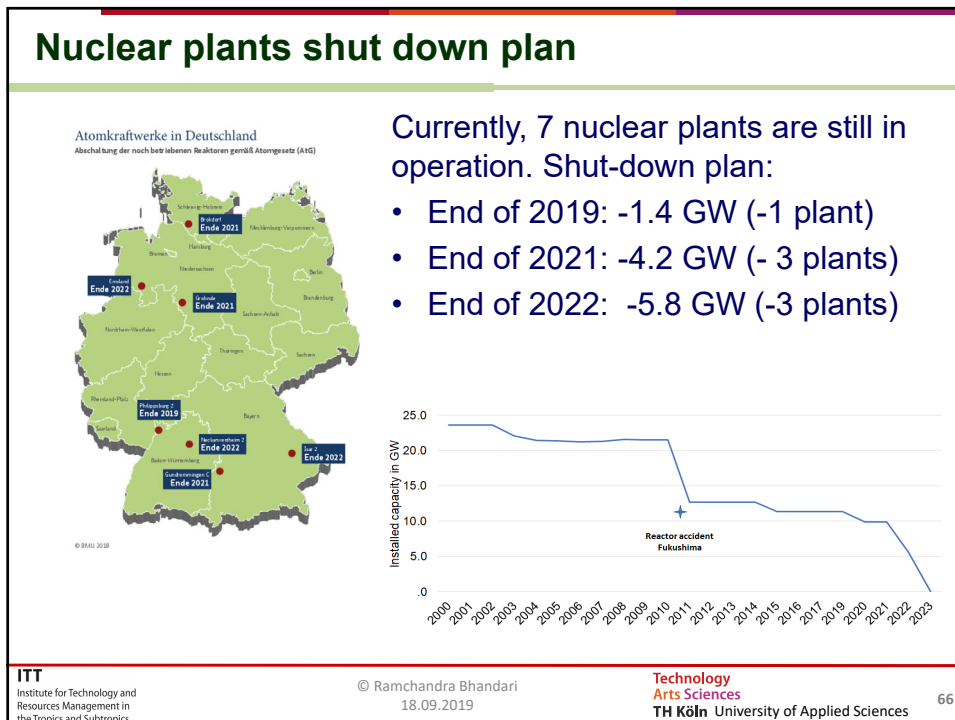
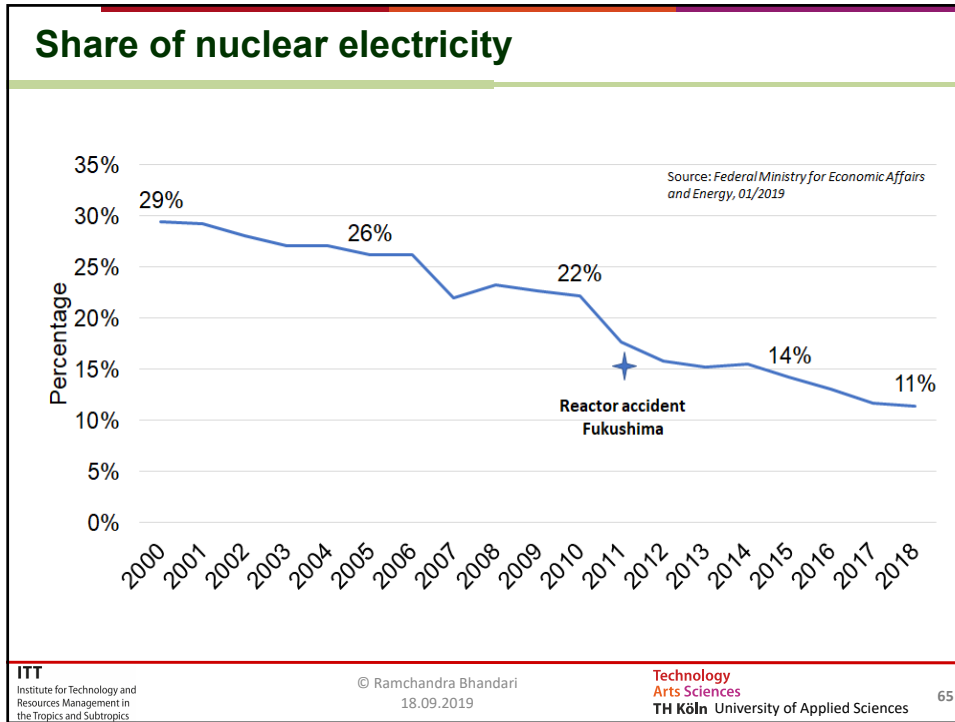


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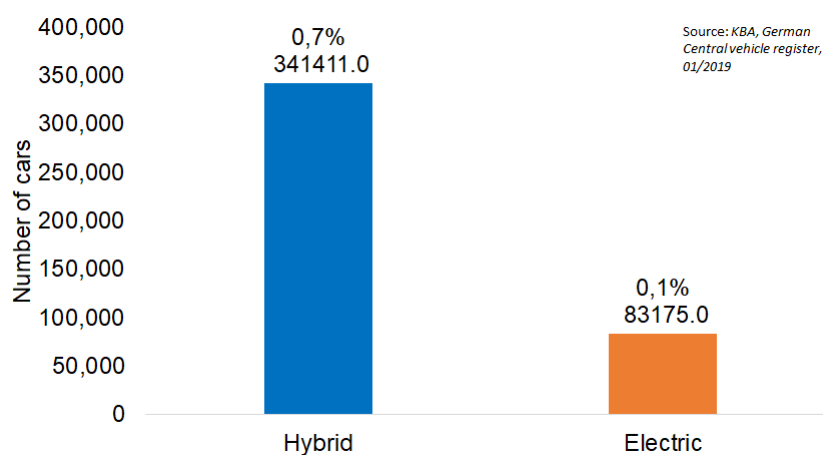
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## E-mobility

- Government says... Germany shall be transformed to be lead supplier and lead market for electric vehicles
- Target: **1 million electric vehicles until 2020** to be on Germany's roads
- Since July 2016: Environmental bonus of 4000 € for battery electric vehicles and 3000 € for plug-in hybrids

## Registered e-vehicles



## January 2019 announcement – coal exit



## New plans – coal exit

The New York Times

*Germany Lays Out a  
 Path to Quit Coal by 2038*



**The New York Times**  
 26.01.2019

**Germany agrees to end reliance on coal  
 stations by 2038**

Fossil fuels provide nearly 40% of country's power as tensions rise  
 on phaseout timetable



▲ The lignite-fired power plant in Niederaußen, Germany. Photograph: Federico Gambarelli/AP/Getty Images

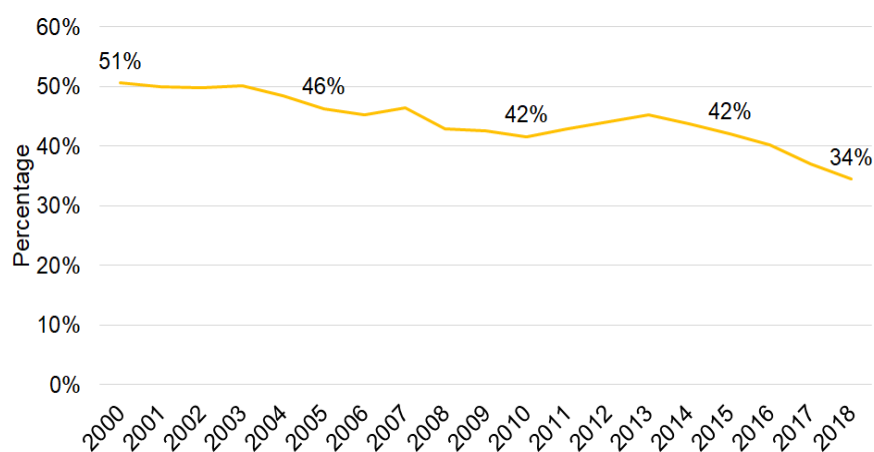
Germany has agreed to end its reliance on polluting coal power stations by 2038, in a long-awaited decision that will have major ramifications for Europe's attempts to meet its Paris climate change targets.

**The Guardian**  
 26.01.2019

## Coal exit plan

- By the end of 2017, 42.6 GW of coal power plants were installed in Germany, which contributed 21,6% of the total primary energy consumption and 36% of gross electricity generation
  - 2022: max. 25 GW (-17 GW)
  - 2030: max. 17 GW (-25 GW)
  - 2038: full exit (-42.6 GW)
- Structural assistance for coal mining regions to compensate job and infrastructure losses
- Reduction for electricity tariffs for both household and industry customers, to compensate the increasing electricity prices due to the accelerated coal exit – **but the framework not known yet..**

## Share of coal electricity



Source: Federal Ministry for Economic Affairs and  
Energy, 01/2019

## Remarks

- Germany is a mature market for RE and the main attribute of this growth must be given to feed-in-tariff law
- Out of about 38% renewable electricity, PV contributes today about 20% in the country, wind has highest contribution
- Since 2013, a brake is pulled down to slower the German PV market growth - a political decision
- In global scenario, PV module price may fall below 300€/kWp once the installation crosses 1 TW mark

**Renewable energy is the future of tomorrow, but it lies on the hand politicians rather than that on technology developers. Developing and implementing a proper policy instrument is vital for solving the problems of energy sufficiency, energy security and combating global GHG emissions.**

**Thank you for listening me !**

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