FRAUNHOFER ISE
SMART CITIES ACTIVITIES

Annette Steingrube

Gerhard Stryi-Hipp

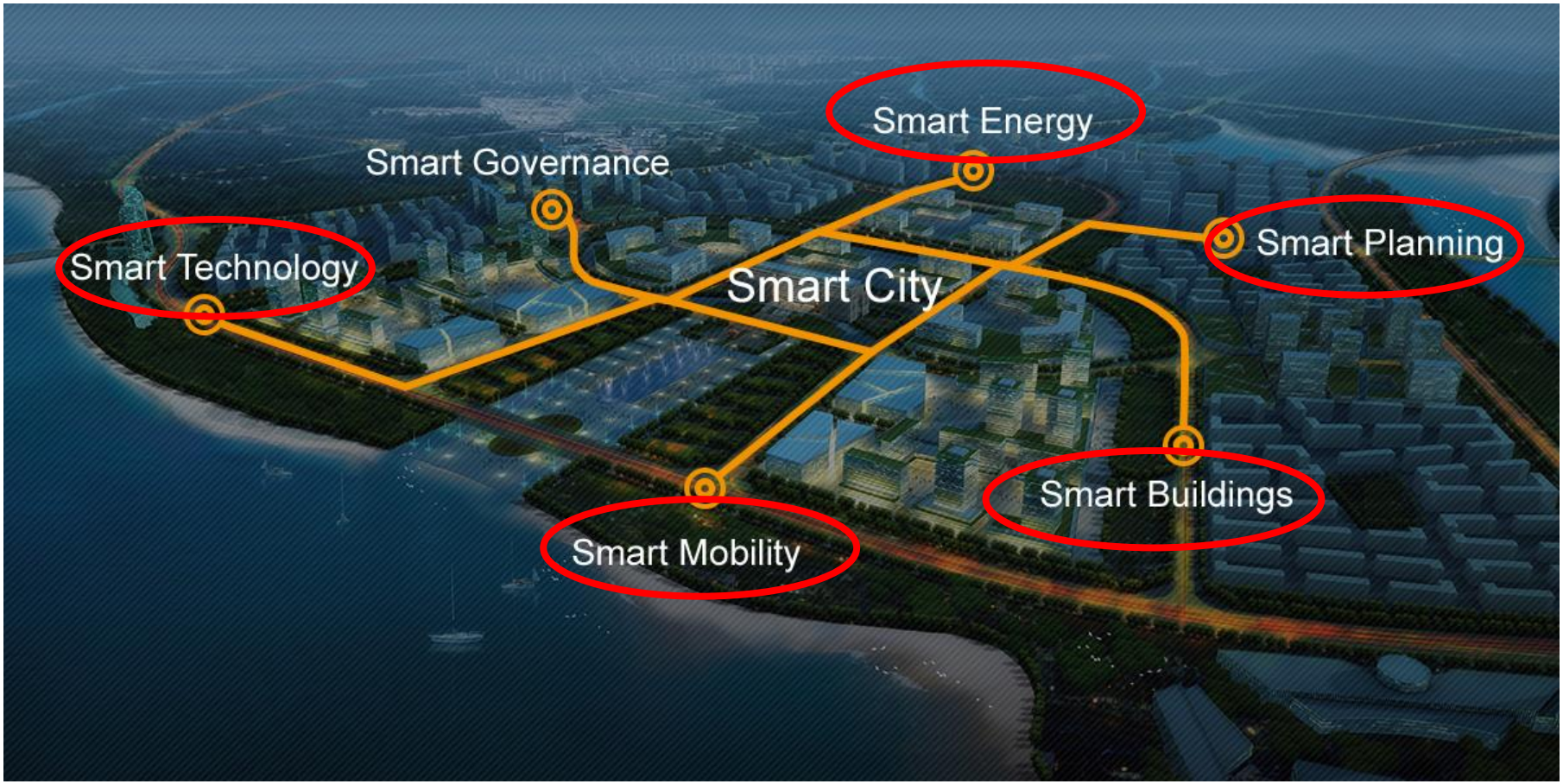
Group Cities and Districts

Fraunhofer Institute for
Solar Energy Systems ISE

Local Renewables Study Tour
Freiburg, 27 October 2016

Fraunhofer
ISE

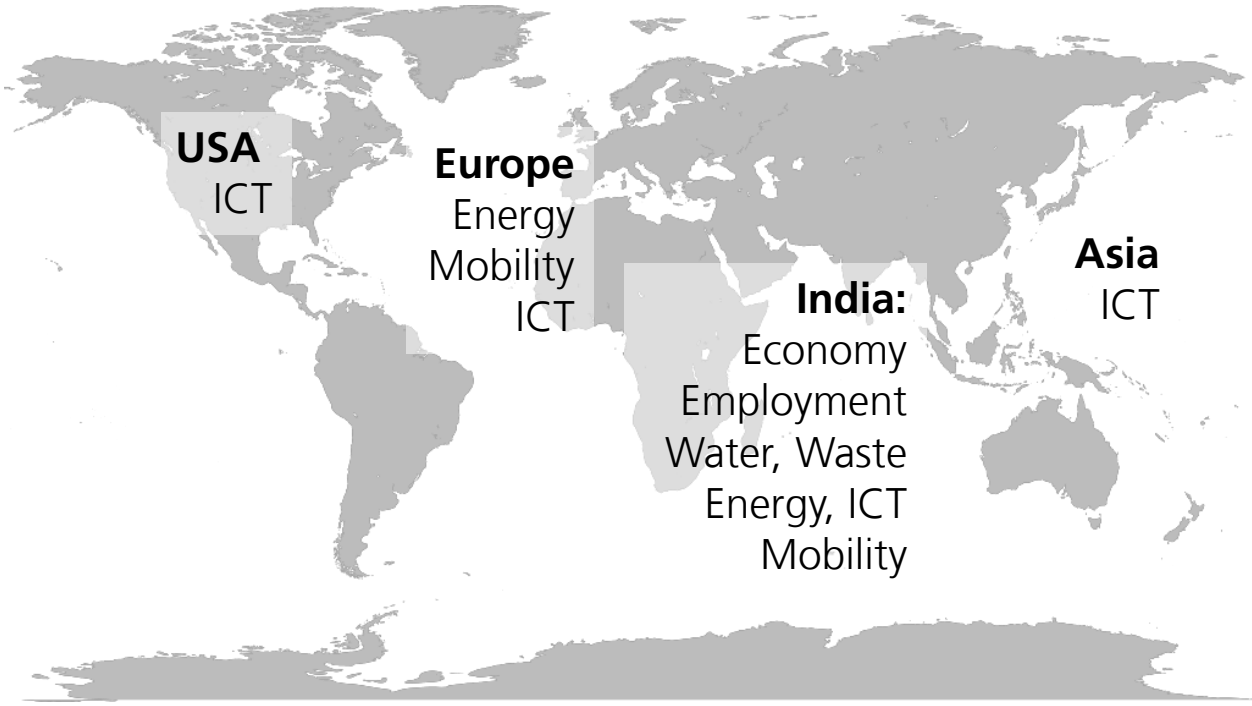
What is a Smart City?



Source: http://www.urban-hub.com/wp-content/uploads/2014/11/1200_C_100_img_smart_city1.jpg

Smart Cities worldwide: different definitions

- **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



Mega trends for cities and regions

Energy system
fossil-nuclear, centralized, import dependency, …
➔ **renewable, decentralized, higher level of autonomie,...**


Bild: Solarsiedlung

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,...**


Bild: MIT stackable car

Water / sewage water
Partly high consumption, outdated wastewater systems,…
➔ **economically, separate sewerage system, waste heat usage,...**

Information and communication (ICT)
simple, separate systems,…
➔ **connected, smart, improved service and comfort,...**


Bild: oecd.org

Economy, demography, education, health, climate, security,...
Basic changes of the society are challenging the city...
➔ **improved living standard, mitigation of climate change, resilience,...**

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

- **75% of greenhouse gas emissions** are produced in cities & communities
- **Energy transformation will mainly happen on local level**
- **Active contribution** of the investors, industry, public sector, and citizens is needed, they do and they will
  - invest in energy efficient buildings
  - invest in renewable energies
  - build up smart energy management, smat grids, storage capacities, heating networks,...
  - switch to emission free mobility and use public transport
  - change their behaviour
  - ...

Challenges to identify optimized sustainable energy systems of a city or region

Decentralization: local generation must be adapted to local load profiles

➔ **Individual solution are necessary for each city and region**

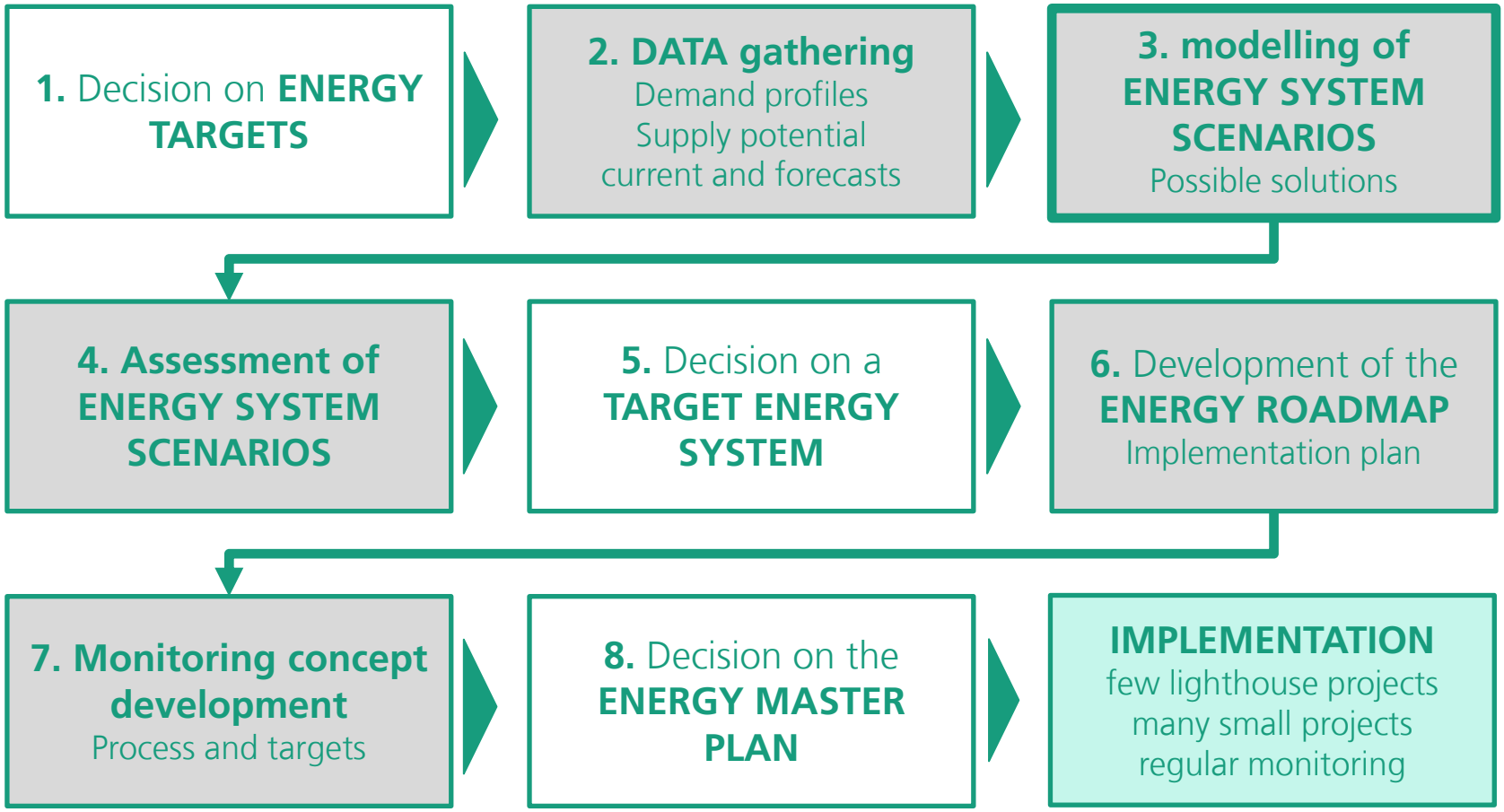
Transformation period: 20 to 40 years are needed to implement a sustainable energy system, short term solutions can be counterproductive long term

➔ **Short term measures must be in line with long term goals**

Growing complexity: due to fluctuating generation, integration of thermal and electric storage, demand-side management, combined heat and power, power to heat, power to gas, electric mobility,....

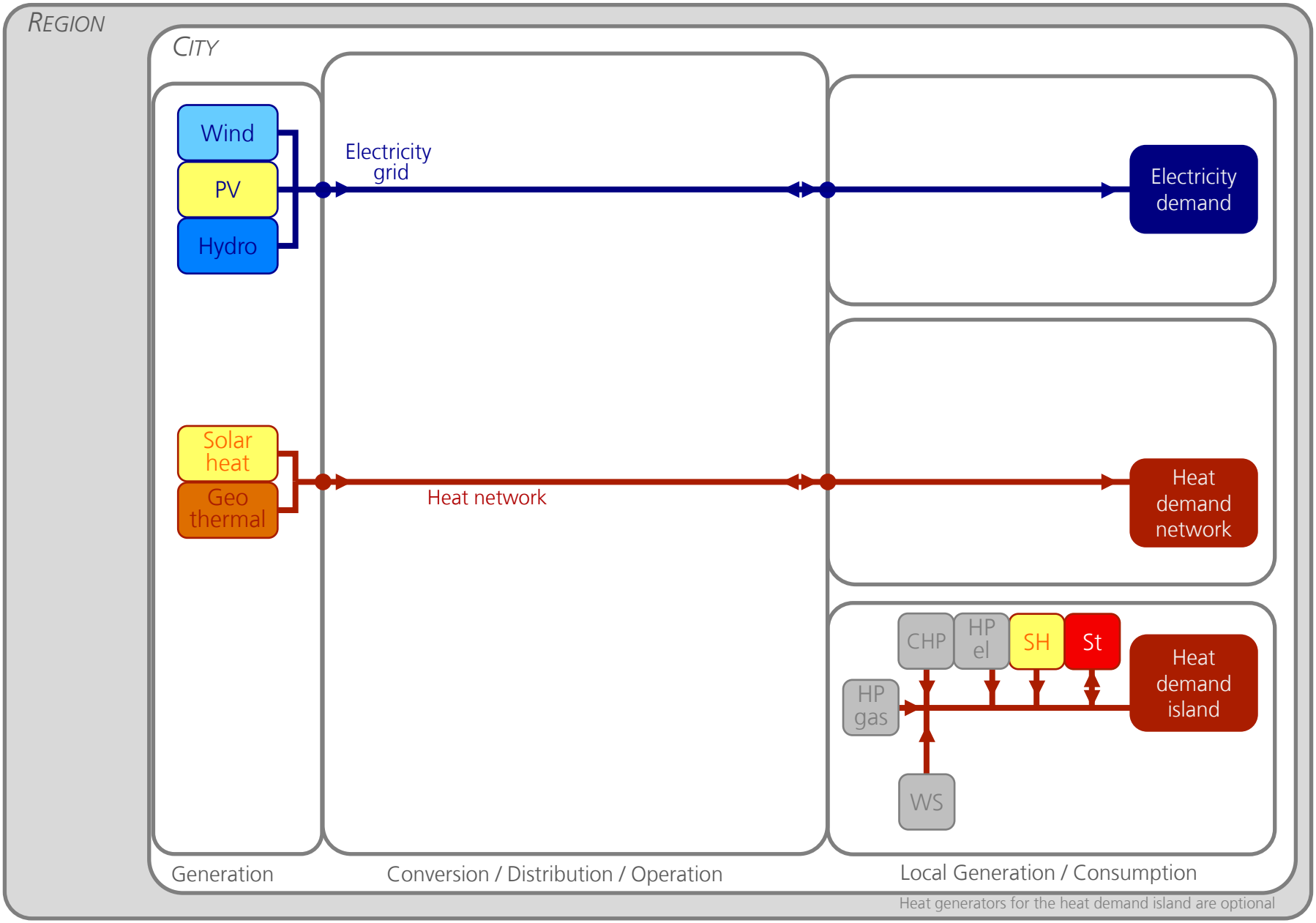
➔ **Temporal dynamic and interdependencies of energy sectors must be taken into account**

Transformation strategy for energy systems
developed by Fraunhofer ISE



Fraunhofer ISE

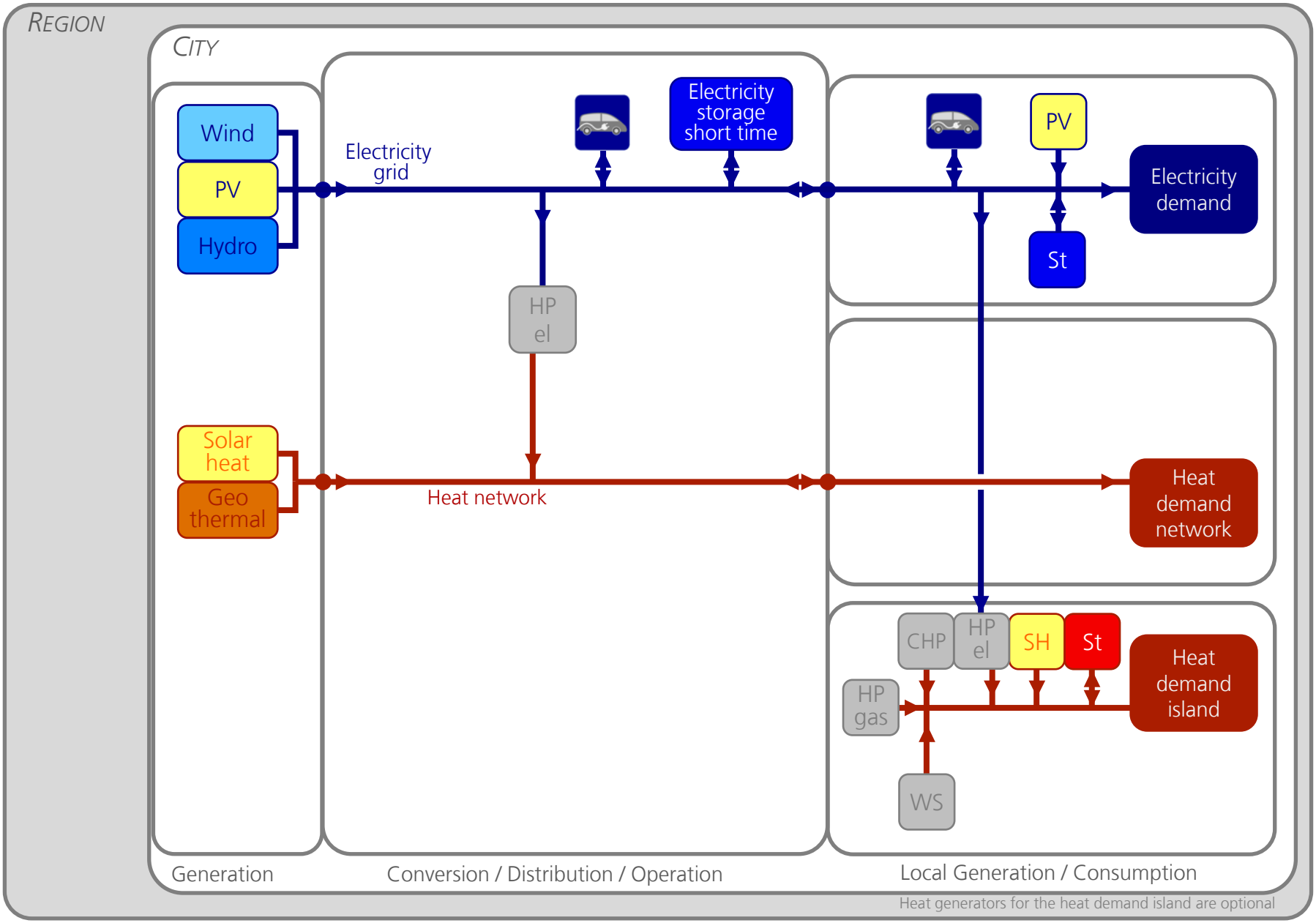
Smart energy systems with 100% renewables: dealing with high complexity



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, ACh/CCh = Ab-/Adsorption / Compression Chiller

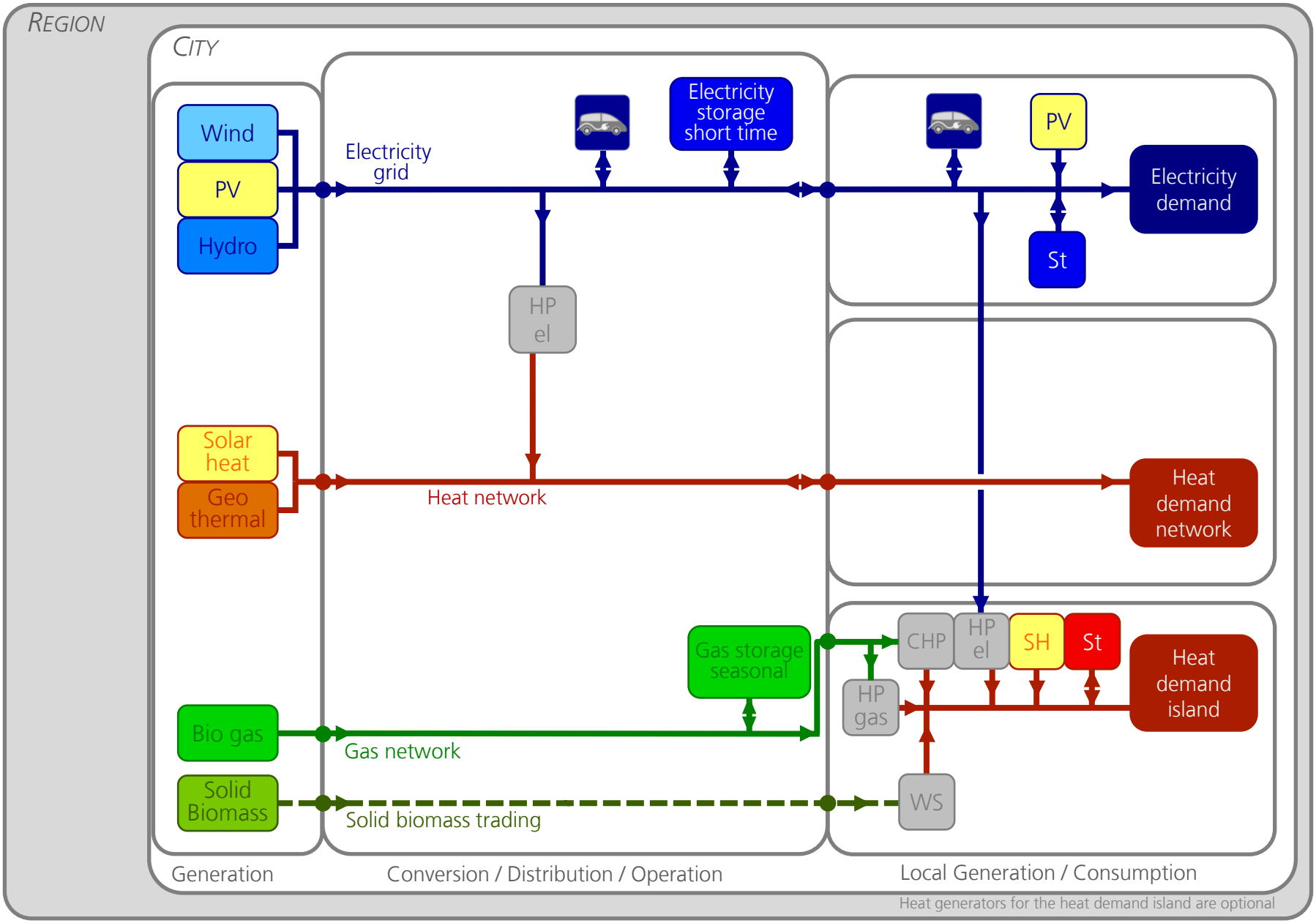
Smart energy systems with 100% renewables: dealing with high complexity



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, ACh/CCh = Ab-/Adsorption / Compression Chiller

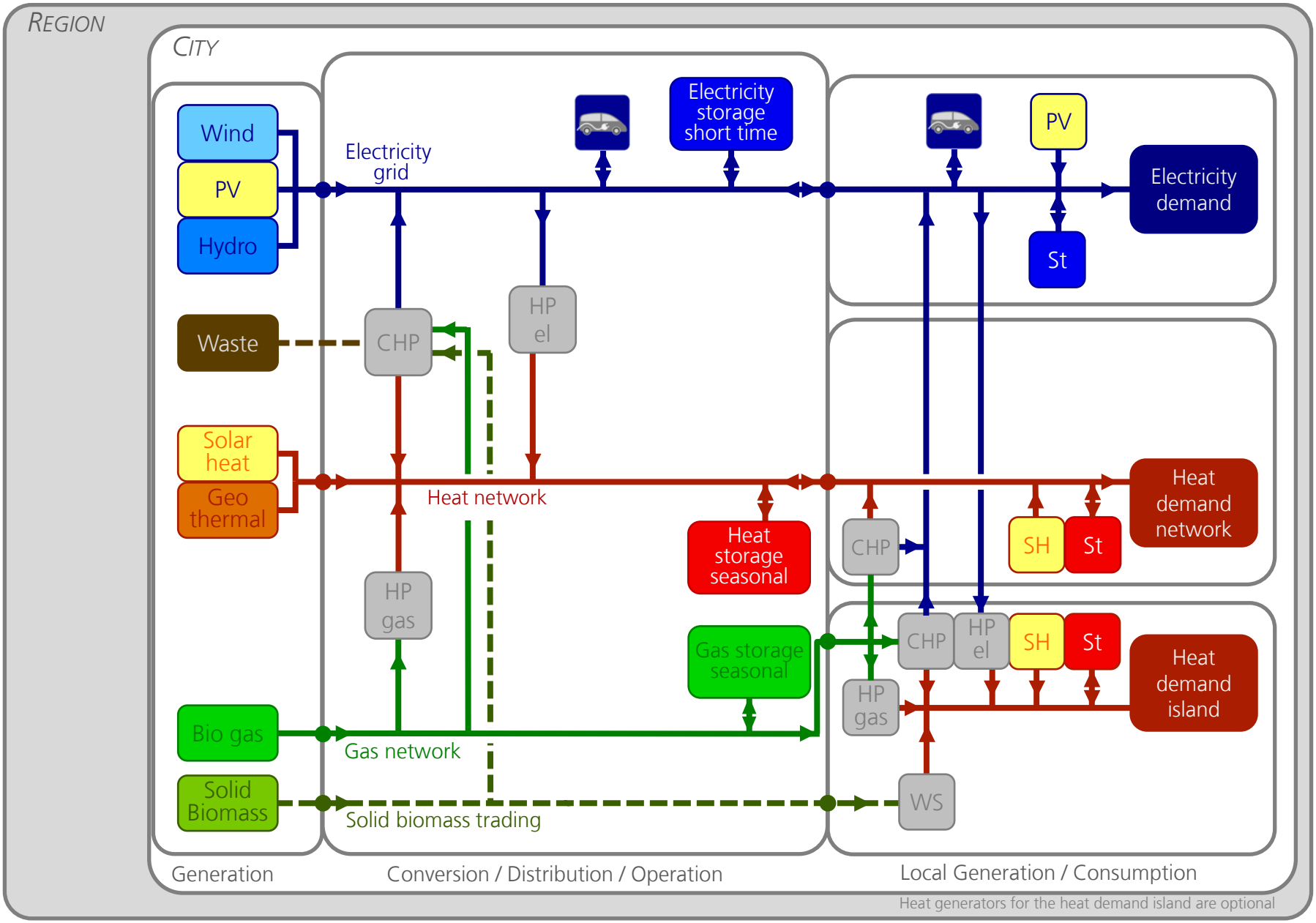
Smart energy systems with 100% renewables: dealing with high complexity



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, ACh/CCh = Ab-/Adsorption / Compression Chiller

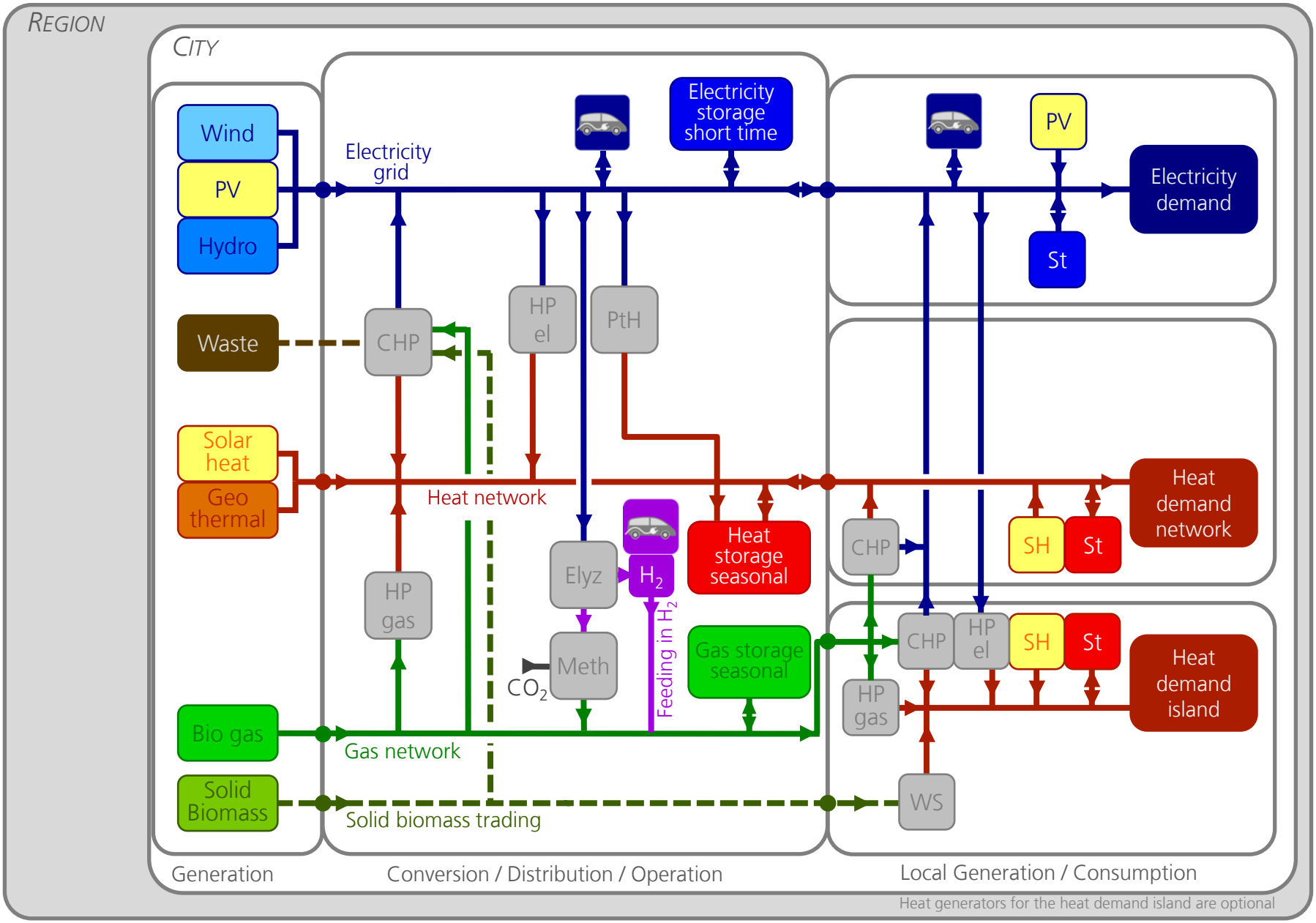
Smart energy systems with 100% renewables: dealing with high complexity



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, ACh/CCh = Ab-/Adsorption / Compression Chiller

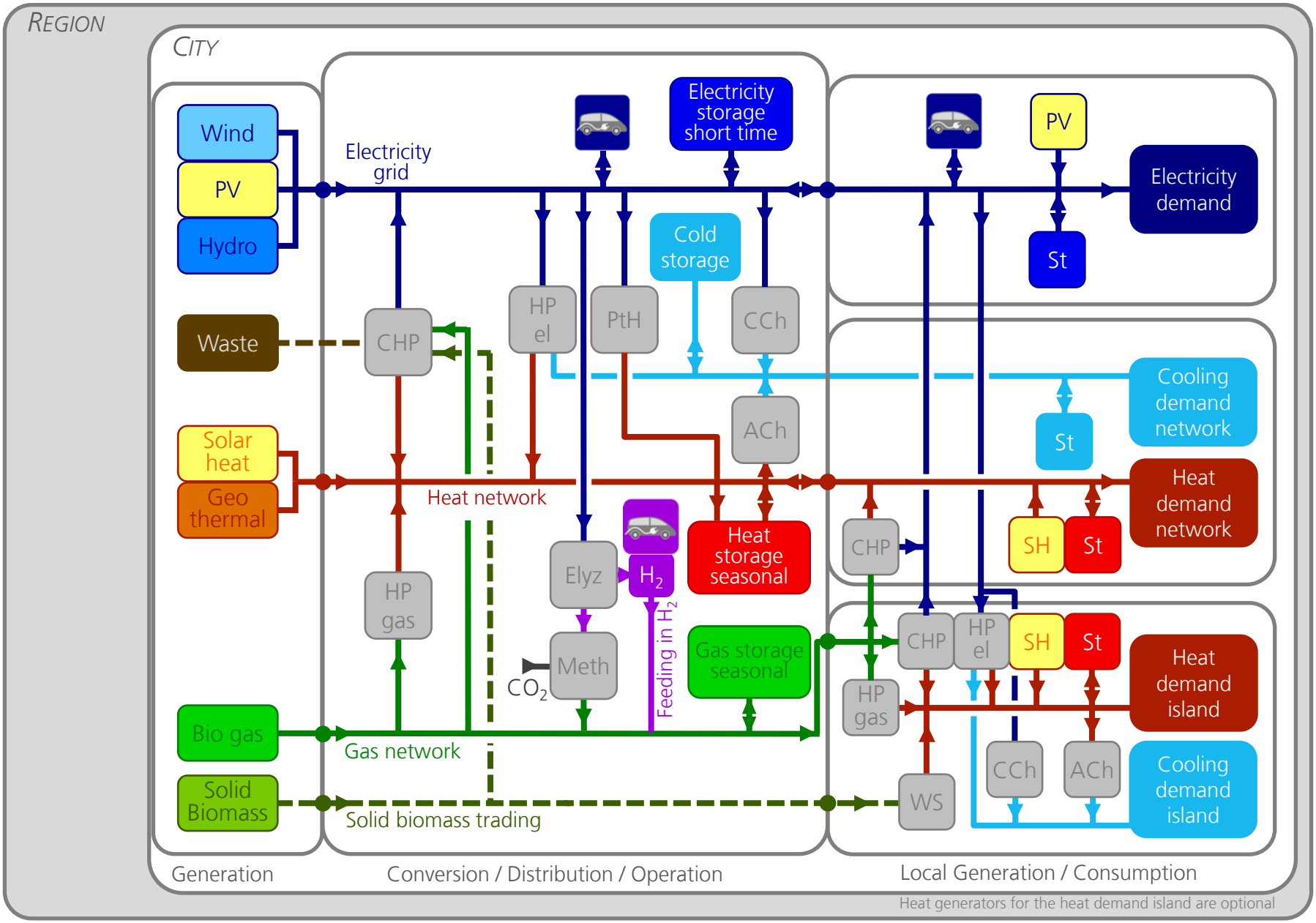
Smart energy systems with 100% renewables: dealing with high complexity



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, ACh/CCh = Ab-/Adsorption / Compression Chiller

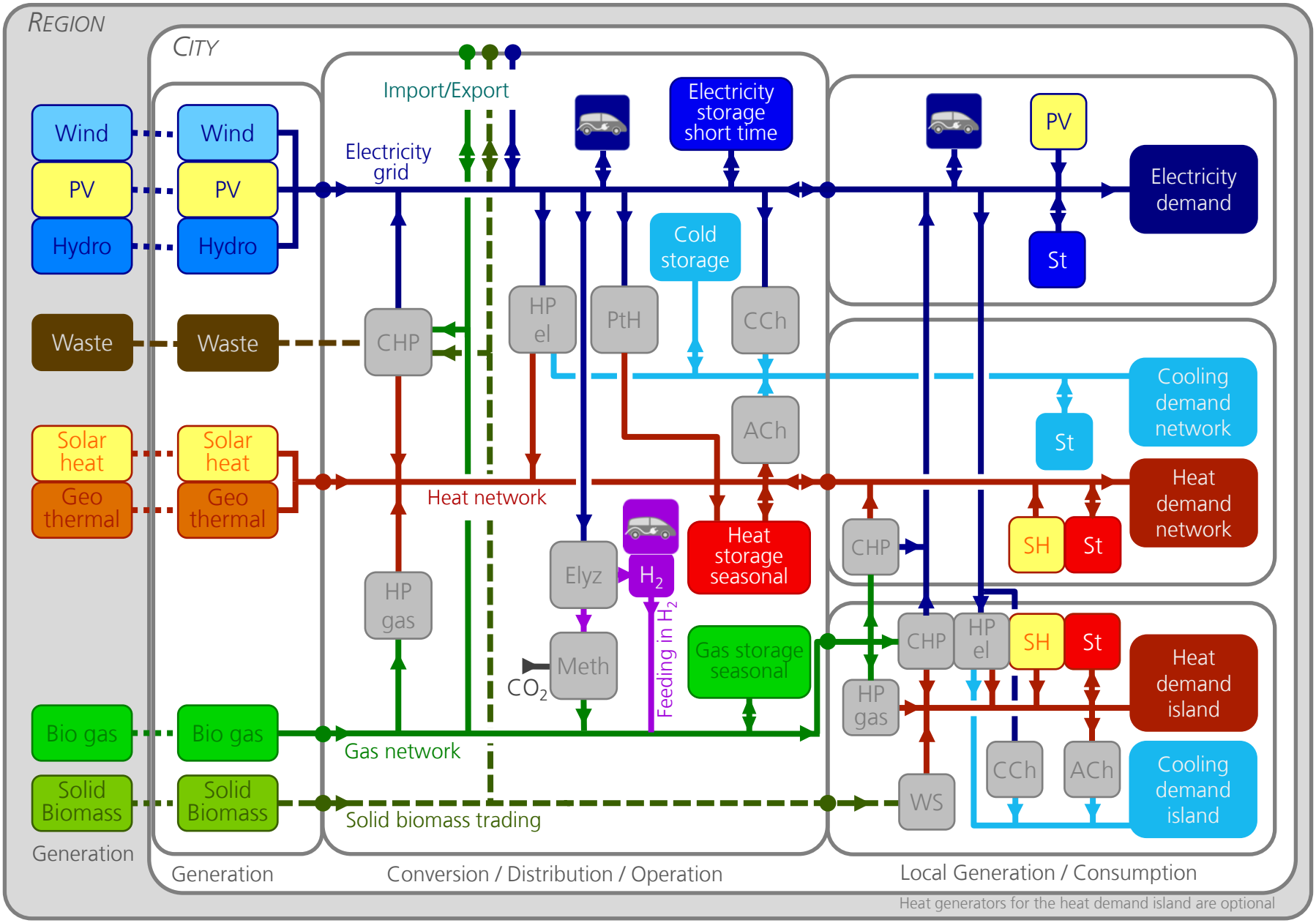
Smart energy systems with 100% renewables: dealing with high complexity



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, ACh/CCh = Ab-/Adsorption / Compression Chiller

Smart energy systems with 100% renewables: dealing with high complexity



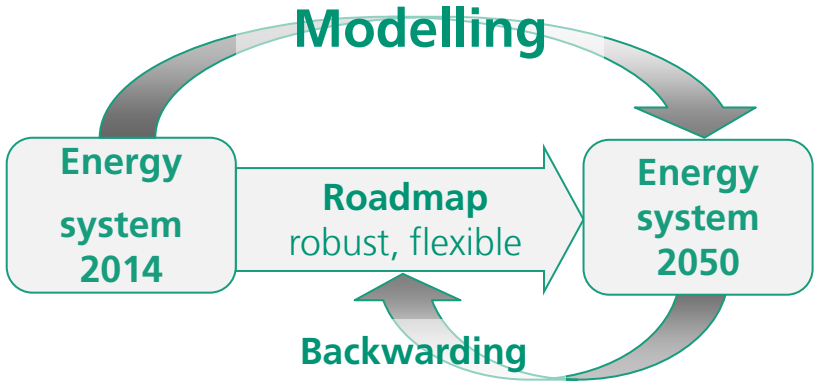
HP el/gas = Heat pump electric / gas driven, CHP = Combined heat and power, WS = Wood stove, St = storage, SH = Solar heat, Elyz = Elektrolyzer, Meth = Methanation, ACh/CCh = Ab-/Adsorption / Compression Chiller

New energy system modelling tool

to identify the most cost-effective sustainable energy system

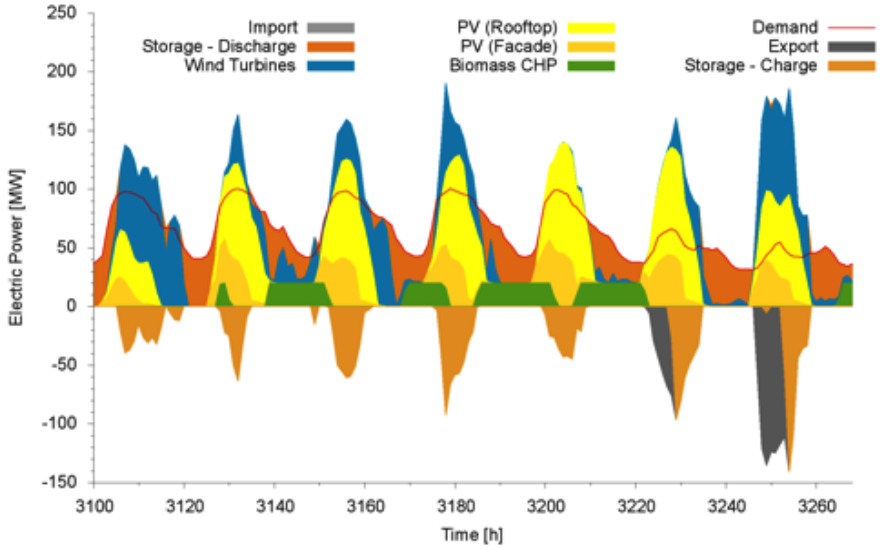
Fraunhofer ISE developed the modelling tool »KomMod«

- to calculate optimized target energy systems for cities and regions
- by temporal highly resolved modeling of electricity, heating, cooling, transport



Output:

- **Cost-effective design** of a sustainable energy system
- Possible energy system **structures**
- Necessary **capacities** on generation, grid and storage
- Remaining **energy import/export**
- Investment and operation **costs**



Fraunhofer ISE

How the city of Frankfurt/Main could be supplied by 95% renewable energy from the region by 2050

- The city of **Frankfurt/Main aims to be supplied by 100% renewable energy sources (RES)** from the region by 2050
- Fraunhofer ISE was asked to investigate, if this is possible and if yes, how
- The energy system (electricity, heating, cooling, local mobility) of Frankfurt/Main was captured, assumptions were made for energy demand and energy scenarios simulated for the target year 2050

Results

- 100% RES supply is possible, if the RES potential of the region is used
- 95% regional RES is much more economic, due to a lower storage capacity needed

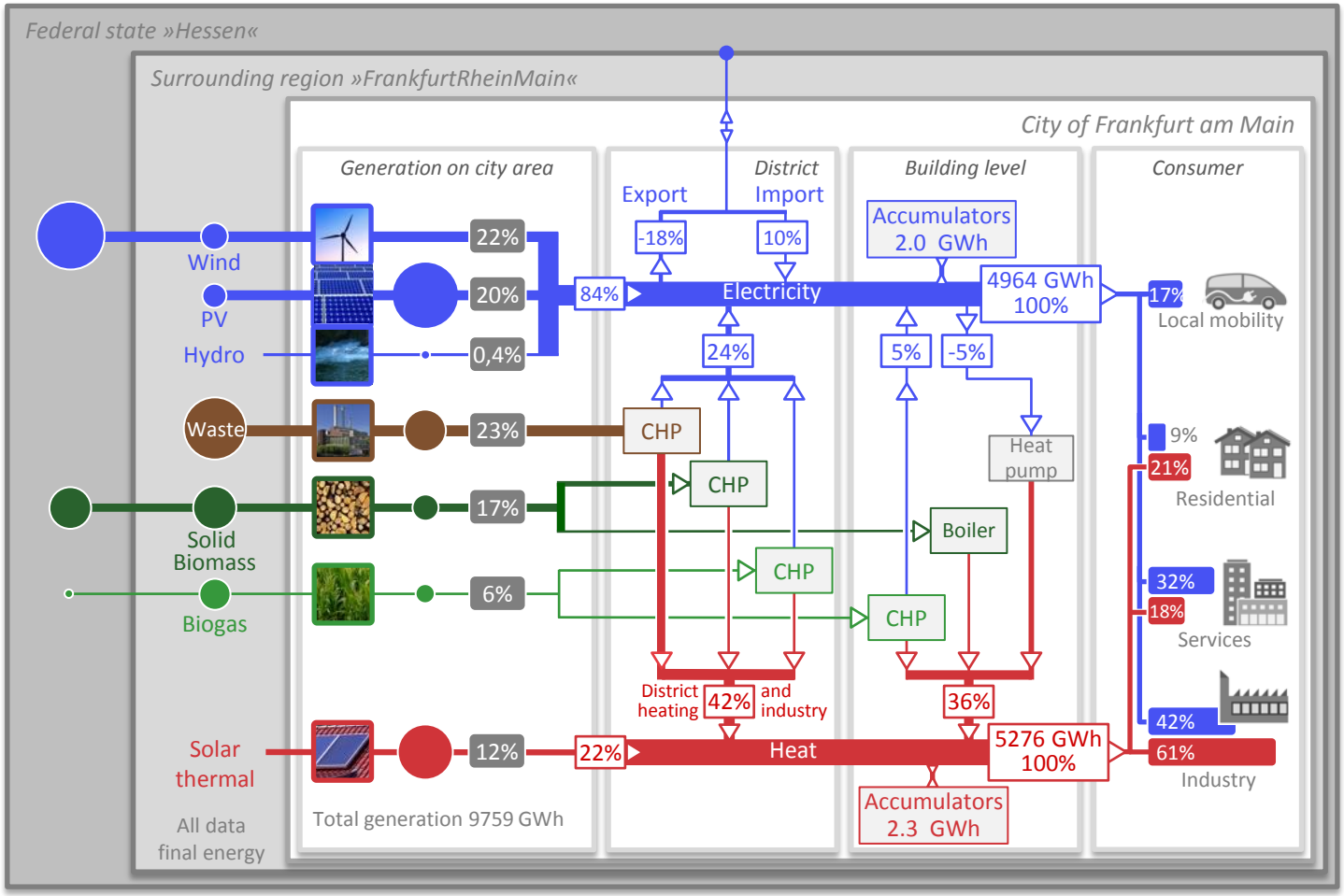
ENERGY STRATEGY

1. Significant increase of **efficiency**
2. Maximal use of **local renewable energy sources**
3. **Energy cooperation with region**
4. **Smart technologies**: smart grid, storage, electric vehicles, smart management, real-time energy data for consumer, new business models,...

Structure of the energy system Frankfurt/M 2050

Based on 95% renewable energy sources regionally generated

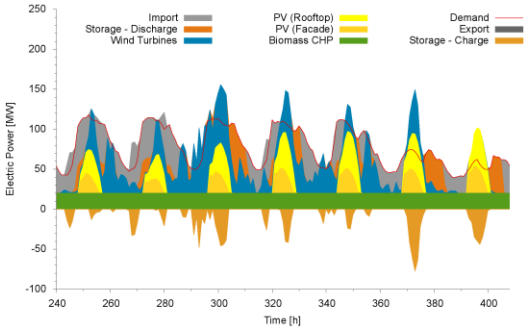
Result of a temporal highly resolved simulation (hourly basis). RES Potentials: All RE and waste potential of the city, 50% of the potential of the region and 11.6% of the potential of the federal state of Hessen from Wind und Biomass (= share of Frankfurt citizens of Hessen)

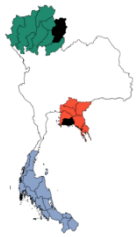


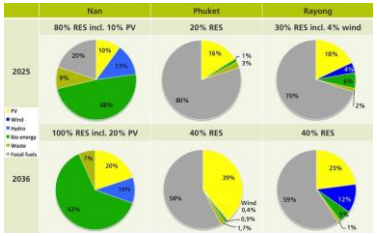
Fraunhofer ISE

Other projects on the local and regional level

- City quarter of Freiburg-Haslach
- Rural municipality in the federal state of Baden-Württemberg (Laupheim)
- Supply zone of a municipal energy supplier in the black forest
- three communities in Baden-Württemberg in the project EnSource (quarter of Stuttgart, Island Mainau in the lake Constance and Rainau)
- City of Kaiserslautern
- District of Xiuzhou (Jiaxing); China
- State of Luxemburg
- Industrial site of a large company

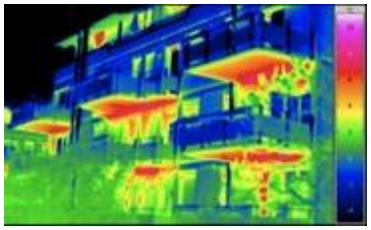


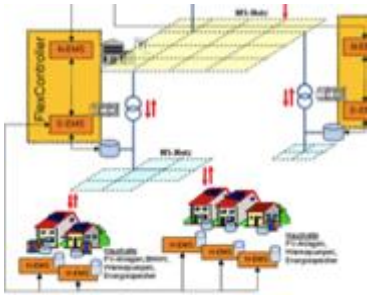




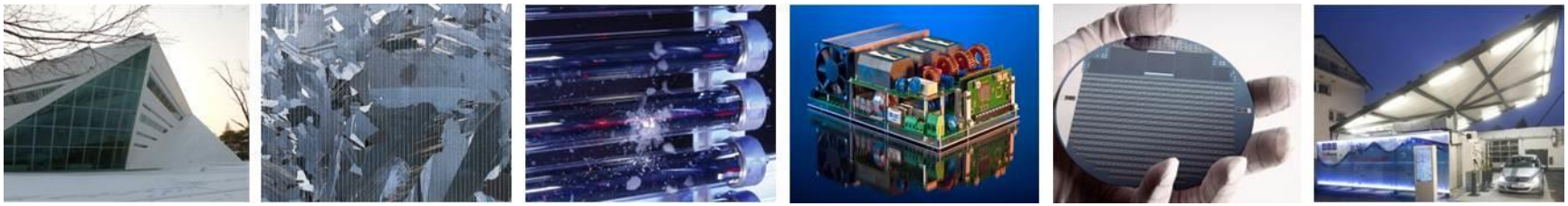
Conclusions

- **Smart cities are based on sustainable infrastructure and aim to provide higher quality of life to their citizens by using new technologies - energy is a key sector for most smart cities**
- A cost-effective transformation of a cities energy system needs **systematic planning & implemention**
- **New modeling tools** allow to calculate the optimal sustainable energy system
- **Fraunhofer ISE showed on the example of Frankfurt/Main, how large cities can be supplied mainly by local renewable energy sources**





Thank you very much for your attention!



Fraunhofer-Institut für Solare Energiesysteme ISE

Gerhard Stryi-Hipp gerhard.stryi-hipp@ise.fraunhofer.de

Annette Steingrube annette.steingrube@ise.fraunhofer.de

www.ise.fraunhofer.de