Smart Cities – the European Approach

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Agenda

- Case for action
- Smart City
  - Definition, approach, research fields
- The European Research Policy Landscape
- Smart City Projects and Key topics
  - Smart City Vienna

The Austrian Institute of Technology is Austria‘s largest non-university research institute

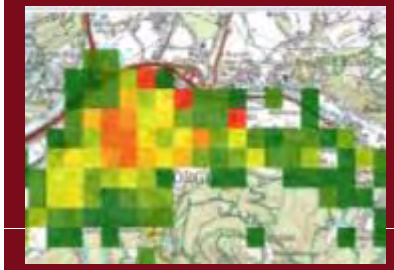
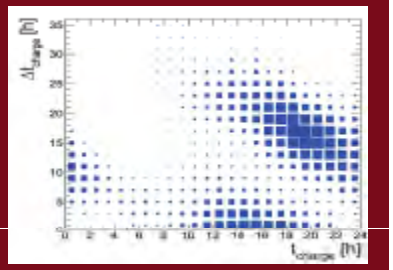
The Austrian Institute of Technology – AIT

- Mobility Department
- Safety & Security Department
- **Energy Department**
- Innovation Systems Department
- Health & Environment Dep.

Integrated Energy Systems

- Smart Cities & Regions
- Complex Energy Systems



Energy Infrastructure

- Smart Grids
- Thermal En. Syst.
- Smart Buildings
- PV




Focus on Integrated System – Technology Approach

- Innovation in energy systems needs integrated system approach

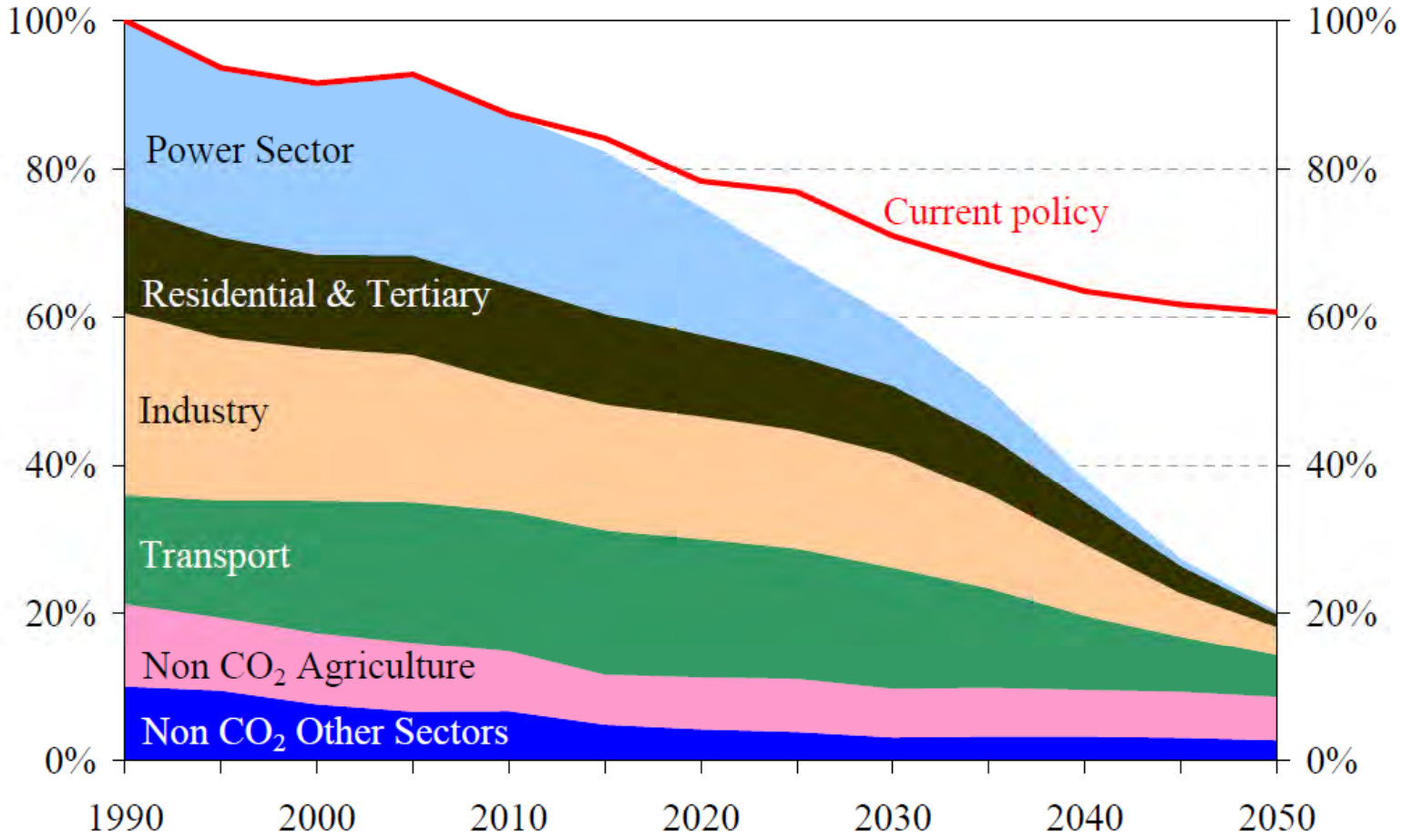
- Multi-technology perspective
- From passive to active systems
- Towards decentralised generation
- From singular technology implementation to large-scale-deployment
- Multi stakeholder involvement

- Adressed by **USP** of AIT Energy Department:
- Holistic scientific understanding of energy systems combined with technological excellence in design, optimization and diagnosis of components and subsystems.

IEA Energy Technology Perspectives 2012, Pathways to a Clean Energy System


THE CASE FOR ACTION

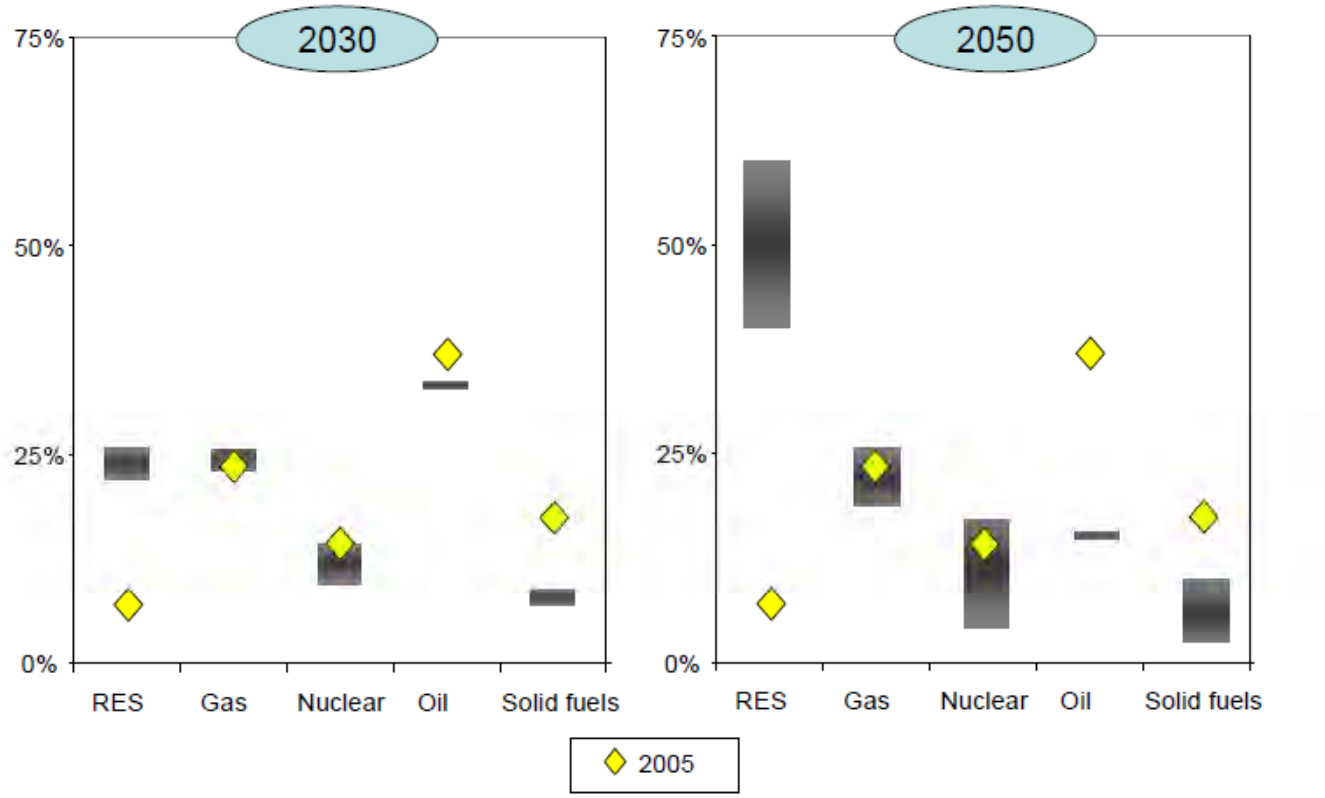
Low Carbon Economy Roadmap



EU GHG emissions towards an 80% domestic reduction (100% =1990)

Energy Roadmap 2050

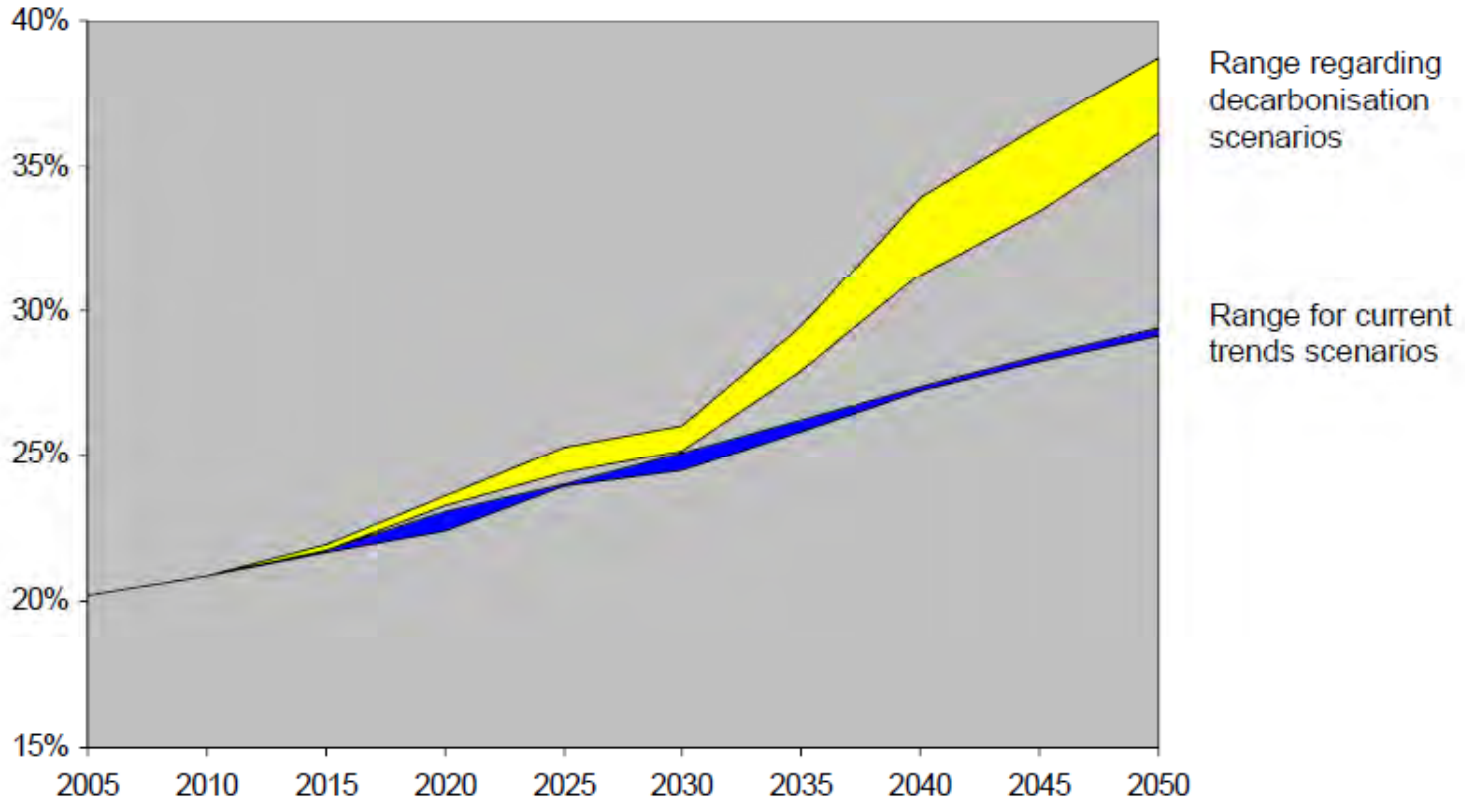
Graph 1: EU Decarbonisation scenarios - 2030 and 2050 range of fuel shares in primary energy consumption compared with 2005 outcome (in %)



Source: European Commission, Brussels – COM (2011) 885/2

Energy Roadmap 2050

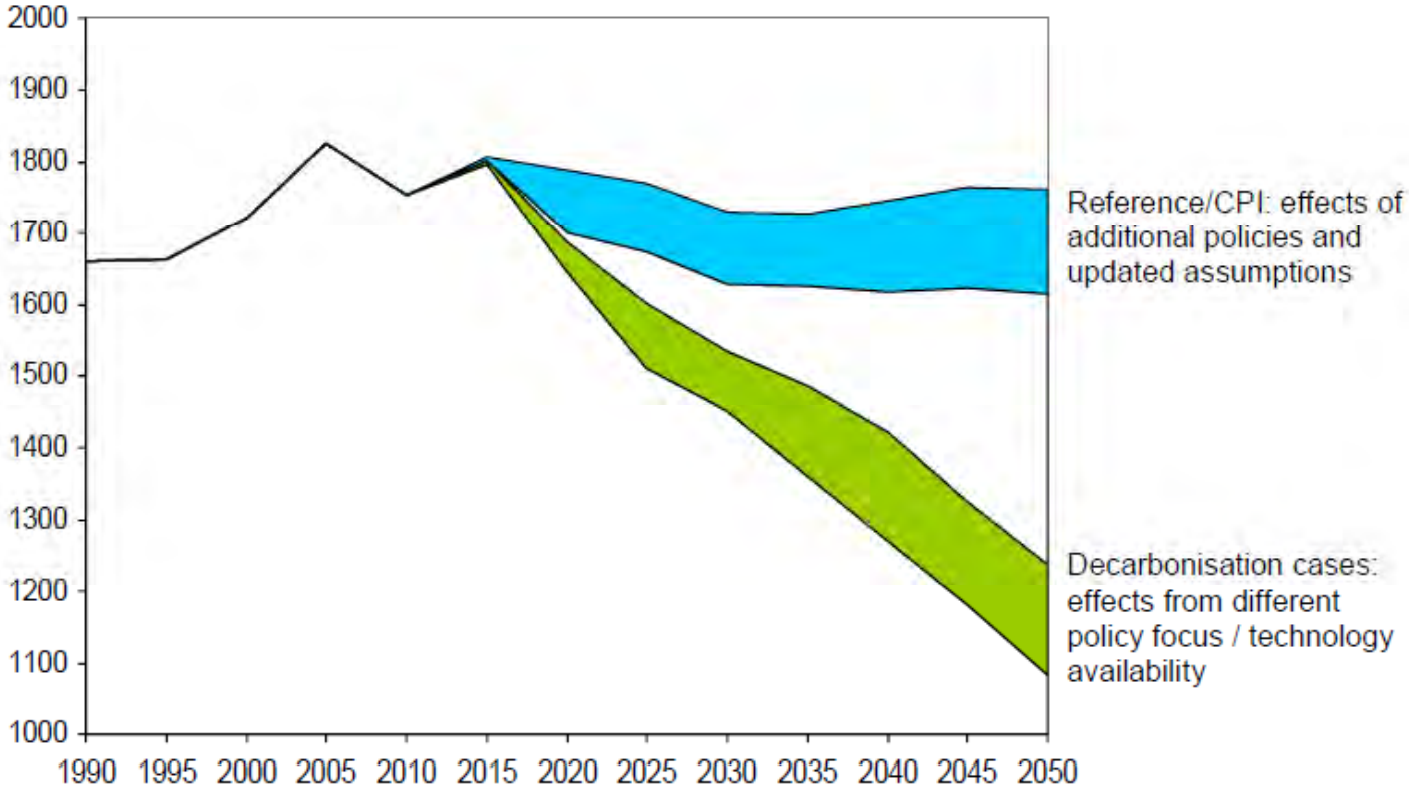
Graph 2: Share of electricity in current trend and decarbonisation scenarios (in % of final energy demand)



Source: European Commission, Brussels – COM (2011) 885/2

Energy Roadmap 2050

Graph 3: Gross energy consumption - range in current trend (REF/CPI) and decarbonisation scenarios (in Mtoe)



Source: European Commission, Brussels – COM (2011) 885/2

Cities – a powerful lever

- 70% of total CO_2 emissions in Europe emerge in und around urban areas

- 74% of the European population lives and works in cities – with a rising trend

- They consume 75% of the energy used in the EU

RADICAL INNOVATIONS ⇨ SMART CITY

Targets for Cities

- Contribute actively to climate policy goals
- E.g. Urban areas display huge potential for energy efficiency
- and additionally…

- Cities as centers for innovation
- Cities as centers for education and training
- Cities at the forefront of policy, industry and research
- Cities as drivers for economy
- Cities as Living Labs to learn to cope with new technologies

Smart City Concept

A Smart City……

- ..will contribute significantly
  to the 2050 CO2 Emission reduction targets
- ..by following sustainable development
  (sustainability triangle)
  - boosting economic development
  - demonstrating ecological development
  - enhancing quality of life and social welfare
- creating a zone of innovation and turning
  challenge into advantage and leadership

Smart City Concept

ICT & Energy Technologies are merging
Intelligent energy management on regional & city level

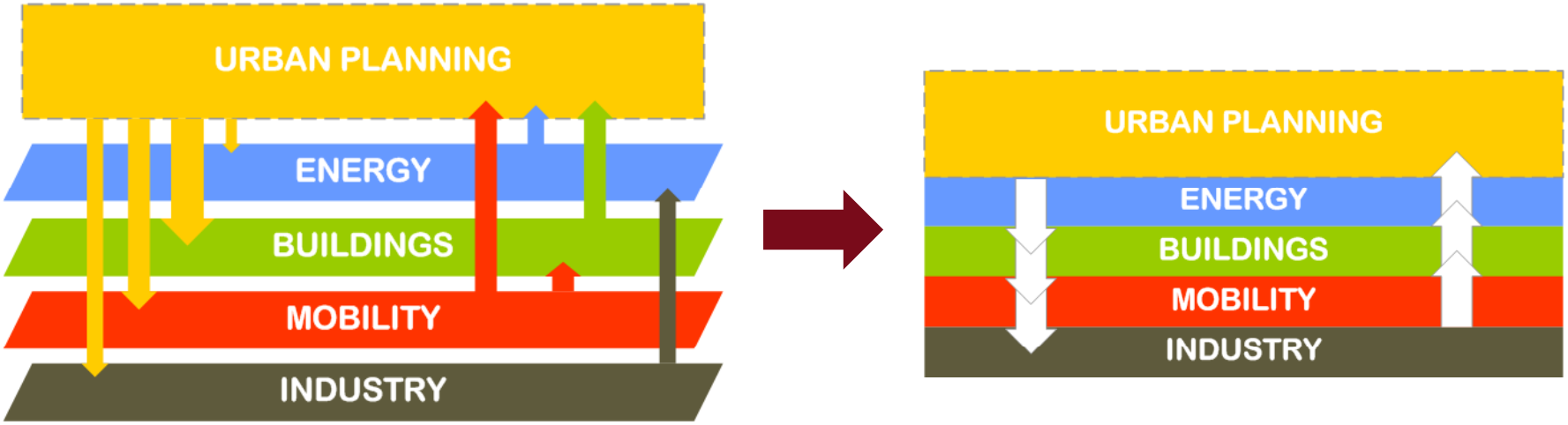
New integrated planning approach

- Integrated Urban Planning
- Smart Grids
- Active Buildings
- Energy Supply
- Mobility

- New Business Models
- New innovation processes (testing field, stakeholders etc)

Integrated Smart Infrastructure Development

- **Understanding + optimising infrastructure on a system level …**
- **..for design and management….**
- **….**by developing methods and concepts which focus on a comprehensive approach targeting all energy related infrastructure layers



Smart City – the Method

The Smart Cities concept relies on the **integration of**:

- processes (e.g. policy, urban planning, infrastructure planning, detailed design, financing and stakeholder processes)
- concepts (e.g. energy efficiency measures; decentralised and centralised energy production strategies for heat, cold, electricity and fuels; mobility, waste and water strategies)
- and technologies (e.g. CHP, heat pumps, solar PV and thermal collectors, smart electrical and thermal network components Information and Communication Technologies).

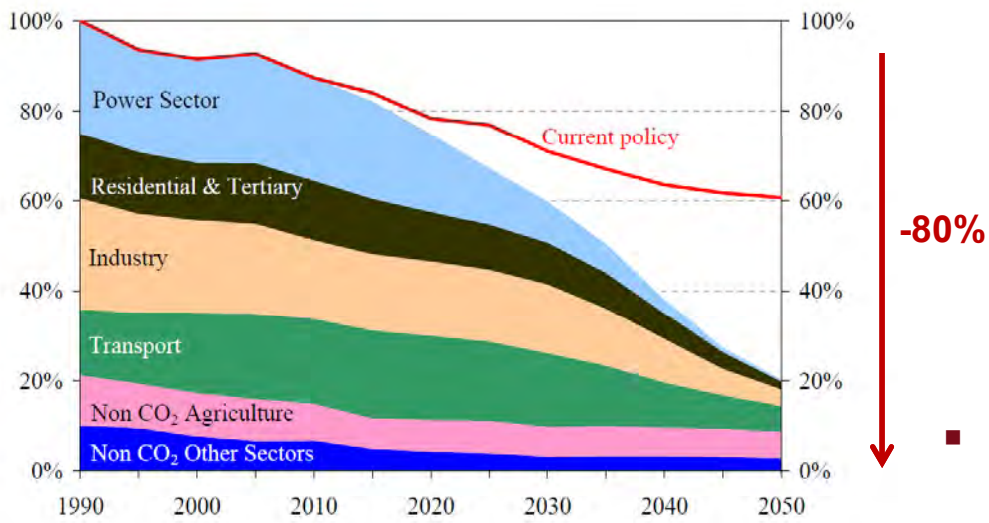
Living labs

- Real life Ecosystem
  - natural settings, cities, regions
- User-involving, open innovation approach
  - Co-Creation and exploration through participation
  - All stakeholders on equal terms, technology push & application pull
- “Laboratory” experimental approach
  - ‘bring the lab to the people’ (ulder et al., 2008)
  - Integration of new technologies
  - Implementing Innovation Cycle
    (innovation into market, assessement, lessons learned, feedback process, use the Living-Lab for project oriented education..)
- Little experience

Source: Katrien De Moor (MICT-IBBT, Ghent University)/Ozcan Saritas (PREST-MIoIR, University of Manchester)/Dimitri Schuurman (MICT-IBBT, Ghent University)


THE EUROPEAN POLICY LANDSCAPE

Policy Background - European climate policy targets



- European 20-20-20 targets
  - Reduce GHG-emissions by 20%
  - Increase share of renewables in EU energy consumption up to 20%
  - Achieve an energy - efficiency target of 20%
- Roadmap 2050
  (..for a low Carbon Economy)
  - 80% GHG reduction
  - Boosting the economy by technology innovation

Source: EC, Low Carbon Economy Roadmap 2050

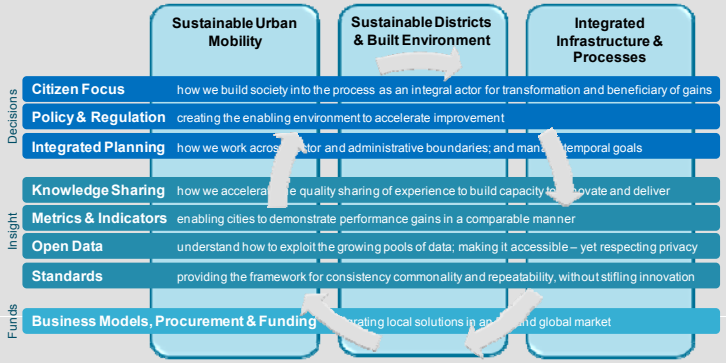
European research policies and instruments reflect the importance of smart city approaches to tackle climate change

Energy Efficiency – The Smart City Initiative

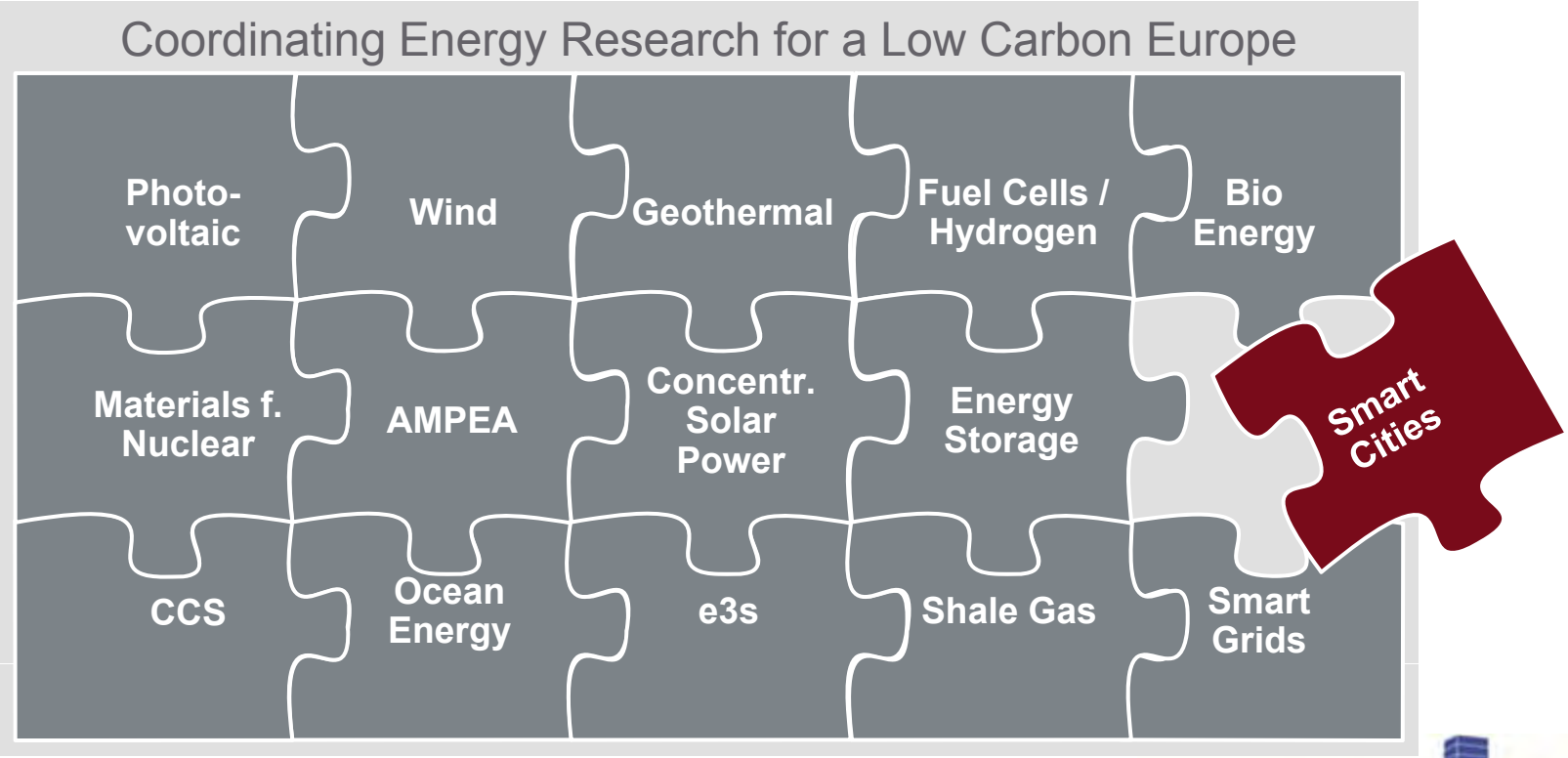
„[…] aims to **improve energy efficiency** and to step up the deployment of **renewable** energy in large cities going even further than the levels foreseen in the EU energy and climate change policy. […] It will bring the cities involved to the forefront of the development of the **low-carbon economy**."

Member States Initiative Smart Cities and JPI Urban Europe

European Innovation Partnership – Smart Cities and Communities: Strategic Implementation Plan



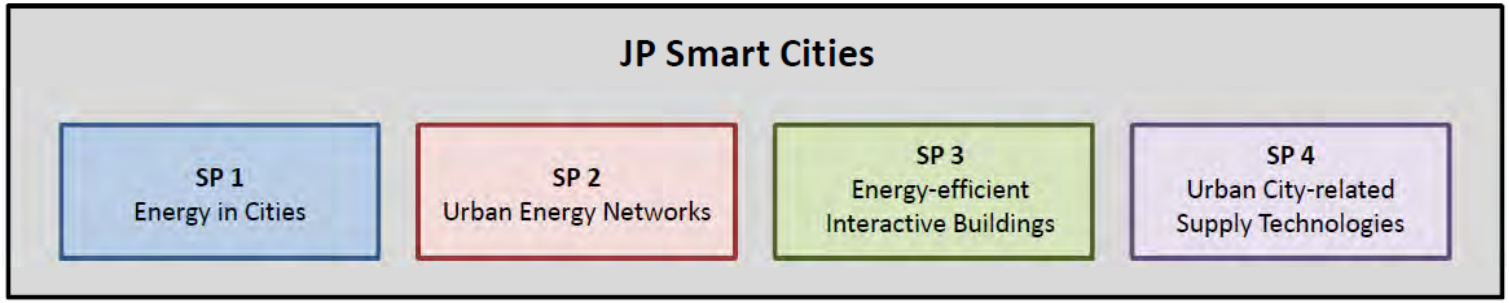
EERA, the European Energy Research Alliance, is a key instrument of the SET Plan



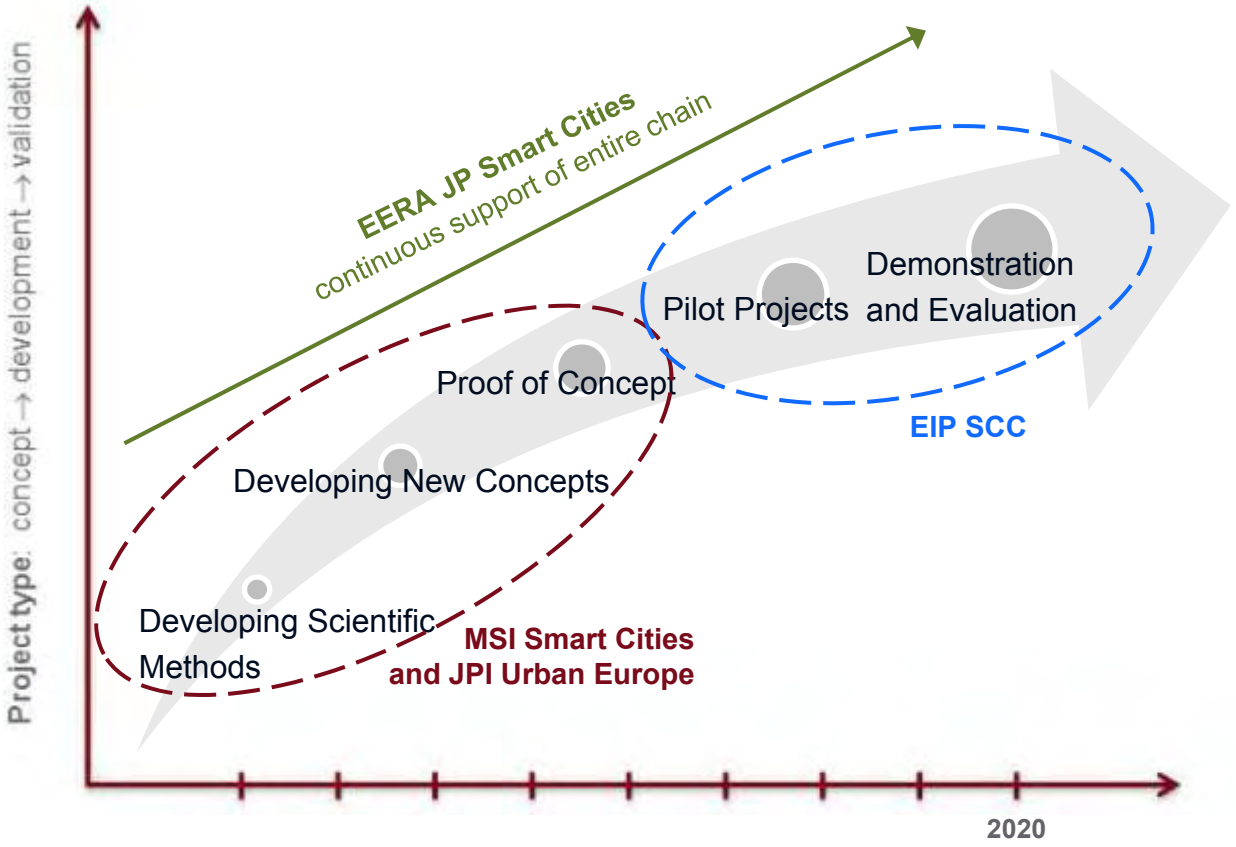
EERA Joint Programme Smart Cities

- Overall JP coordination (AIT Energy Department)
  - 200 pyr/ yr

- 4 sub-programmes:
  - Energy in Cities (coordinated by AIT + VITO)
  - Urban Energy Networks (coordinated by ENEA + AIT)
  - Energy-efficient Interactive Buildings (coordinated by SINTEF + NTNU)
  - Urban City-related Supply Technologies (coordinated by Univ. Zaragoza + AIT)



The entire innovation chain in Smart City development is covered by MSI SC, EIP SCC and EERA JP SC




SMART CITY PROJECTS
and KEY TOPICS

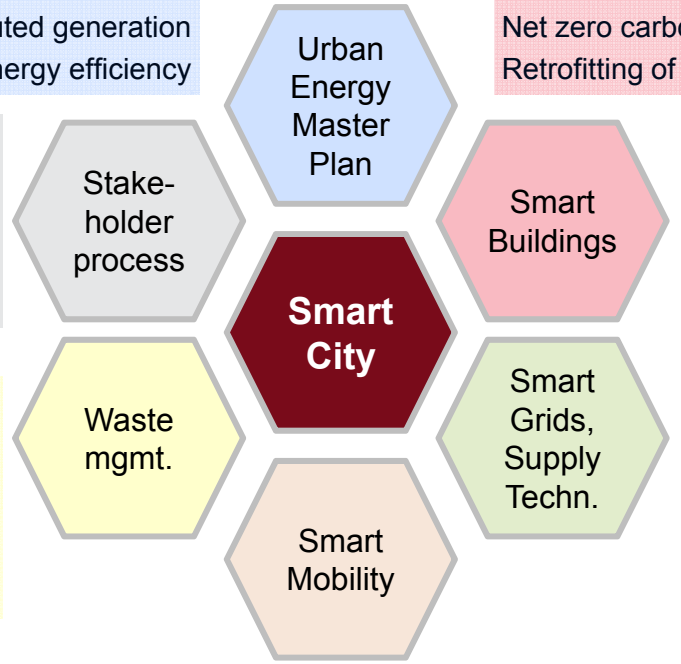
Smart City – a variety of research questions

Renewables
Distributed generation
Energy efficiency

Net zero energy
Net zero carbon emissions
Retrofitting of existing building stock

Public participation
Social innovation
Smart Urban Living labs
Sustainable and participatory urban planning

Efficient logistics for packaging, selling and doing shopping
Differentiate garbage and use it for producing energy
Minimise quantity of waste production and maximise quality of it



Heating and Cooling: Biomass, solar thermal, geothermal; Hybrid H&C systems
Electricity: Smart grids – renewable generation, electric vehicles charging, storage, demand response and grid balancing. Smart metering and energy mgmt. systems.
Smart appliances to foster local RES electricity production (esp. PV, wind)

Low carbon transport
Smart applications for ticketing
Intelligent traffic mgmt. and congestion avoidance
Demand management
Travel information and communication, etc.

Future Role of Buildings in Smart Cities & Smart Grids

- Consumer including high amount of Energy efficiency
- Energy supply (on site renewables)
- Storage (thermal and electric)
- Energy demand side management services
- New business models
- Use smart devices in buildings for
  - On-the-fly diagnostics, total quality management
    (model-based real time management, surveillance of performance)
  - Predictive control and operations
    (e.g. model-based 24h energy management in advance)
  - Ancillary services, grid stabilization
    (Real time demand response)
  - Economic optimization, CO2 optimisation
  - Increased comfort and efficiency

Source: Smart Grids Austria

Future Role of Smart Grids in future Cities
(thermal and electric)

- Efficient hosting and distribution of energy
  - distributed resources (on site renewables, waste heat etc.), micro-networks
  - connection to energy sources in surrounding regions/ supra-regional connections
  - electric-vehicle integration
- Optimized interfaces in the urban energy system
  - linking heat pumps and CHP (combined heat and power production)
  - bidirectional balancing/ shifting of thermal and electrical energy
- Supply and demand side management
  - load shifting, demand response
  - central and distributed storage units
  - optimized utilisation of the existing network capacities
- Thermal grids in particular: adapting the temperature level to the consumer
  - Increase the potential of renewable energy resources (cascade usage)
  - reduce distribution losses and (possibly) investment costs

Future Role of Urban Energy Planning in future Cities

Urban energy planning brings the components of future urban infrastructure system - buildings, grids and energy production technologies, mobility….. - together into optimally integrated concepts.

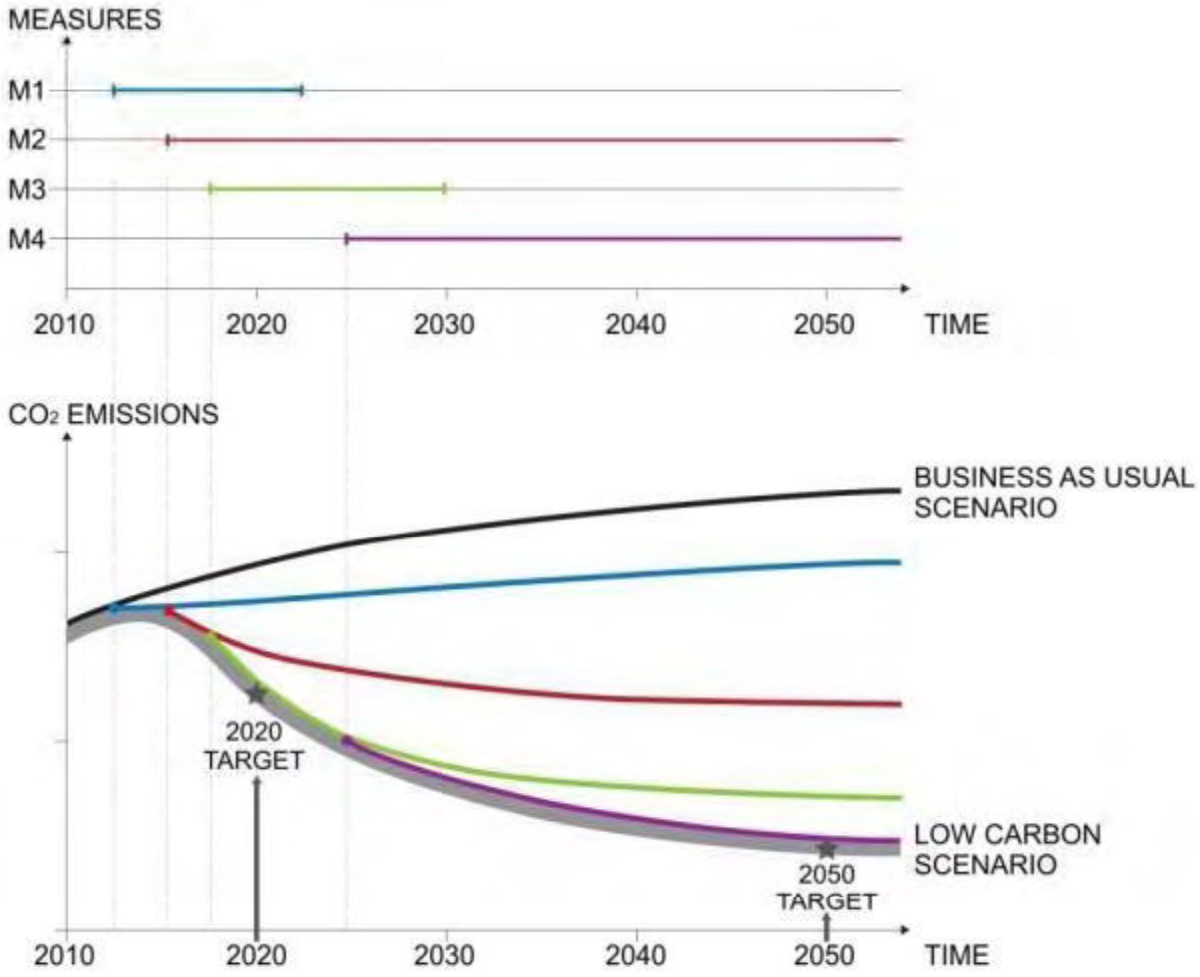
This includes:

1. Development of a roadmap for the transformation of the city into a Smart City

2. Implementation plan for the actions planned within the roadmap:
   - Adressing relevant stakeholders and citizens
   - Design, planning and operation on system and technology level
   - Development of business models
   - …..

Transformation towards a Smart City

…..needs scenarios, facts and figures



Smart City Vienna – a Stakeholder Process

Smart Energy Vision 2050

- Qualitative
- Quantitative
  - CO2
  - Energy Efficiency
  - Renewables
  - Modal split

Roadmap for 2020 any beyond

- Scenarios
  - Business as usual
  - Low carbon
  - …
- Impact of technologies and measures

Action Plan 2015

- Measures
- Demonstration projects

Aspern - Vienna‘s Urban Lakeside

- New ultra-modern district, **240ha converted within next 20 years**
- 8.500 dwellings, 25.000 jobs, **5bn € investment**

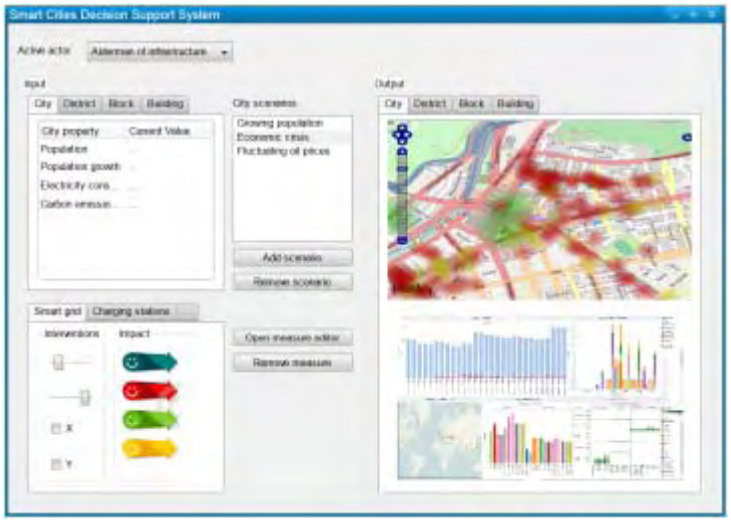
AIT involvement:

- Innovative **holistic energy concepts** (district heating & cooling, spatial planning, ...)
- **Integrated renewable energy** sources (solar thermal, PV, wind, heat from sewage water pipes,...)
- New **demand side management** strategies (smart grid technologies, GIS,...)
- Advanced **mobility concepts & E-Mobility** test region

TRANSFORMation Agenda for Low Carbon Cities

Outcome

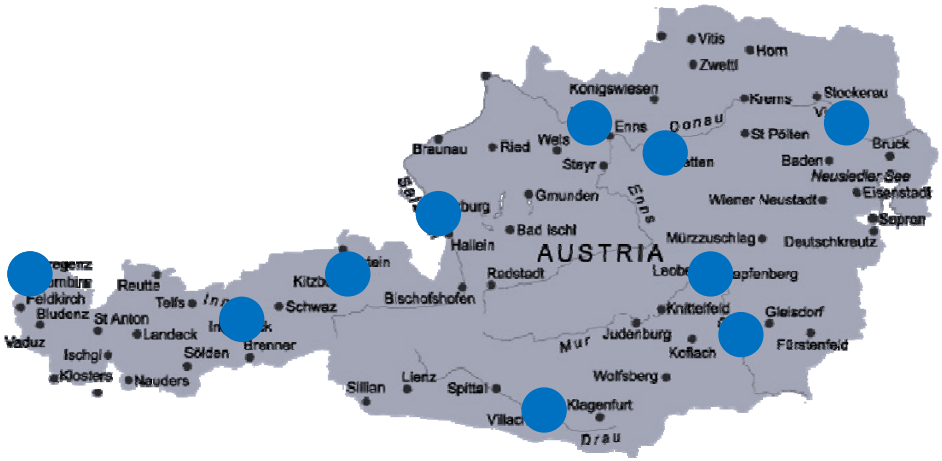
- SWOT analysis of all cities and their surroundings
- Transformation agenda based on SWOT, quantitative & qualitative models
- Implementation plan on district level
- “Smart Energy City Handbook” for replication
- Decision support model



Other Smart Cities projects in Austria

- First Step: 10 Austrian cities

- Amstetten, Bregenz, Bruck / Mur, Graz, Innsbruck, Linz, Salzburg, Villach, Wien, Wörgl



International Projects

e.g. China and Singapore

- Focus on huge and fast infrastructure development
- Complementing AIT Energy innovation processes
- Projects with Chinese cities (Nanchang, Nantong)
  - Low Carbon Roadmaps and Action plans
  - Low Carbon planning, linking spatial planning, infrastructure planning
  - Training courses for administration
- Focus on building sector in Singapore
  - Clean-Tech Campus Projects with developer
  - Scientific cooperation under development (adaptive facades, BIPV)



Smart Cities are key..

- .. in the transformation of Europe`s energy system (Smart Infrastructure scenario)
  - With large scale energy efficiency, renewable integration and demand side management
- …in the understanding of integration of social values (sustainability) Into driving forces
- …in developing new Systemic approaches to integrate innovative technologies and approaches
- By serving as a test bed for evaluating technology and system performance
- By serving as a living lab for integrating users and other stakeholders in the whole innovation cycle
- To deliver clear USP for economy related to innovative urban technologies

- ..and built together by cities and citizens, research, industry, policy……..

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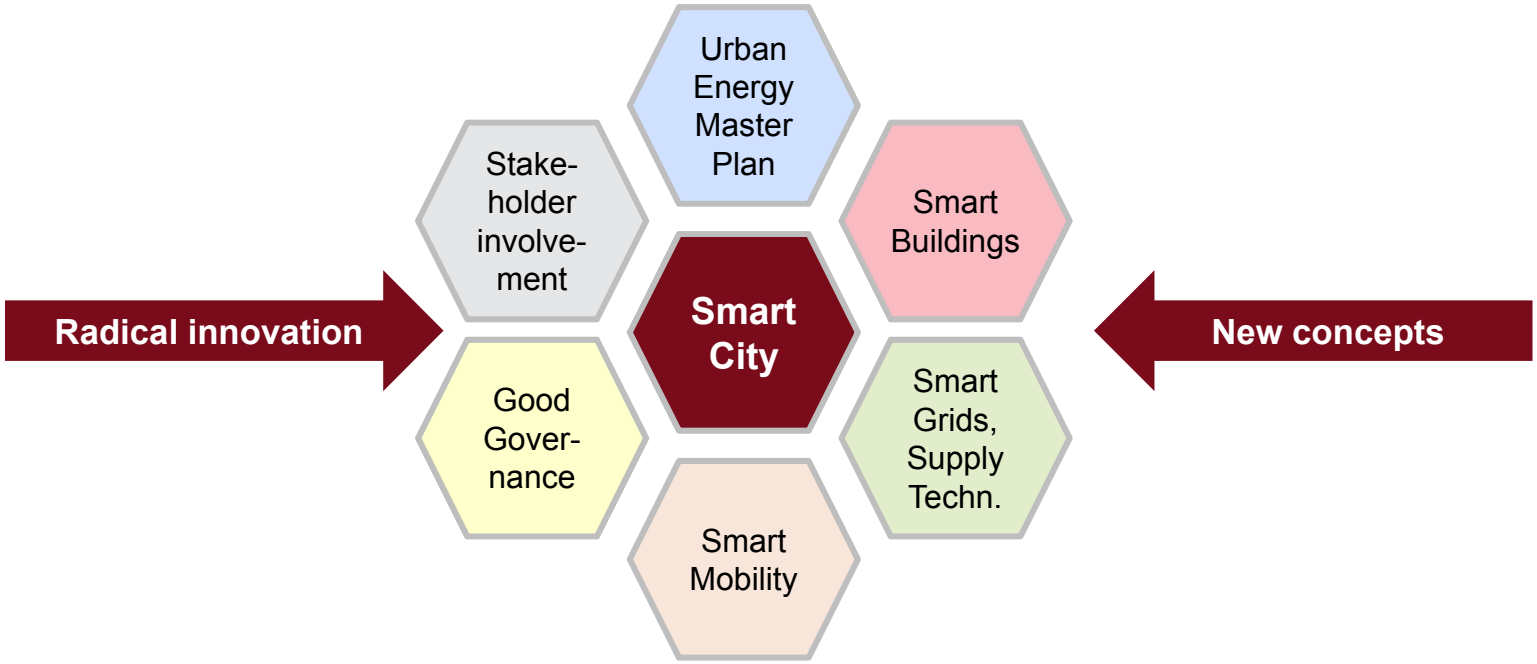
SC key topics

- A sustainable and smart city combines technological issues with societal dimensions to boost sustainable development, economic development, social welfare, ecolocical development and quality of life:

- **Economy** (High productivity, entrepreneurship and ability to transform)
- **Mobility** (Strong infrastructure and sustainable transport systems)
- **Environment** (Sustainable resource management, pollution prevention, environmental protection)
- **Energy (**Environmental & climate friendly and sustainable energy use)
- **Culture** (Cultural facilities, housing quality, health issues, diversity and public life)
- **Governance** (Political strategies and perspectives, transparency and community participation in decision making)

Smart City – a multi-technolgy, multi-disciplinary and co-operative approach



Urban areas need radical innovations and new concepts

Smart energy infrastructure

Multidisciplinary planning processes

From a single to a multi technology approach

Cooperative, innovative processes with stakeholder integration

SC key topics

- A sustainable and smart city combines technological issues with societal dimensions such as:

- **Economy** (High productivity, entrepreneurship and ability to transform)
- **Mobility** (Strong infrastructure and sustainable transport systems)
- **Environment** (Sustainable resource management, pollution prevention, environmental protection)
- **Energy (**Environmental & climate friendly and sustainable energy use)
- **Culture** (Cultural facilities, housing quality, health issues, diversity and public life)
- **Governance** (Political strategies and perspectives, transparency and community participation in decision making)

European Policy

- Directives in the fields of
- **Energy Efficiency**
- **…..**

Integrated Smart Infrastructure Development

- Smart Cities require new approaches
  - Fully integrated designed and intelligent managed energy systems
  - From a single technology perspective to multi technology perspective
  - Multi-stakeholder involvement
  - Transdisciplinary approaches

Smart City – the Concept

The Smart Cities Concept:

- adopts an integrated approach, considering the city as a whole in all its complexity

- to meet the European Commission's (more particularly the Covenant of Mayors') targets for 2020 and aspirations for 2050 regarding:
    - Greenhouse gas emissions' reductions
    - Renewable energy production
    - Energy efficiency

Smart City – the Scope

- Energy efficiency in the refurbishment of existing buildings and construction of new buildings

- Smart energy networks:
  - Smart electrical *and thermal grids*
  - Active buildings that play an active role in an intelligent energy networks
  - Role of decentralised energy storage and production

- Local integration of renewable energy (and low carbon) technologies and meta-regional integration of renewable energy production

- Interactions between energy and mobility, water, waste, the quality of life of its citizens and socio-economic conditions within the city

Smart City – the Challenge

In order to become “smart” cities need support:

1. At the level of **concept planning** in producing a **roadmap** for their transformation into a Smart City (e.g. Sustainable Energy Action Plan, Low Carbon Action Plan)

2. At the level of **detailed design** in **implementing** the **measures** decided with the roadmap

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Smart City Research Projects @ AIT

NextGenerationHeat – Low temperature district heat for the use in regions with a low density of heat demand

Duration: 06/2012 – 05/2015

- **Aim of the project:** to develop and evaluate
  - economically and ecologically optimized concepts for **low temperature district heating networks** tailored to different regions in Austria using 4 case studies
  - optimized solutions to the problem of **hygienic warm water generation**, taking into account heat pumps and other external energy sources

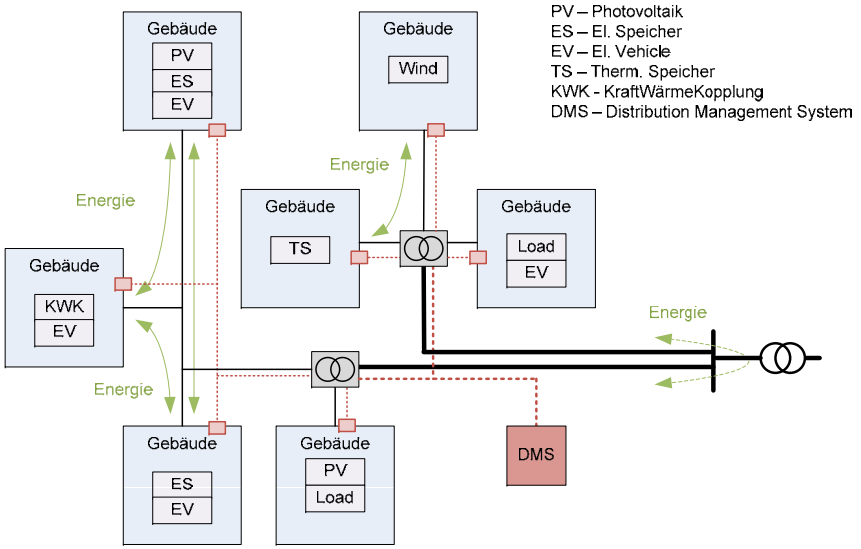
- **Method:**
  - dynamic **network/ building simulation**, development of **technical system variances**, focus on **heat pumps**
  - Development of **monitoring** concepts, models for increasing **consumer acceptance**, outlining first business models.

Smart City Research Projects @ AIT

CoOpt – Coordinated optimization of renewable energy within grids and buildings

Duration: 03/2012 – 08/2014

- **Aim of the project:**
  to improve and optimize the energy efficiency as well as to increase the coverage of individual demand by renewable energy within urban electricity networks and buildings

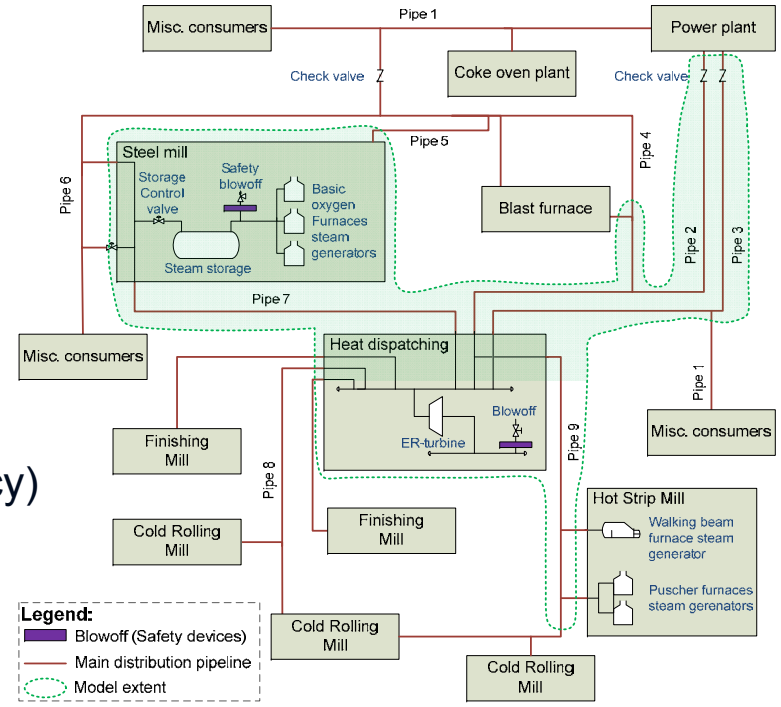


- **Method:**
  - model predictive control and prognosis

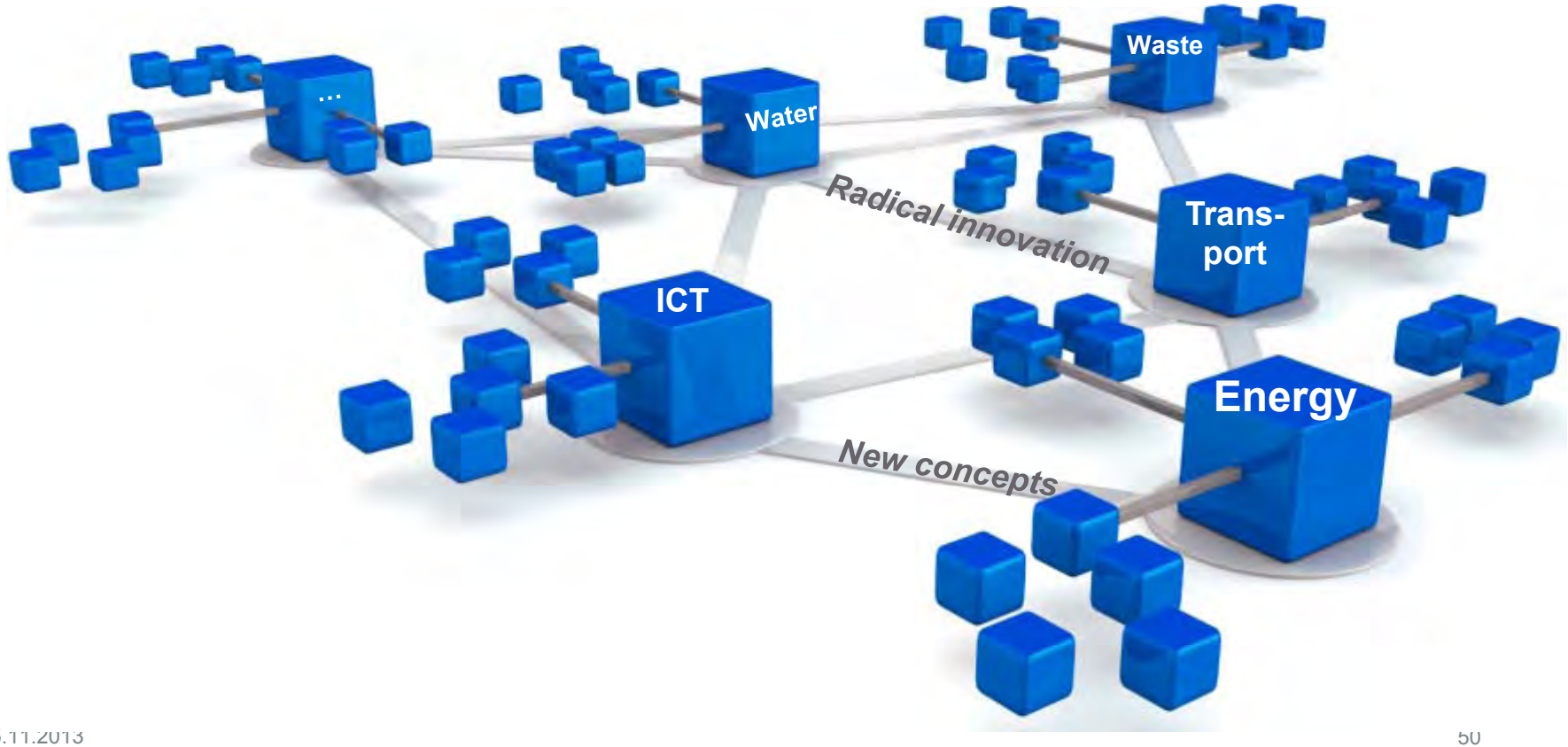
Smart City Research Projects @ AIT

Dynamic simulation of the gas and heat networks (vapour, district heat) **of an integrated smelting plant using APROS**

- **Tasks**:
  - Analysis of the operating behaviour;
  - Improvement of the regulation parameters in order to reduce steam exhausts and torch losses
  - Integrated planning (increase of capacity, use of waste heat, increase of energy efficiency)
  - Improvement of the medium quality (p, T)
  - Safety analyses
  - Improvement of the control of the steam storage



A Smart City integrates processes, concept and technologies to improve the quality of life



Smart City – Challenge & Chance

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MORE INFORMATION

Smart City – a variety of research questions need to be addressed

Urban Energy Master Plan

- Renewables
- Distributed generation
- Energy efficiency

Smart Mobility

- Low carbon transport
- Smart applications for ticketing
- Intelligent traffic mgmt. and congestion avoidance
- Demand management
- Travel information and communication, etc.

Smart Buildings

- Net zero energy
- Net zero carbon emissions
- Retrofitting of existing building stock

Stake-holder process

- Public participation
- Social innovation
- Smart Urban Living labs
- Sustainable and participatory urban planning

Smart Grids, Supply Techn.

- *Heating and Cooling:* Biomass, solar thermal, geothermal; Hybrid H&C systems
- *Electricity:* Smart grids – renewable generation, electric vehicles charging, storage, demand response and grid balancing. Smart metering and energy mgmt. systems.
- Smart appliances to foster local RES electricity production (esp. PV, wind)

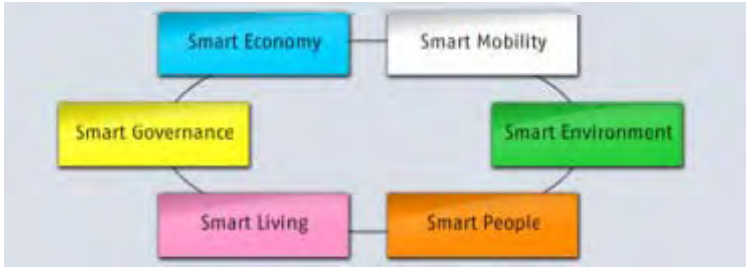
Waste mgmt.

- Efficient logistics for packaging, selling and doing shopping
- Differentiate garbage and use it for producing energy
- Minimise quantity of waste production and maximise quality of it

Commonly used definitions

- The level of "intelligence" of the citizens of a city is defined by the European Smart Cities project for its performance in seven factors: level of skills, appreciation for lifelong learning, social and ethnic diversity, flexibility, creativity, cosmopolitanism / openness and participation in the life public. (UFRJ)

- A Smart City is well-performing in six characteristics built on a smart combination of talents and activities of self-decisive, independent and aware citizens:
  (www.smart-cities.eu/model.html)



- A Smart City is more than a digital city. A Smart City is one that is able to link physical capital with social one, and to develop better services and infrastructures. It is able to bring together technology, information, and political vision, into a coherent programme of urban and service improvements
- http://www.networks-etp.eu/fileadmin/user_upload/Publications/Position_White_Papers/White_Paper_Smart_Cities_Applications.pdf

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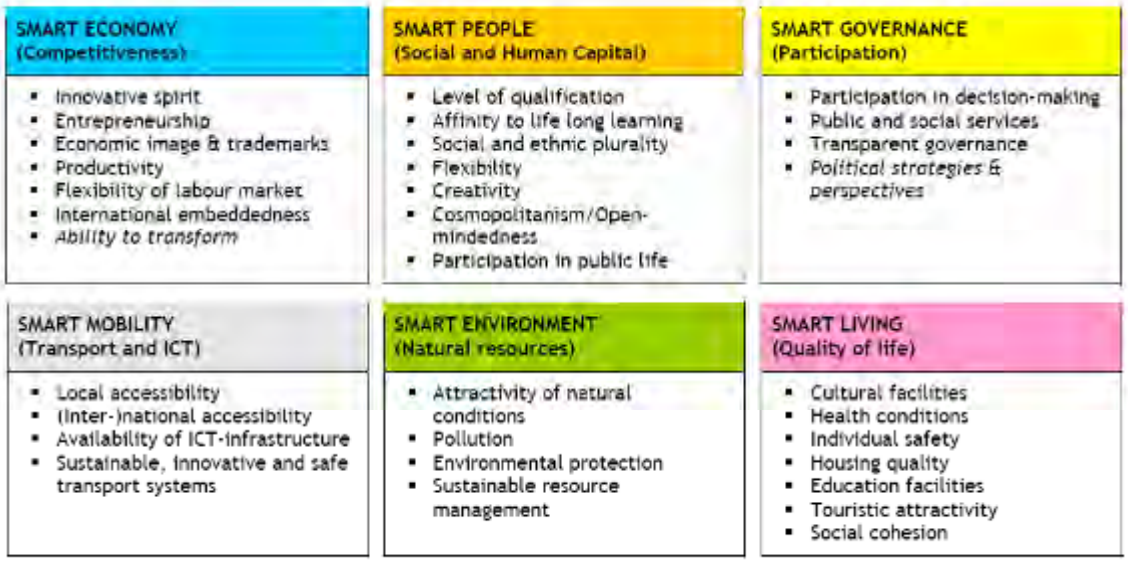

Figure 1 - Characteristics and factors of a Smart City (extracted from [GFKK07]).

R. Giffinger, C. Fertner, H. Kramar, R. Kalasek, N. Pichler-Milanovic and E. Meijers, Smart Cities – Ranking of European Medium-Sized Cities, Research Report, Vienna University of Technology , Vienna, Austria, 2007 http://www.smart-cities.eu/download/smart_cities_final_report.pdf.

- **Buildings:**
- New buildings with net zero energy requirements or net zero carbon emissions when averaged over the year by 2015, thus anticipating the requirements of the recast Directive on the energy performance of buildings (EPBD). This requirement could be anticipated (e.g. 2012) for all new buildings of the local public authority (city).
- Refurbish of the existing buildings to bring them to the lowest possible energy consumption levels (e.g. passive house standard or level of efficiency that is justified by age, technology, architectural constrains) maintaining or increase performances and comfort. This would include innovative insulation material (solid insulation, vacuum insulation, vacuum windows, cool roofs, etc.)

- **Energy**
- **Energy – supply & demand**

Usage of renewables to reduce carbon footprint,

Increase distributed generation (PV…)

improve energy efficiency in buildings

- **Networks**

Heating and Cooling

Innovative and cost effective biomass, solar thermal and geothermal applications

Innovative hybrid heating and cooling systems - biomass, solar thermal, ambient thermal and geothermal, district heating and cooling systems.

Electricity

Smart grids, allowing renewable generation, electric vehicles charging, storage, demand response and grid balancing. Smart metering and energy management systems.

Smart appliances (ICT, domestic appliances), lighting, equipment, to foster local RES electricity production (especially PV and wind applications).

Transport

Concepts for low carbon public transport and individual transport systems, including smart applications for ticketing, intelligent traffic management and congestion avoidance, demand management, travel information and communication, freight distribution, walking and cycling.

Sustainable mobility: advanced smart public transport, intelligent traffic management and congestion avoidance, demand management, information and communication, freight distribution, walking and cycling.

Public participation - social innovation

Smart Urban Living labs

A LIVING LAB is a research and development infrastructure to research human interaction with, and stimulate the adoption of, sustainable, smart and healthy innovations around the home. Occupant interaction with the home can be studied in an adaptable and controllable home environment.

This way the technical development, the implementation and the social uptake of sustainable innovations can be accelerated.
LIVING LAB brings together Europe's top research institutes and companies and aims to stimulate cooperative projects in the fields of user centred research and product development.

Sustainable innovation

LIVING LAB helps European industries and cities to achieve leadership in the development of successful sustainable products and services for greener households, cities .

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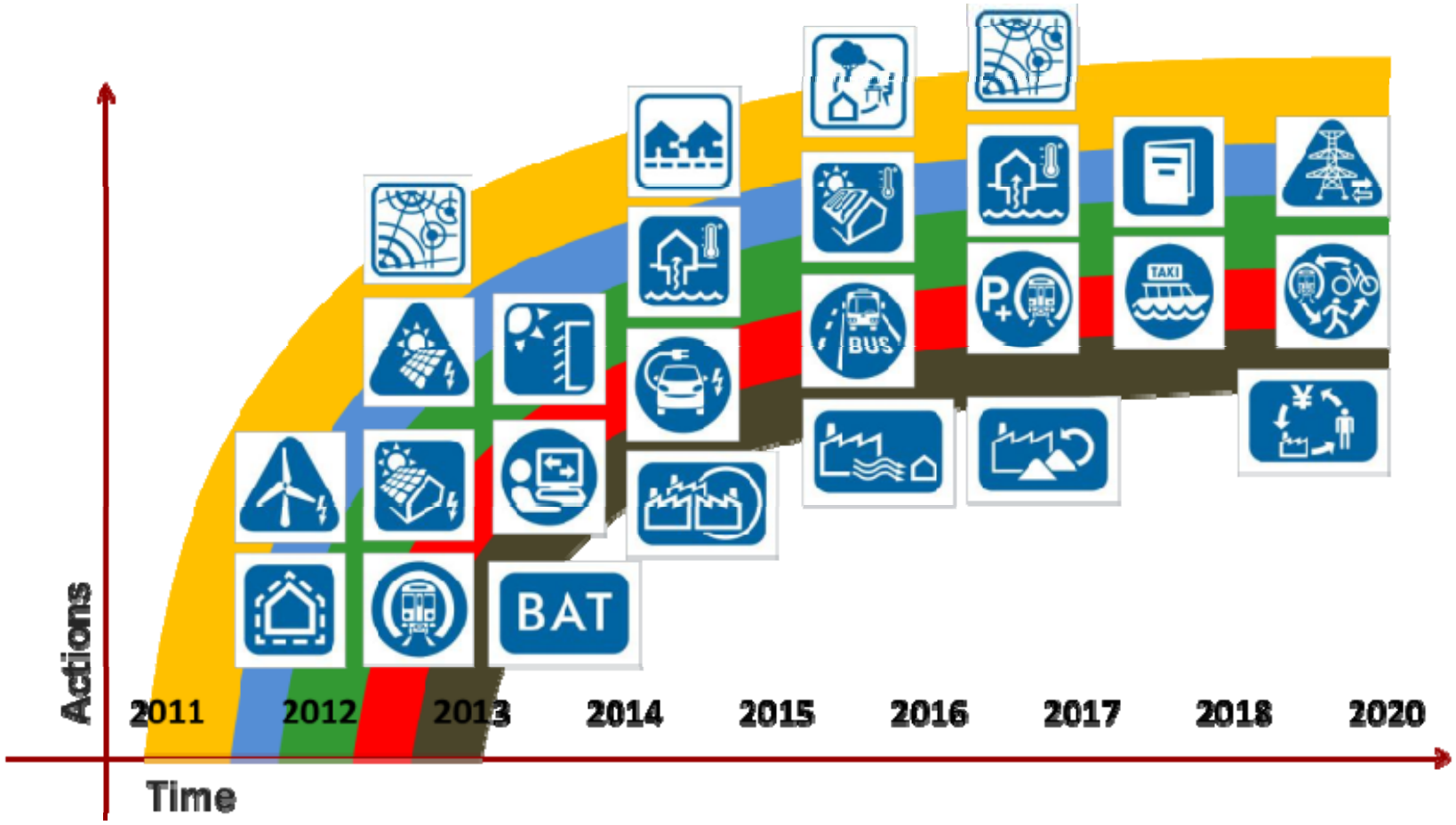
Waste management

Waste management and waste production may entail more efficient ways to organise logistics for packaging, selling and doing shopping; more intelligent ways to differentiate garbage and to use it for producing energy ; incentives based system for encouraging people to minimise the quantity of waste production and to maximise the quality of it; procedures for making local communities willing to host and transform waste and others which want to dispose of it to meet so that the exchanges of waste can be priced

Sustainable and participatory urban planning

Beside the Muinicipal Government and associated stakeholders there's a third player in these solutions, it would be the *Citizens* themselves. They are a critical piece in Smarter Cities planning because the services we define are designed to enable them to live better lives through improved communities.

OSCity (Open Source City) brings spatial planning together with the newest information technology. By directly searching, visualizing and combining spatial data everybody is invited – from citizen, entrepreneur, designer and civil servant – to gain insight into everything that is spatial. With this OSCity tries to create broad perspectives which offer a basis for an innovative spatial planning that can tackle problems of social cohesion, sustainability and generates value for the public good.


BAT
BUS
TAXI
Actions
Time
2011
2012
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2018
2020

Strategic projects and activities with City of Vienna I

- **Smart city Vienna** (Austrian Climate and Energy Fund): in a broadly based stakeholder process a “Smart Energy Vision 2050”, a “Roadmap for 2020 and beyond” and a short-term “Action Plan” were developed under the first “Fit for SET” program in 2011
- **TRANSFORM** (Seventh Framework Programme, Smart Cities & Communities): TRANSFORMation Agenda for Low Carbon Cities
  - Project with 5 other European cities: Amsterdam, Copenhagen, Hamburg, Lyon, Genua
  - Aiming at supporting cities with implementation plans embedded in integrated urban energy planning
- **TRANSFORM+** - Operative und inhaltliche Vertiefung des FP7 Projekts TRANSFORM und Nutzung der Ergebnisse für Österreich
  - Collection and provision of a dataset for the decision support environment
  - Smart Urban Labs: Seestadt Aspern, Liesing
  - 2 pilot applications planned – “Smart Citizen Assistant”, “e-delivery on demand”

Strategic projects and activities with City of Vienna II

- **Seestadt Aspern** – ICT integration of buildings and the electrical grid (Sondierung)
  - Increase of energy efficiency through an integrated approach combining the different infrastructure layers buildings and electrical grid, including the integration of renewable energy sources and storage technologies
  - Development of a concept for the ICT architecture (hardware and software) and technical infrastructure (heat pumps, photovoltaic systems etc.)

Future Role of Urban Energy Planning in future Cities

Urban energy planning brings the components of future urban energy system - buildings, grids and energy production technologies - together into optimally integrated concepts. This includes:

1. Development of a roadmap for the transformation of the city into a Smart City
2. Implementation plan for the actions planned within the roadmap:
   - Design, planning and operation
   - Adressing relevant stakeholders and citizens
   - Design of components and their interfaces (choice and dimensioning of production technologies, storage and distribution networks; measures for energy demand reduction and load-shifting)
   - Smart operation of the interlinked components by real-time monitoring, forecasting of loads and weather conditions and the optimal control of the system as a whole
   - Development of business models for the economical feasibility of the actions‘ construction and operation