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3<sup>rd</sup> Fraunhofer Innovation and Technology Platform:  
Powering a Greener Future

# How to Develop Reliable and Sustainable Energy Systems for Smart Cities?

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*Member*

**Seoul International Energy Advisory Council**

Bangalore, 22 November 2014

# Agenda

Introduction Fraunhofer ISE

The Vision of »100 Smart Cities« of the Indian Prime Minister

Smart Cities definitions worldwide

Energy policy in Germany

Why energy is an important issue in Smart Cities

Energy scenarios for Frankfurt / Main

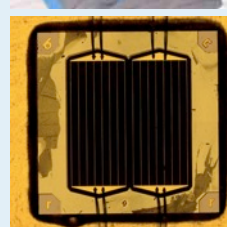
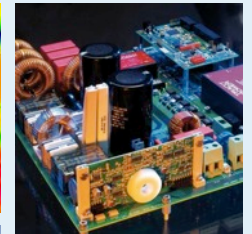
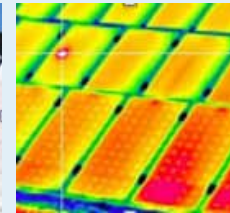
Conclusions

# Fraunhofer Institute for Solar Energy Systems ISE

- Applied research on Renewable Energies since 1981
- Largest Solar Research Institute in Europe  
1300 employees incl. 300 PhD and diploma students
- Director: Prof. Eicke R. Weber
- Part of the Fraunhofer Society more than 60 institutes and 22000 employees, largest applied research network



- Energy Efficient Buildings
- Applied Optics, Functional Surfaces
- Solar Thermal Technology
- Silicon Photovoltaics
- Alternative PV Technologies
- Renewable Power Supply
- Hydrogen Technology



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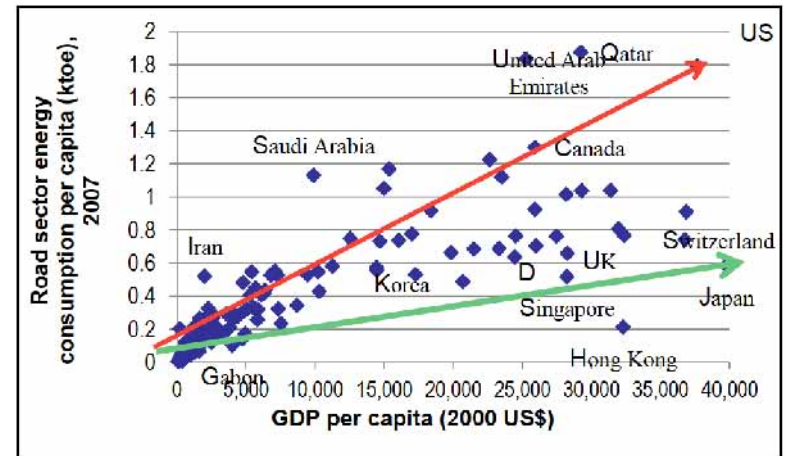
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# Smart City Scheme: Concept Note of MUD - I

Ministry of Urban Development – [www.indiansmartcities.in](http://www.indiansmartcities.in)

- India: share of urban population: 31%  
their share on GDP: 60%
- Smart Cities = »engines of economic growth«**
- Prime Minister’s vision: develop  
»100 Smart Cities« as
    - **satellite towns** of larger cities and by
    - **modernising the existing mid-sized cities**
  - Clearly, India should take the **low energy path**
    - aiming high GDP at low energy demand, see graph
  - **A Smart City needs to offer**
    - **economic activities and employment opportunities**
    - **decent living options to every resident, i.e.**
      - good quality but affordable housing
      - cost efficient physical infrastructure such as 24 x 7 water supply, sanitation, and 24 x 7 electric supply,
      - clean air, quality education, health care, security, entertainment, sports, robust and high speed interconnectivity, fast & efficient urban mobility etc.



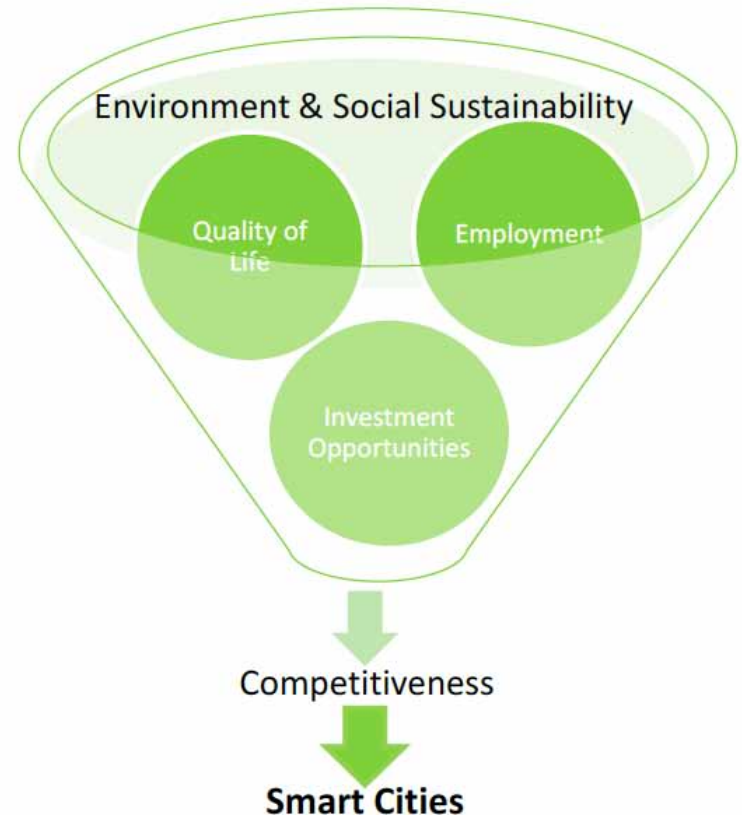
# Smart City Scheme: Concept Note of MUD - II

Ministry of Urban Development – [www.indiansmartcities.in](http://www.indiansmartcities.in)

»Smart Cities are those that are able to attract investments and experts & professionals«

Smart Cities are those which have smart (intelligent)

- **Institutional Infrastructure:** planning and management systems in a city
- **Physical Infrastructure:** (cost-efficient and intelligent) urban mobility system, housing stock, **energy system**, water supply and sewerage system, sanitation facilities, solid waste management system, drainage system, etc.
- **Economic infrastructure** focused on core competence and comparative advantages, with: Industrial Parks and Export Processing Zones, IT / BT Parks, Trade, Financial, Service and Skill Development Centres, and Logistics hubs
- **Institutional Infrastructure (incl. Governance)** with involvement of citizens in decision-making processes. Principle: “**Governance by Incentives rather than Governance by Enforcement**”. Smart Cities would have municipal offices fully automated.



# Smart City Scheme: Mobility

India today:

- Walking and cycling: unsafe
- Public transport: inadequate

Hence, Smart Cities lay considerable emphasis on

- walkability and cycling in the city
- a good freight movement system

Improved mobility in Smart Cities shall be achieved by a three pronged approach: Improvements in:

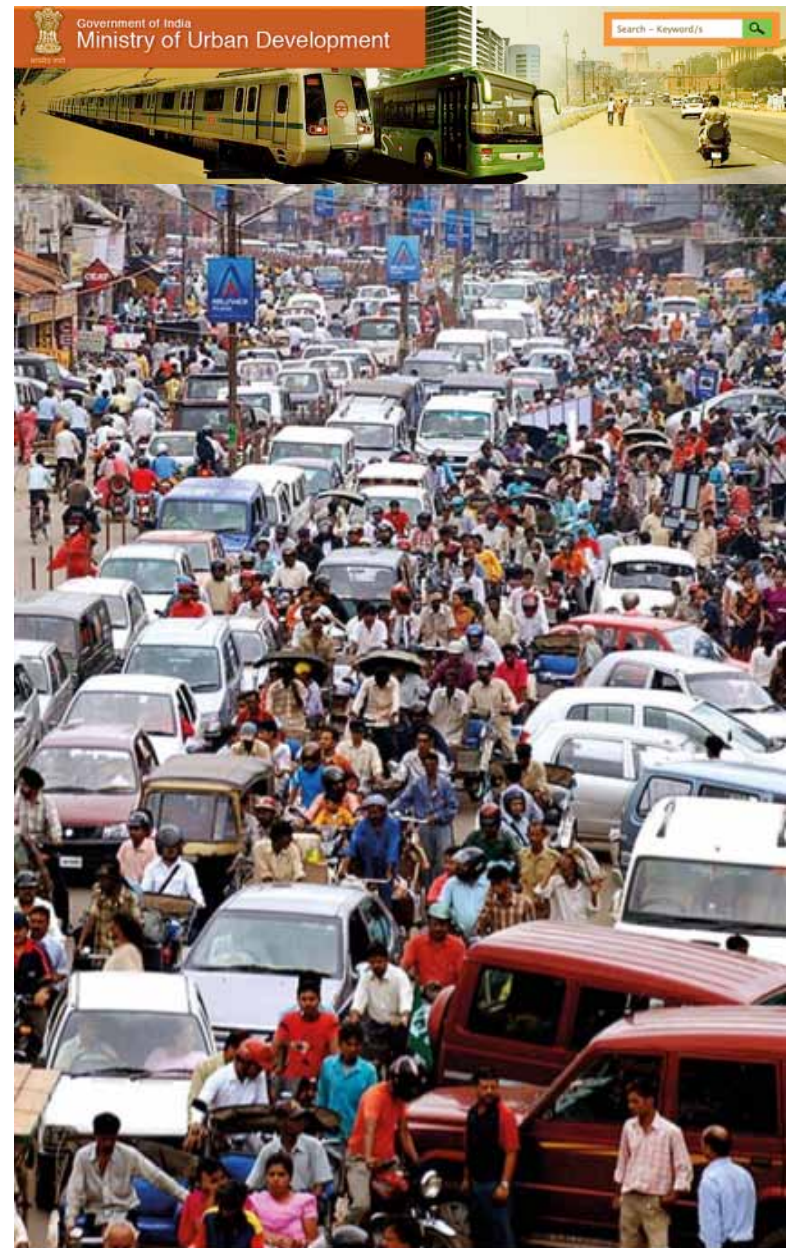
## 1. Public transport

– Metro Rail, BRT, LRT, Monorail, Trams etc.

## 2. Infrastructure of motor vehicles

– ring roads, bypasses, underpasses, elevated roads, improvements in the existing road ways

## 3. Infrastructure for walking, cycling and waterways



Traffic in Bangalore Source: [www.aventure.ac.in/poised-muddle/](http://www.aventure.ac.in/poised-muddle/)

# Smart City Scheme: Reliable Utility Services

## Safe and 24x7 water supply

- Smart cities: availability of 24x7 piped water supply that meets benchmarks of water quality and pressure, etc. across the city.
- Dual water supply systems: drinking water and other needs (allows recycling and conserving water)
- Smart water meters may be installed

## Storm Water Management: technical interventions

## Solid Waste Management

- Indian cities facing a lack of proper collection, segregation, treatment and disposal of waste  
»Only clean cities exhibit a smart character«

## Smart Cities strategies on solid waste

- Segregation of recyclable and non-recyclable waste
- Appropriate technology for treatment of waste
- Effective collection and disposal system
- Products based on recycling of solid waste



© AP / Bikas Das, <http://blogs.sacbee.com>

© picture alliance / dpa

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# Smart City Scheme: Electricity

## Universal access to 24x7 electricity

- Access to electricity: nearly 94% (in urban area households)  
but: concern on availability and quality of the supply

## The cities should shift towards

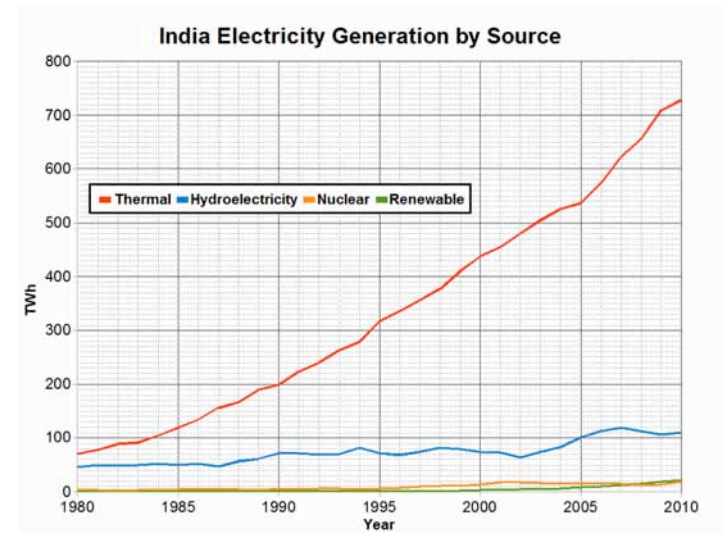
- **smart metering** at the household level
- establishment of a **smart grid**
- The integration of the **renewable energy sources** such as solar and wind energy
- existing distribution system must be strengthened
- power banking systems need to be established
- focus should be on **green buildings and green transport** to reduce the need for electricity

## In general, cities should achieve

- an **integrated billing system** for a variety of services such as electricity, water, gas, internet, house tax, etc. with a common customer care centre and user friendly online payment platform



© Reuters



Source: Wikimedia.org

# Smart City Scheme: Internet / Telephone and Urban Development

## Essential ICT services in Smart Cities

- 100 Mbps internet backbone
- 100% coverage of the area by cell phone towers
- Most services will have to be offered online.
- Fibre Optic connectivity to each home
- Wi-Fi in all public places and educational institutions
- Transparent and efficient system of providing Right of Way by Municipal Authorities is needed

## Urban Development

- Planned development and decongestion of the CBDs instead of unplanned development and urban sprawl
- **Many policies governing urban areas are old and need to be reviewed, building bylaws are archaic,** provisions like parking space requirements and building heights do not meet today's demand
- **Revision of FARs and bye-laws.** Govt would assist smart cities to develop City Development Plans based on ICT, GIS and Spatial Mapping.



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© www.skylineinfra.com

# Smart City Scheme: Energy Efficiency

## Key features of “Smart Cities” on energy

- Tariff structures should incentivise conservation
- Culture of conservation to be built up by awareness programs
- Energy efficiency measure on:
  - building material
  - transport system
  - sewerage and water supply systems,
  - **street lighting**
  - **air-conditioning systems, and**
  - **energy consumption in buildings**



© www.theclimategroup.org



© <http://blogs.ise.ac.uk/>

# Smart City Scheme: Smart Grid

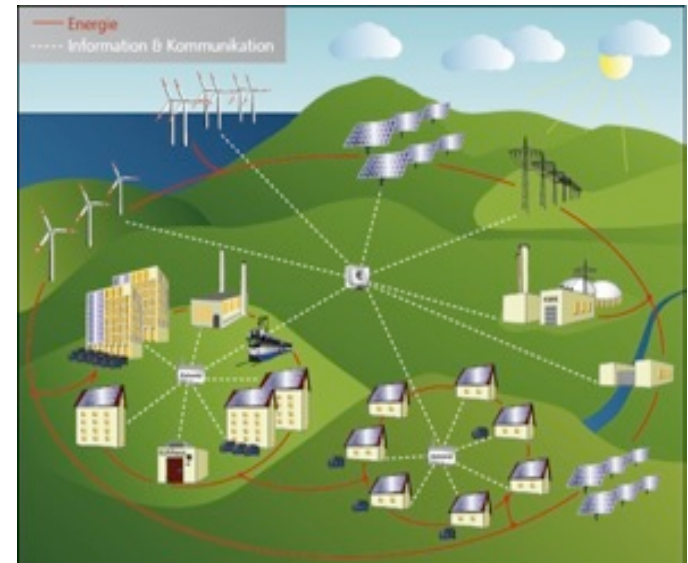
- Electricity network using digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources.

## Motivation

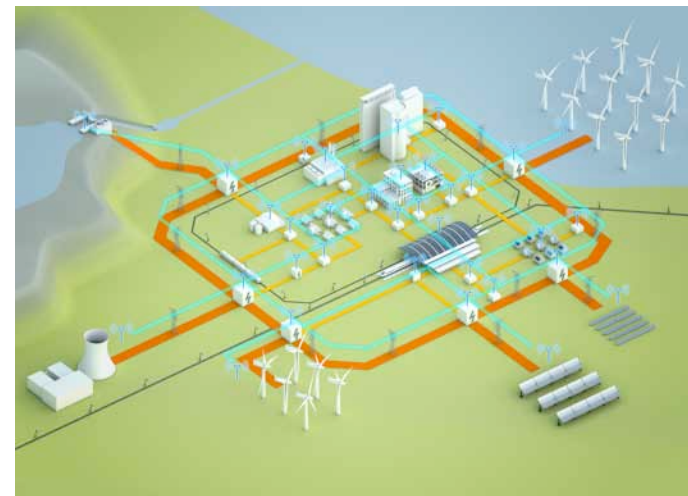
- Installed capacity: 230 GW (2013) > 900 GW (2032)
- Consumption per cap.: ca. 25% of world average
- Lack of access to electricity to a significant proportion of the population.
- 12th Five Year Plan target for 2020:  
**36 GW renewable energy (excl. hydro) (RE)**  
**from 12% (today) to 20%**
- **Smart Cities: 10% of energy shall provided by RE**

## Smart Grid key characteristics

- Self healing: grid detects, analyzes, responds,...
- Provides power quality to consumer and industry
- Accommodates demand responds, combined heat and power, wind, PV, and enc-use efficiency
- Transform the Indian power sector into a secure, adaptive, sustainable and digitally



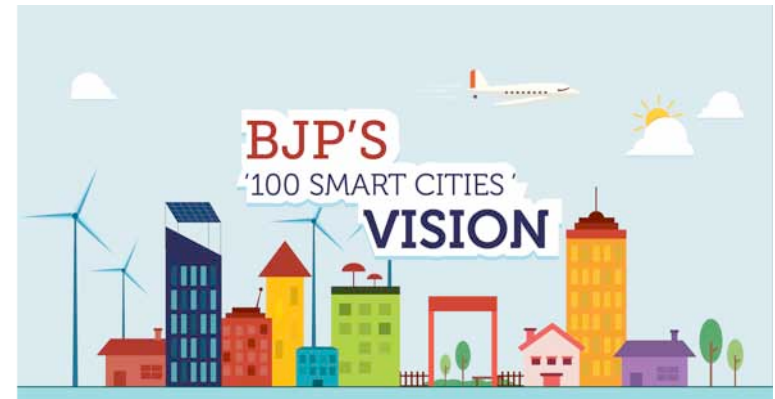
© Fraunhofer ISE



© Siemens

# Smart City Scheme: 100 Smart Cities in India

- 100 Smart Cities will be supported
- Development of greenfield cities have seldom been successful, however, some new cities need to be developed in the Hills and Coastal areas.



Source: [www.commonfloor.com](http://www.commonfloor.com)

## 100 cities may be chosen from:

- Satellite cities of cities bigger than 4 mio people (9)
- Most of the cities of 1 – 4 mio people (35 out of 44)
- All State/UT Capitals (17)
- Cities of tourist, religious and economic importance not included in above (10)
- Cities in the 0.2 to 1.0 mio people range (25)



Source: [www.mapsofindia.com](http://www.mapsofindia.com)

# Smart City Scheme: Operational Procedure

## To be developed

- **Citizens Reference Framework:** be evolved through professional agencies, capturing aspirations and expectation of citizens by wide citizens consultation
- **Smart Cities Development Plan:** GIS, spatial, and ICT mapping as well as master plan, incl. financial requirements and funding
- **Environmental Sustainability Plan:** actions for energy efficient and green technologies / processes.

## Procedure

- Govt will provide financial resources
- Govt will help State Governments/Urban Local Bodies by empanelling professional agencies centrally
- State Governments/ULBs/parastatal will be able to select one of the empanelled agencies of their choice for each of the aforementioned plans.



Source: [www.city-form.org/india/](http://www.city-form.org/india/)

# Challenges: Capacity Building

- **The current capacity is weak** to take up such a large program.
- A strong **cadre of urban planners has not developed** in the civil services.
- **A large number of professionally trained manpower** will be needed.
- Thus, there is a **need for a large capacity building program** that encompasses training, education, contextual research, knowledge exchange and a rich database.
- **Ministry of Urban Development will take up a national program towards Capacity Building** through
  - (i) a Mother Institution: developing curriculum, standards, contacts and ensuring quality,
  - (ii) Regional Institutions ( 5 to 8): conduct of courses, adherence to standards, protocols etc.
  - (iii) Training Institutions (about 50)
- Existing institutions will be strengthened



INSTITUTE OF TOWN PLANNERS, INDIA



Source: [www.laimyours.com/7680/urban-planning-as-art-in-long-beach/](http://www.laimyours.com/7680/urban-planning-as-art-in-long-beach/)

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## **Smart Cities definitions worldwide**

Energy policy in Germany

Why energy is an important issue in Smart Cities

Energy scenarios for Frankfurt / Main

Conclusions



# »Smart Cities« dimensions: challenges → opportunities

## Energy system

fossil-nuclear, centralized, import dependency, ...

→ **renewable, decentralized, higher level of autonomie,...**



## Buildings

high demand on energy and other resources,...

→ **efficient, sustainable, flexible, high comfort,...**



## Mobility

congestions, growing land consumption, noise, emissions,...

→ **efficient, public transport, emission free, multi modal,...**



## Information and communication (ICT)

simple, separate systems,...

→ **connected, smart, improved service and comfort,...**



## Demography, economy, education, health, ...

Basic changes of the society are challenging the city...

→ **social equalization, security of living standard,...**



# Smart Cities worldwide: Different focuses

- **General aim: Cities shall become sustainable and more livable for their citizens**
- **General component: Using Smart Technologies (ICT)**
- **Differences due to: Cities are reacting on local needs and challenges**
  - population growth, demography, economy, traffic, climate,...
  - New built cities or transformation of existing cities



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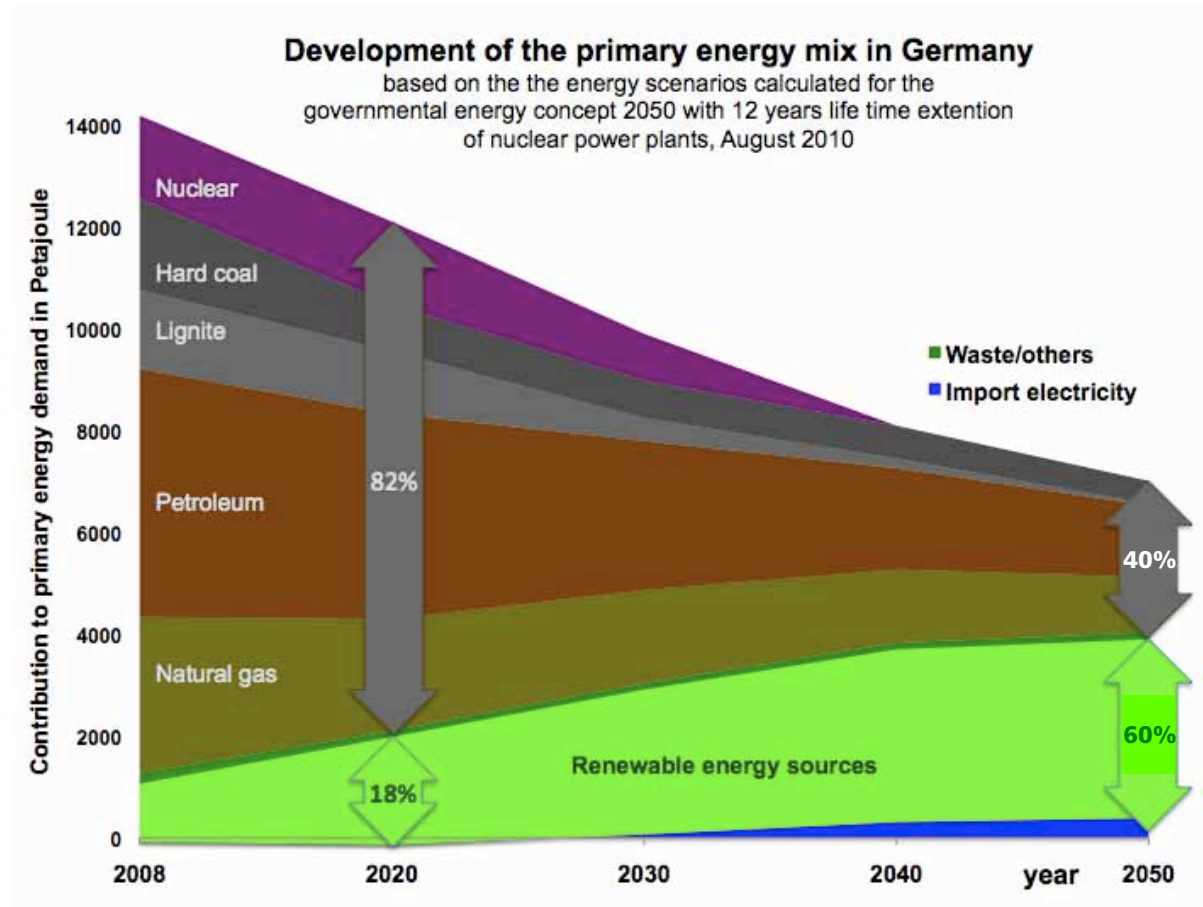
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# German governmental plan of the future energy mix

German government agreed in Sept 2010 on the energy concept 2050

## ■ Targets for 2050

- Primary energy reduction by 50%
- 60% RES on primary energy
- 80% RES on electricity production
- After the disaster in Fukushima, the German government decided to fade out nuclear power until 2022



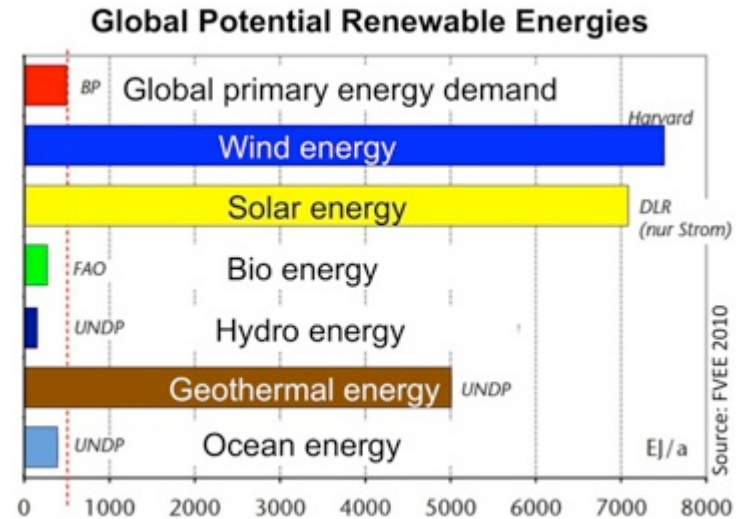
# Perspectives for renewable energy sources (RES)

## Benefits

- RES reduce import dependency
- RES stabilize energy prices
- RES increase local added value
- RES create jobs
- RES mitigate climate change

## Challenges

- RES are usually more expensive (but becoming cheaper and cheaper)
- RES need to be integrated within an intelligent energy system with storage to compensate fluctuations



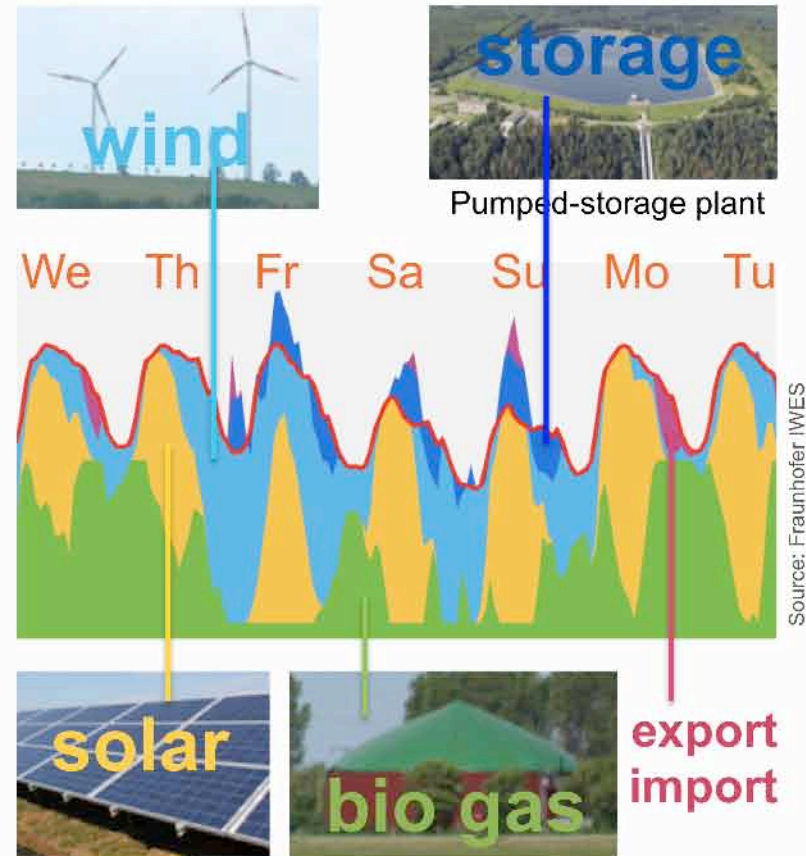
# Challenge: variation of solar and wind energy generation

Secure electricity supply with the right RES mix and intelligent operation

Measures to secure electricity supply:

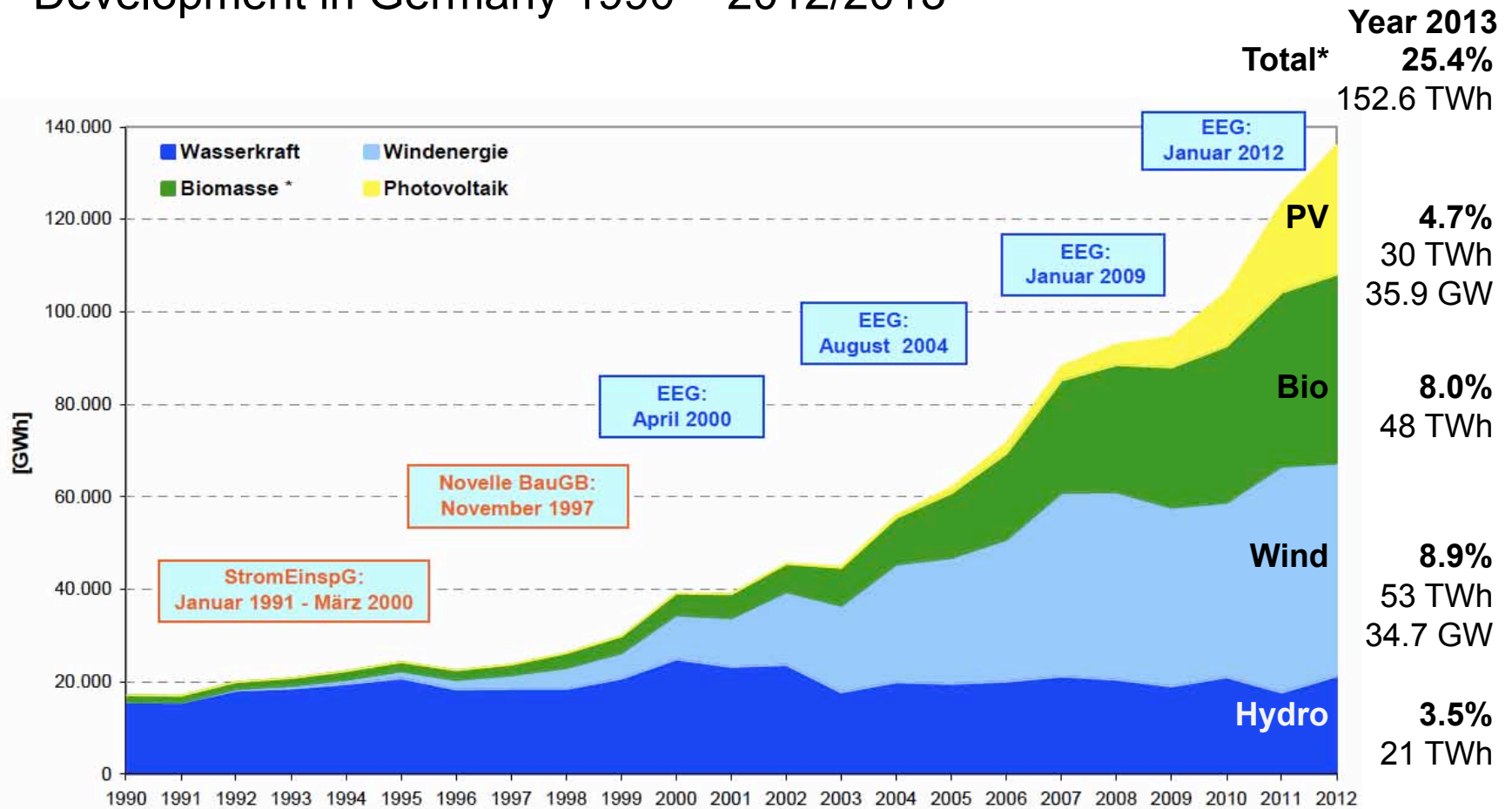
- **Optimal mix of RES**
- **Expansion of the distribution grid**  
to capture solar electricity and balance differing regional solar electricity generation
- **Expansion of high-voltage grid**  
to bring wind electricity to consumers and balance differing regional generation
- **Smart Grids**
- **Demand-side management**  
“consumption follows generation”
- Build up **short time storage capacities**  
for peak shaping
- Build up **seasonal storage capacities**

Following a typical load curve with RES (one week example)



# Electricity generation from renewable energy sources

Development in Germany 1990 – 2012/2013



\* Feste und flüssige Biomasse, Biogas, Klär- und Deponiegas, biogener Anteil des Abfalls; 1 GWh = 1 Mio. kWh;  
 Aufgrund geringer Strommengen ist die Tiefengeothermie nicht dargestellt; StromEinspG: Stromerzeugungsgesetz; BauGB: Baugesetzbuch; EEG: Erneuerbare-Energien-Gesetz; \* Gross electricity demand  
 Quelle: BMU - E 11 nach Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat); Stand: Februar 2013; Angaben vorläufig

# Electricity generation from PV and Wind in Germany

## Wind and solar power are ideal partners in the right mix

Monthly electricity generation from Wind and PV in 2013

Monthly generation  
Wind + Photovoltaic:

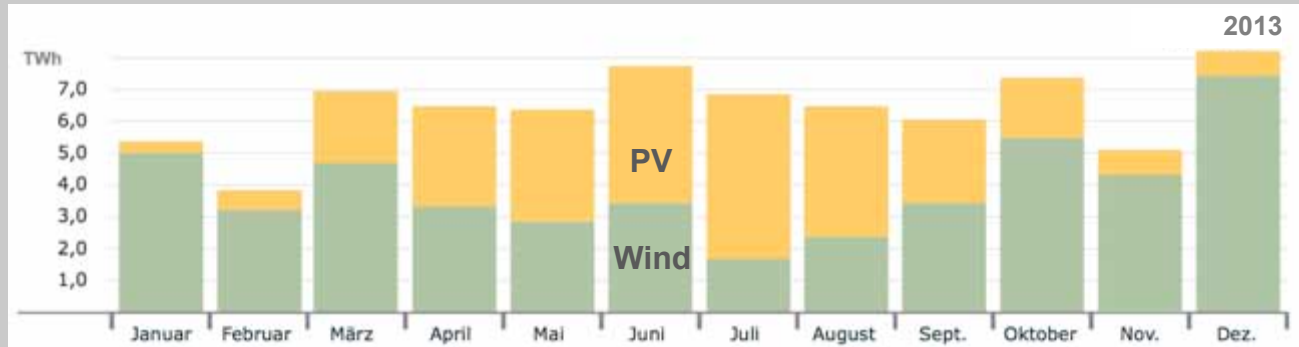
Min.: 3.9 TWh

Max.: 8.2 TWh

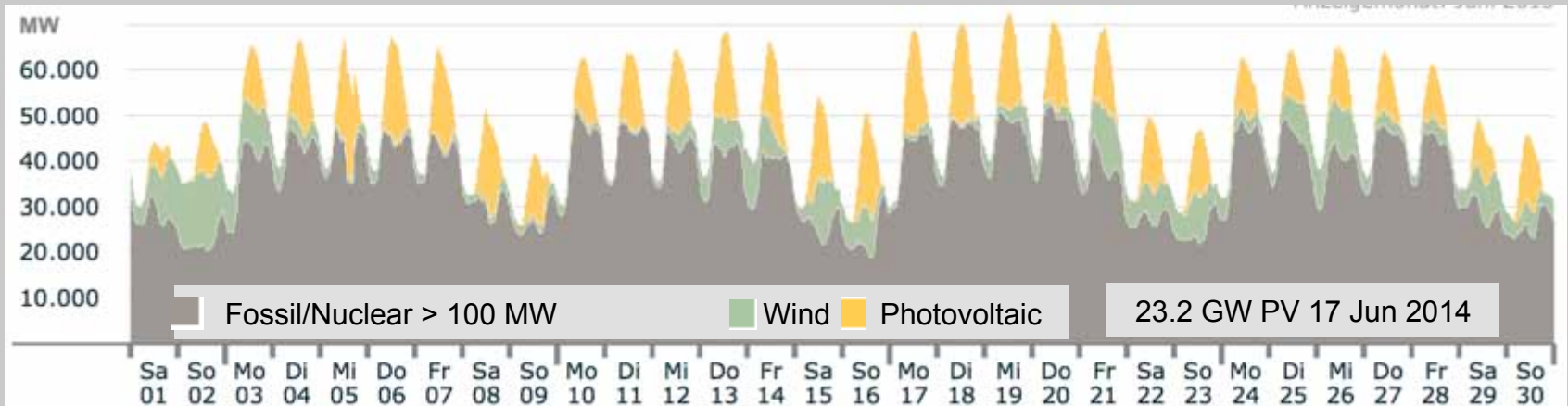
Annual generation:

PV: 29.7 TWh

Wind: 47.2 TWh

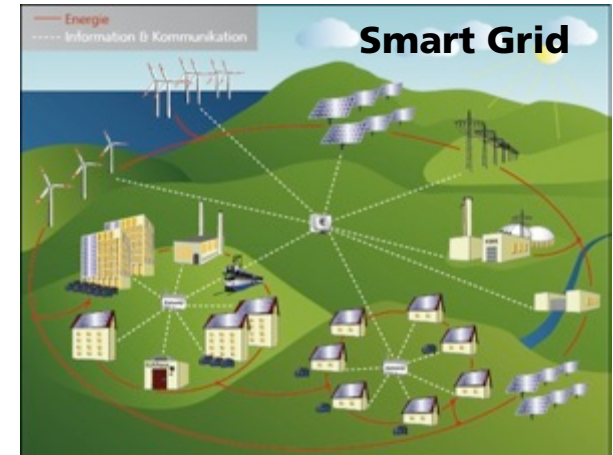
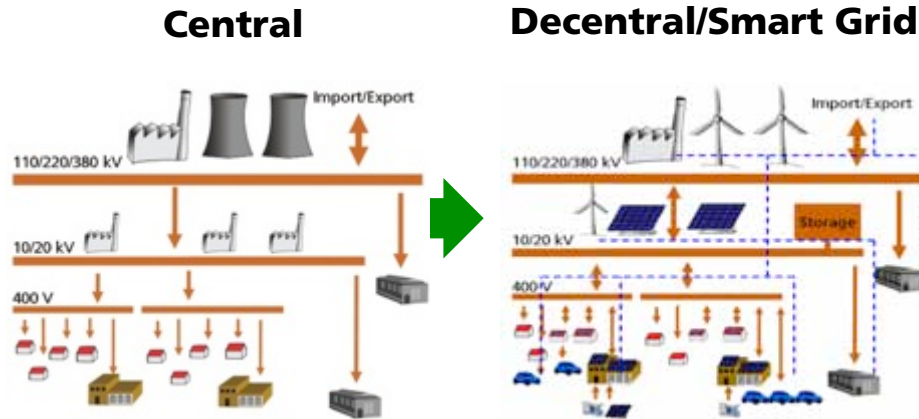


Electricity generation June 2013: Wind, PV and fossil/nuclear power stations > 100 MW





# Important elements of the future electricity system



## Combined heat & power, district heating

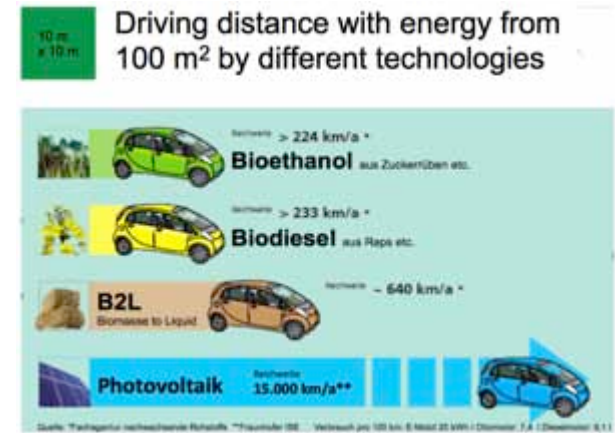


Natural gas => bio gas



© MTU, St. Peter

## Advantage Electric Mobility



Source: Fraunhofer ISE (all graphs)

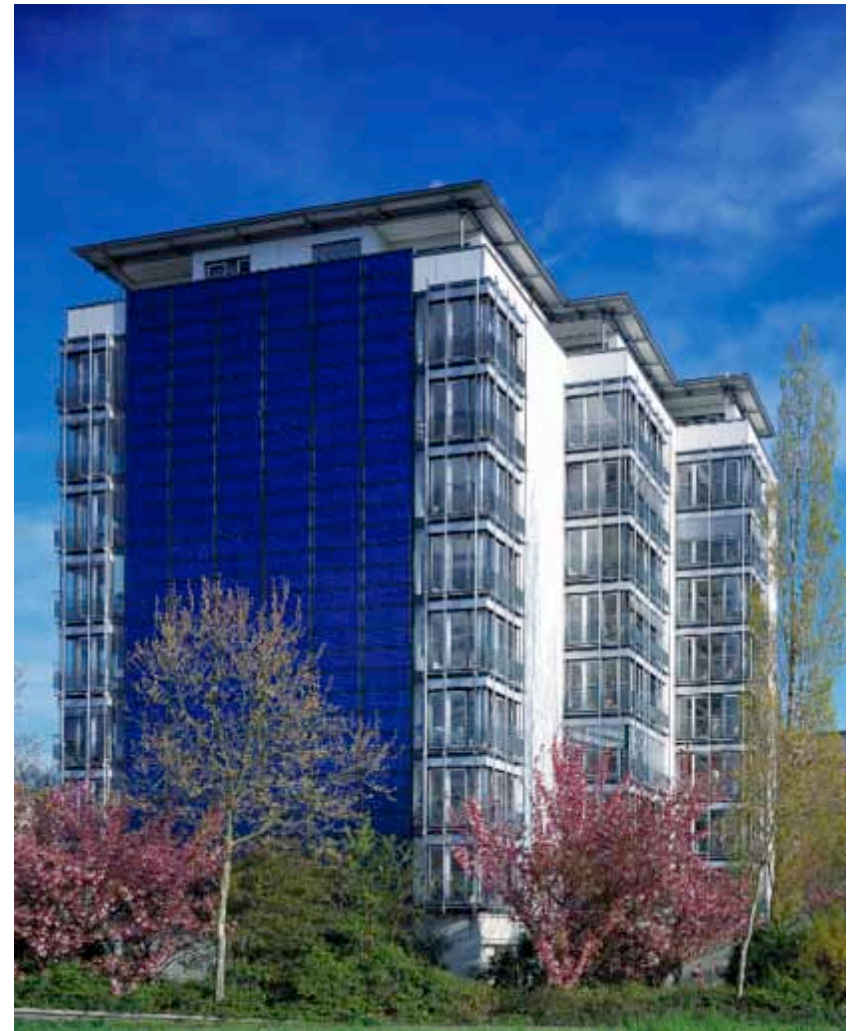
# Buildings will become zero or plus energy houses

European building directive:  
From 2021 on, new buildings must be  
“Nearly zero-energy buildings”

Buildings will use their roof and their  
façades to produce electricity and heat



Source: Schüco



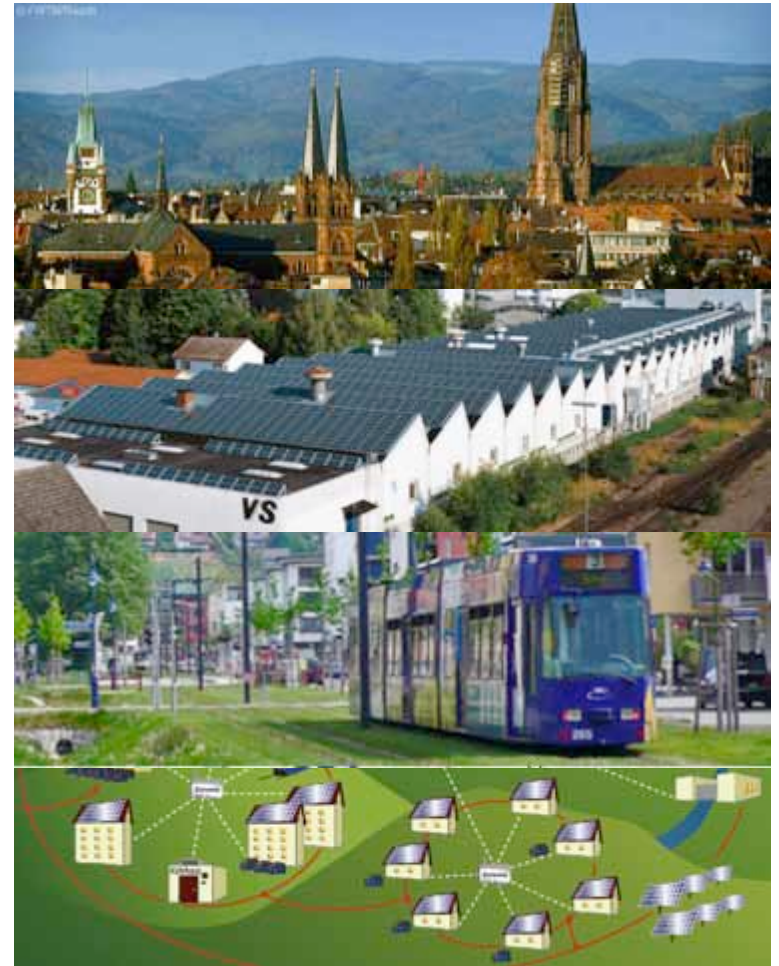
Source: Hotz Architekten



# Why energy is an important issue in Smart Cities

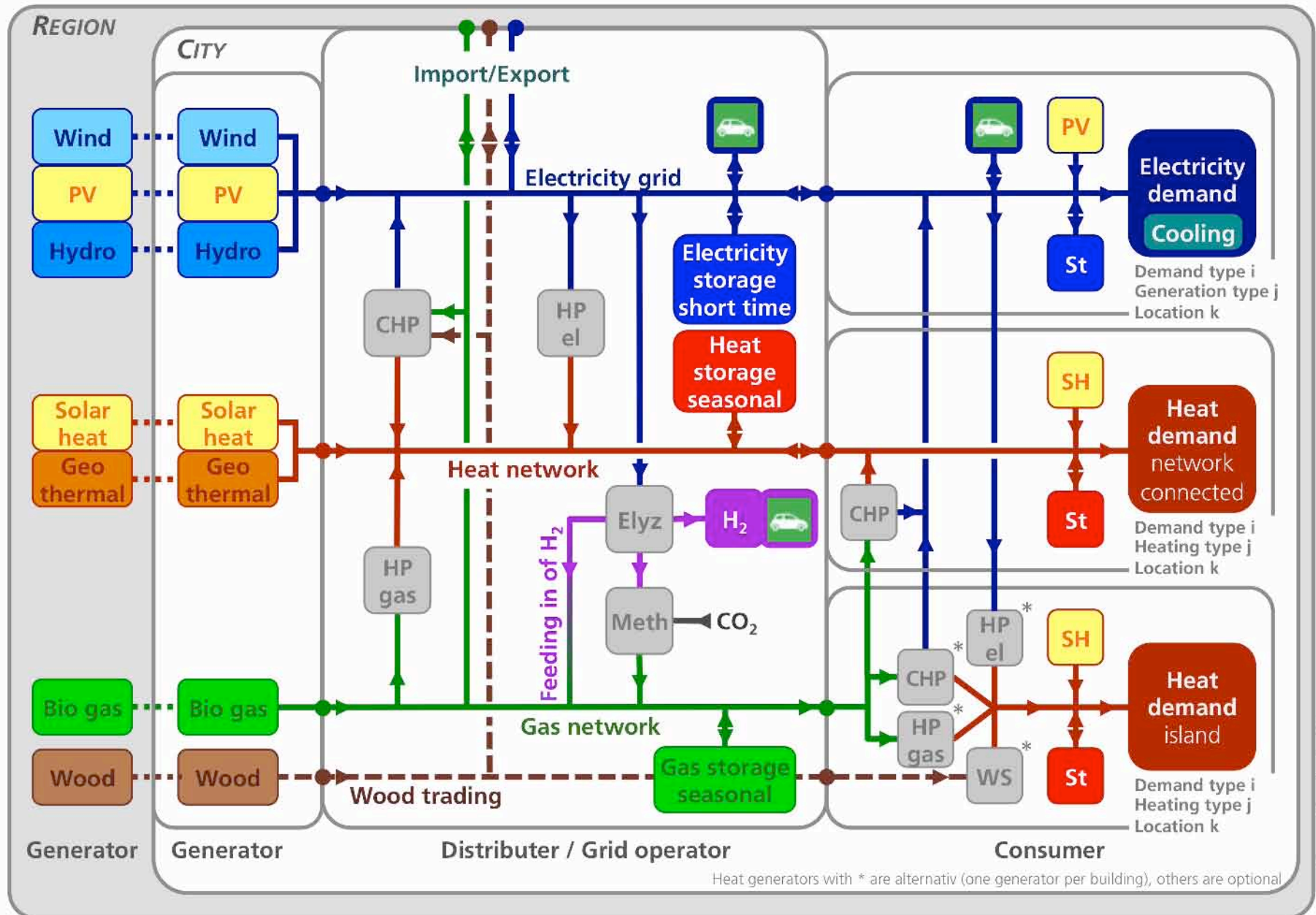
# Smart Energy Cities and Regions will play a key role by transforming the energy system

- **75% of greenhouse gas emissions** are produced in cities & communities
- A lot of the transformation measures must be realized on **local level**
- **Active contribution** of the citizens, industry, public sector etc. is needed, they have to
  - invest in energy efficiency and RES
  - change the type of mobility, use public transport
  - change behaviour and accept the changes
  - ...



Source: SMA / ISE / FWTM Freiburg

# Neighborhood / City / Regional Energy System based on Renewable Energies



Source: Fraunhofer ISE

HP el/gas = Heat pump electric / gas driven, CHP = Combined heat and power, WS = Wood stove, St = storage, SH = Solar heat, Elyz = Elektrolyzer, Meth = Methanation

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# Energy scenarios for cities and regions

## Sound planning basis by new energy modeling tool

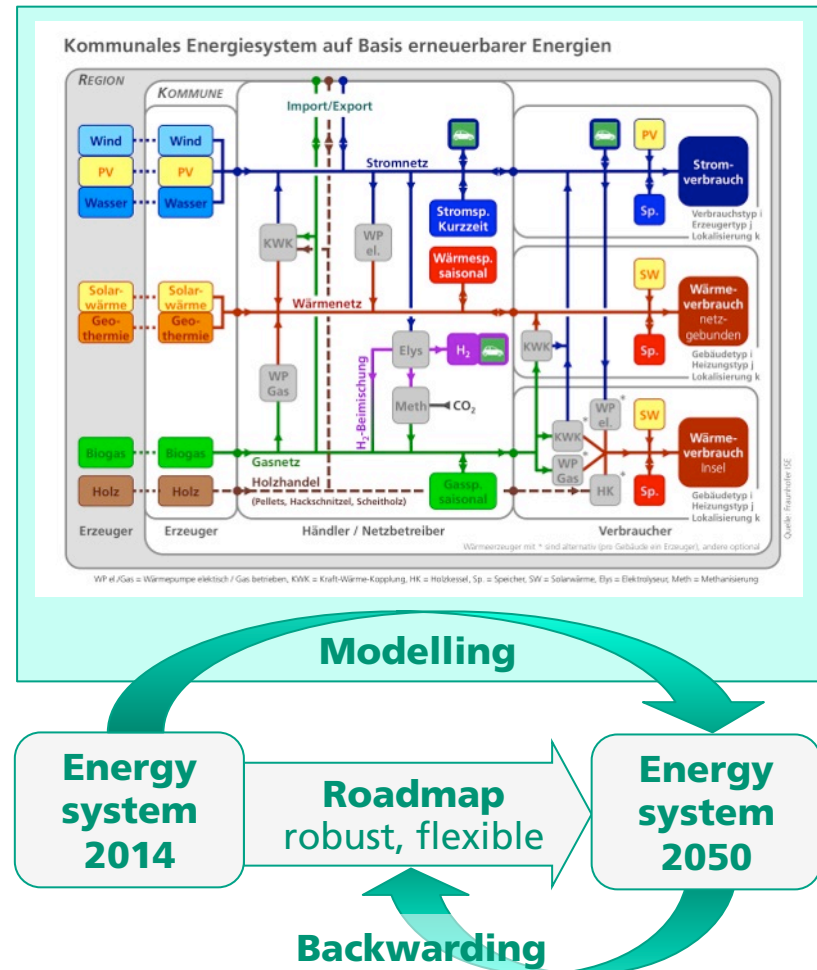
### Characteristics of sustainable urban and regional energy systems:

- High share of **fluctuating** solar and wind energy
- **Decentral** generation
- High **interdependency** of electricity, heating, cooling and mobility sectors
- Use of thermal and electrical **stores**

➔ To identify the cost-effective target energy system needs **temporal highly resolved modelling**

Concept:

- 1) Modelling target system 2050
- 2) Backwarding roadmap



# Energy system modelling for the identification of sustainable target energy systems

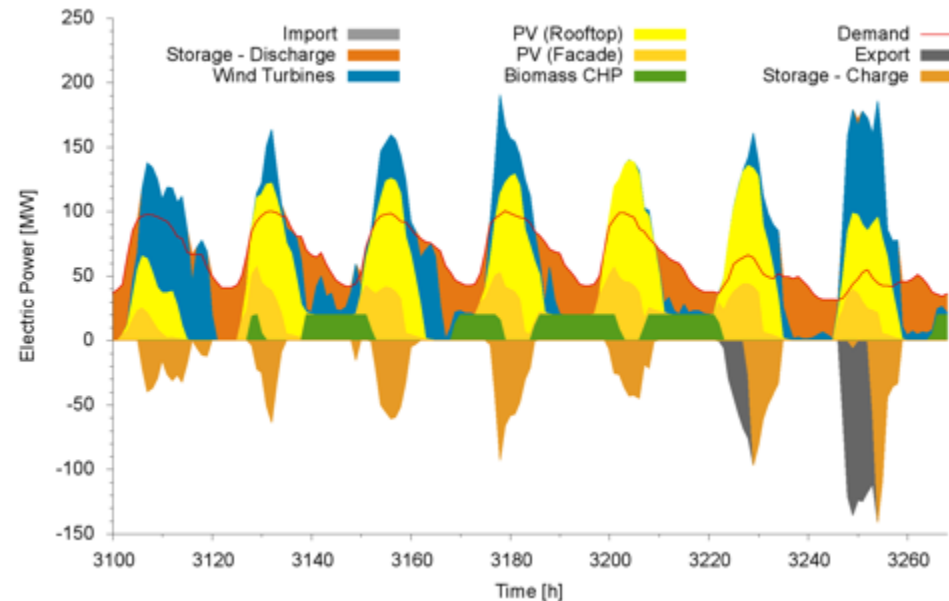
Fraunhofer ISE developed modeling tools to calculate optimized target energy systems for cities / countries

- Temporal highly resolved simulation of electricity, heat/cold, transport

## Questions answered:

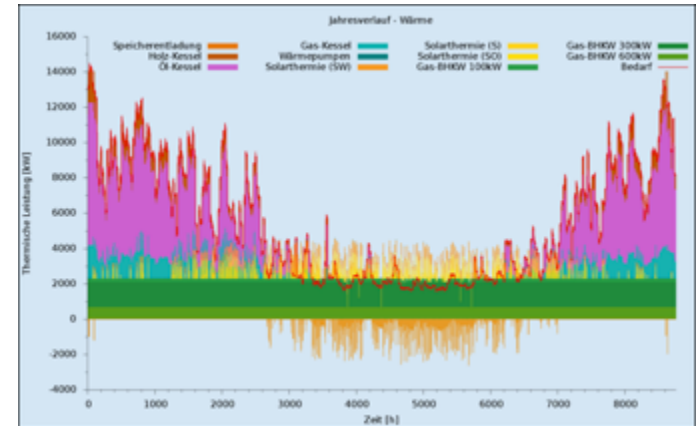
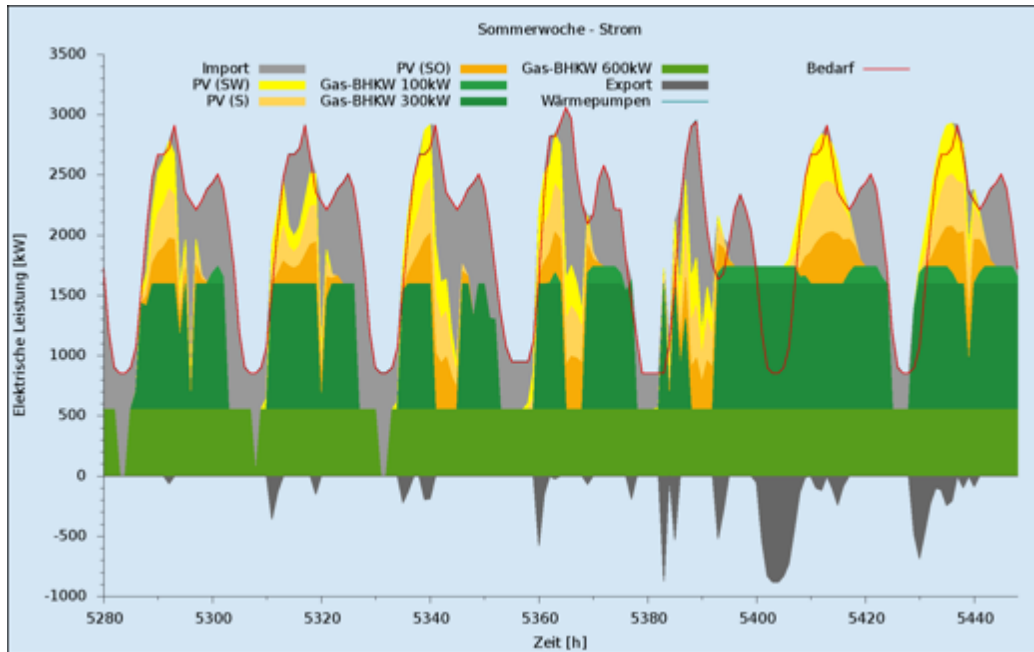
- Design of the energy system to achieve x% renewable energy supply at lowest costs
- Physically possible energy concepts
- Necessary generation, grid and storage capacities
- How much energy import/export to the city/region is necessary
- Investment and operation costs

## Example: Electricity supply and demand of one week in spring





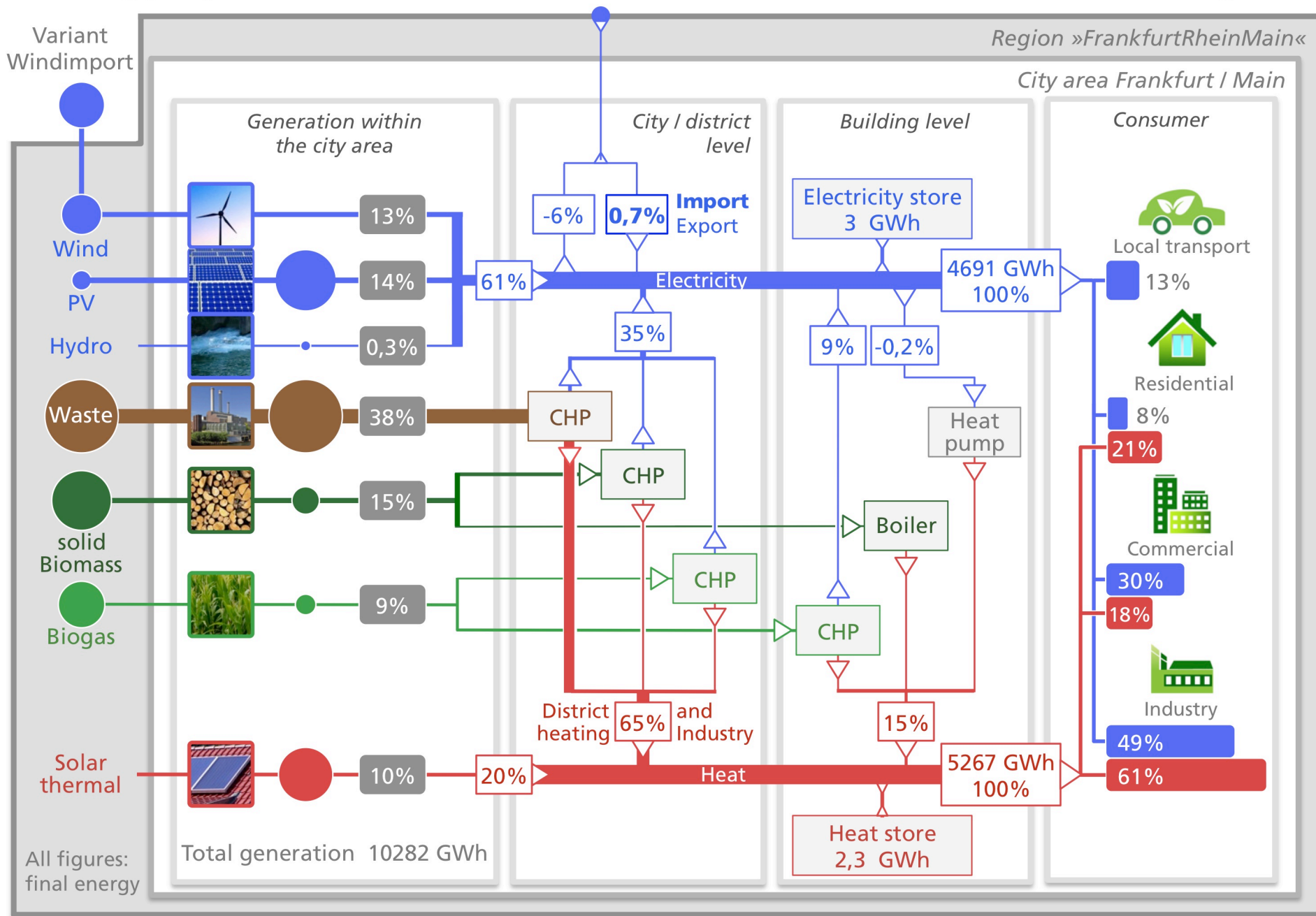
# Examples of simulation results



Annual development of heat demand and supply

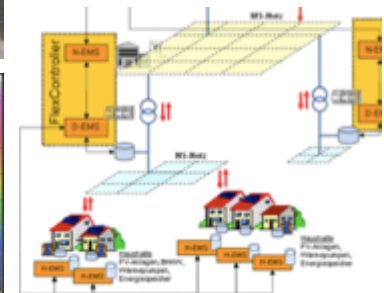
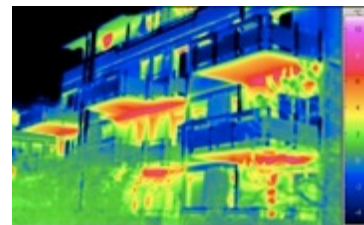
Electricity demand and supply of one week

# Energy System Frankfurt am Main: 100% renewable energies



# Conclusions

- **Smart Cities is a strong movement worldwide, but definitions are varying**
- **Cities and regions are key players** by transforming the energy system of a country, **energy is a key aspect of Smart Cities**
- **»100 Smart Cities« is an ambitious vision of the Indian Government** with a very broad approach focusing on economy, employment, water, waste, sewage, energy, mobility, and ICT
- Modelling tools help to identify the **most cost-effective design of sustainable urban or regional energy systems**



# Creating 20 Lakh Jobs



# ICORE 2014

12<sup>TH</sup> INTERNATIONAL CONGRESS ON RENEWABLE ENERGY (ICORE)  
8 - 9 DECEMBER 2014 | MANEKSHAW CENTRE, NEW DELHI

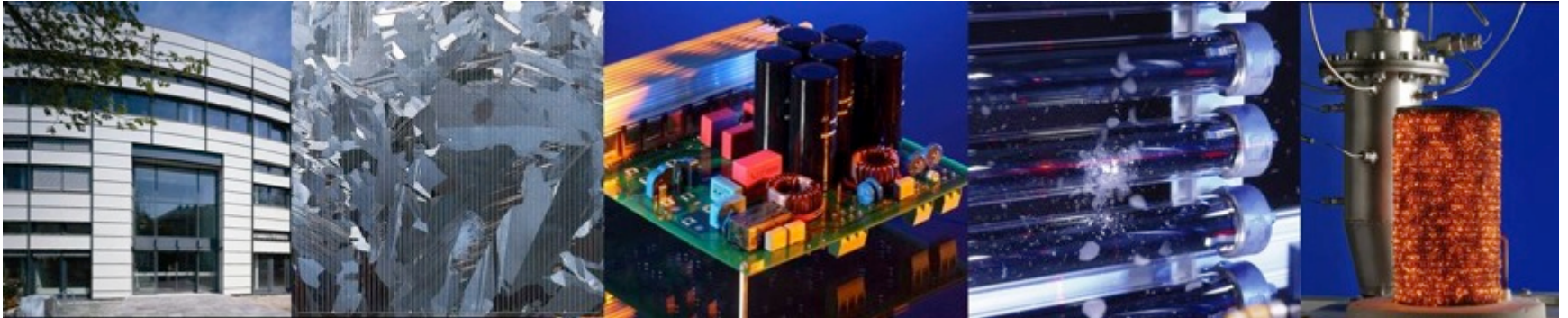


## Further discussions on Smart Cities and Smart Villages: ICORE 2014 8 December 2014, New Delhi

### Day 1, 8th December , 2014

- |           |   |
|-----------|---|
| Session 1 | Inaugural Session - Keynote Address   |
| Session 2 | <b>Energising 6 lakh villages &amp; creating 20 lakh jobs through solar</b> <ul style="list-style-type: none"><li>• Mini Grid</li><li>• Rural Industry through Solar</li><li>• Irrigation</li><li>• Cold chain/cold storage for milk and vegetable.</li></ul>   |
| Session 3 | <b>Smart Cities and Smart Villages</b> <ul style="list-style-type: none"><li>• Solar Efficient Architecture</li><li>• Smart energy</li><li>• E-vehicle</li><li>• Smart Village / Saansad Adarsh Gram / Border Villages</li></ul>  |
| Session 4 | <b>Interface between academia and industry</b> <ul style="list-style-type: none"><li>• Applied research – German case study.</li><li>• Research on Solar at Indian Institutions</li><li>• Need of Solar University for skill application and industrial growth.</li><li>• Introducing accountability in Indian education system</li></ul> |

# Thank you very much for your attention!



Gerhard Stryi-Hipp

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# Questions for the Discussion

- **What is needed to implement the »100 Smart Cities« vision of the Indian Government successfully?**
- **Where are the technological challenges?**
- **Which Research and Development, and which Innovations are necessary for Smart Cities?**
- **Who are the actors implementing Smart Cities?**
- **How will the Smart Cities be financed?**
- **What will happen in the other cities and villages?**
- **Which international cooperation is helpful?**