







## Introduction



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**European countries are faced** with a huge challenge to increase energy efficiency and reduce greenhouse gas emissions in order to achieve their ambitious climate protection goals. The characteristics of urban morphology and the growing trend toward urbanisation give cities enormous leverage in this respect. Smart Cities use innovative technology and an integrated approach to provide high energy efficiency, sustainability and quality of life. They therefore play a prominent part in the European Strategic Energy Technology (SET) Plan as fundamental building blocks of tomorrow's low-carbon energy system. Concerted research efforts and innovation are required to achieve this paradigm shift in urban energy management and pave the way into the Smart Cities era.

**The research questions involved** in transforming cities into Smart Cities are highly complex and can only be solved by taking an interdisciplinary, transnational approach. The European Energy Research Alliance (EERA) provides an ideal framework for this joint effort by pooling high-level energy research expertise and infrastructure across Europe. The EERA Joint Programme Smart Cities focuses on enhanced energy efficiency and the large-scale integration of renewable energies, enabled through smart energy management at city level. This collaborative approach is anticipated to provide added value for Europe by boosting energy expertise and positioning Europe at the forefront of international Smart Cities research.



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## EERA - Coordinating Energy Research for a Low-Carbon Europe

**The European Strategic Energy Technology Plan** (SET Plan) sees energy technologies as crucial in combating climate change and securing energy supply at the European and global level in the long term. Successful achievement of Europe's 2020 and 2050 targets and visions on greenhouse gas emissions strongly hinges on the development and deployment of novel technologies designed to increase energy efficiency and enable large-scale integration of renewable energy.

The European Energy Research Alliance (EERA) is a joint effort by leading European research institutes to take up the challenge of accelerating the development of these new energy technologies to pave the way towards a low-carbon Europe. The key focus is on streamlining and coordinating national and European research activities and pooling resources in order to maximise synergies and optimise pan-European energy research capabilities and infrastructures. EERA's two-pronged approach involves the sharing of world-class national facilities in Europe and the implementation of joint research programmes in support of the SET Plan priorities.

The EERA Joint Programmes constitute strategic, permanent collaborations between major research organisations and institutes to form a virtual centre of excellence. They are designed to address the key topics of Europe's energy future and currently involve close to 3000 researchers from over 150 public research centres and universities. The topics addressed in these Joint Programmes range from photovoltaics, wind energy, fuel cells and hydrogen to smart grids and smart cities.



## Joint Programme Smart Cities

**More than half** of the seven billion people on our planet live in cities and the trend towards urbanisation is gathering pace at an enormous rate. This has led to a drastic increase in urban energy consumption and associated CO<sub>2</sub> emissions – almost two thirds of global energy is consumed in urban environments.

The development of sustainable and energy-efficient "smart cities" is expected to move the energy system towards a more sustainable path. This will require an integrated systems view as well as innovative, intelligent approaches to the design and operation of urban energy systems.

The Joint Programme Smart Cities aims to develop new scientific methods, concepts and tools designed to support European cities in their transformation into smart cities. The key focus is on large-scale integration of renewable energies and enhanced energy efficiency, enabled through smart energy management at city level.



The key areas of tomorrow's smart cities are reflected in the four sub-programmes:

- Sub-Programme 1** **Energy in Cities** takes an integrated approach towards urban energy planning and transformation processes.
- Sub-Programme 2** **Urban Energy Networks** concentrates on the intelligent planning, design and operation of thermal and electrical networks in cities.
- Sub-Programme 3** **Energy-efficient Interactive Buildings** focuses on sustainable buildings as interactive elements of the urban energy system.
- Sub-Programme 4** **Urban City-related Supply Technologies** addresses renewable supply technologies and their integration into the urban infrastructure.

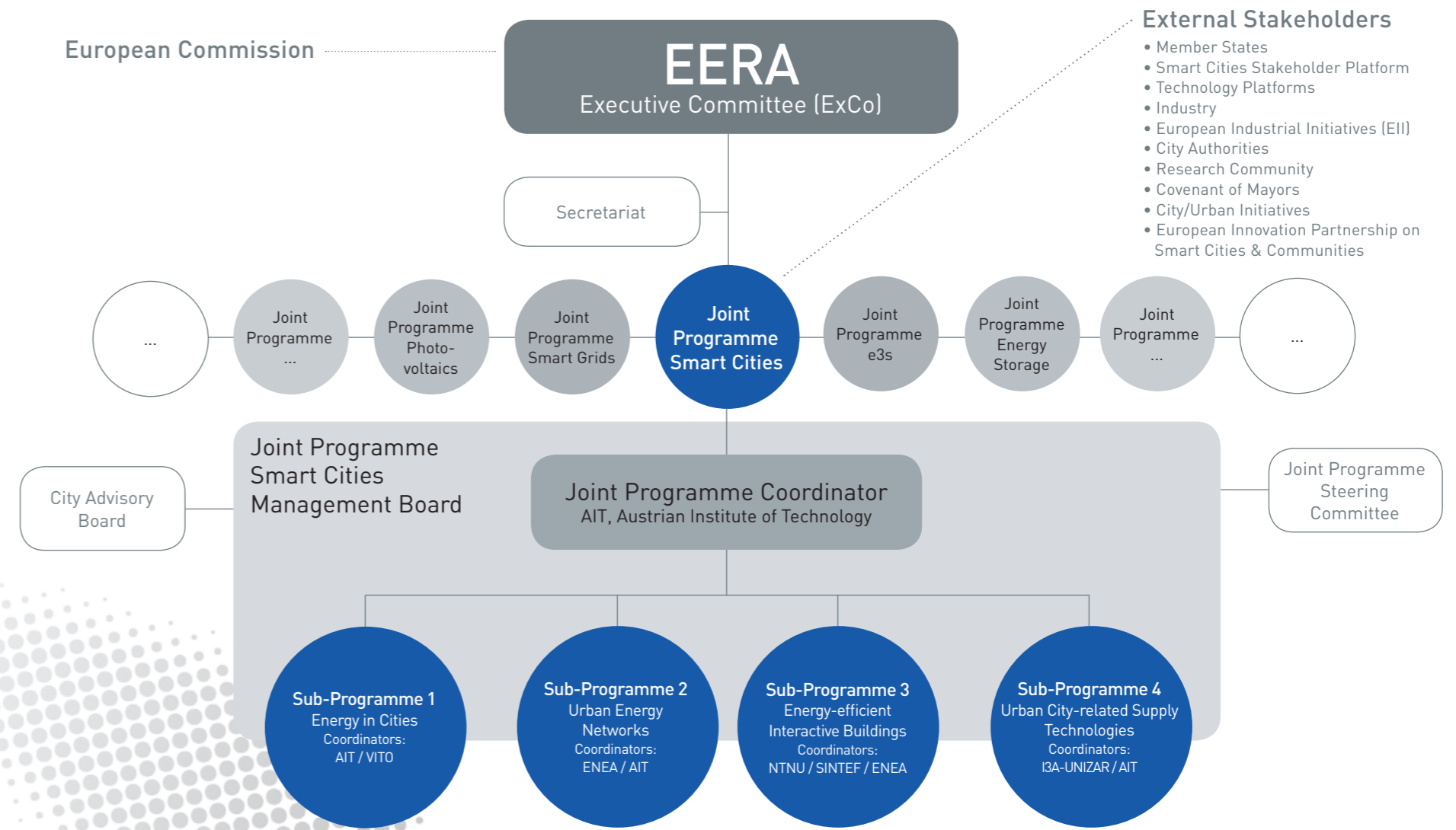


## Structure & Management

The **governance structure** of the Joint Programme is designed to enable smooth management and coordination with a minimum of bureaucracy. The Joint Programme Management Board consists of the Joint Programme Coordinator and the coordinators of the four sub-programmes. It is responsible for overall management and communication with the EERA and other relevant stakeholders and for steering and monitoring research progress. The Joint Programme Steering Committee, which comprises one representative from each of the currently 24 full participants, decides on the admission of new partners, the integration of new research topics and the strategic positioning of the research framework.

Special focus is placed on close communication with the European Commission, the Member States Initiative on Smart Cities and external stakeholders like city authorities, the scientific community and industry in order to maximise synergy and keep the research strategy aligned to the real-life needs of cities and the economy. A City Advisory Board has been established to ensure mutual knowledge transfer between research and municipal authorities. Its major aim is to initiate the transfer of new scientific findings, methods or tools into cities and in return provide feedback on their usability in practice.

The strategic management process includes regular thematic meetings and smaller events throughout the year as well as two large annual workshops.







## Objectives & Added Value

### Sustainable and energy-efficient cities

The key objective of the Joint Programme is to develop new scientific methods and tools to support European cities in their transformation into smart cities. This will be achieved by the extensive use of low carbon technologies and smart energy management based on innovative design and operation of the entire urban energy system – from generation to distribution and consumption. The results obtained will provide the basis for unlocking the full potential of energy efficiency and large-scale integration of renewable energies in urban areas. This will lead to significant reductions in energy demand and greenhouse gas emissions while at the same time creating a liveable environment for residents.

### Enhanced research expertise

The research partners involved in the Joint Programme will develop essentially new scientific methodologies for the integration of energy and urban planning. A strongly interdisciplinary and multi-technology approach will be applied to capture the complex interactions between the different layers of urban energy systems, i.e. energy networks, buildings, supply technologies, mobility, and consumers. This knowledge will be used for the intelligent integration of technologies with a view to optimising the overall energy system. The tools developed will also enable decision makers to assess the economic and social impact of energy infrastructures, policies and regulations with a focus on renewable energy sources and energy efficiency.

### Collaboration for a low-carbon Europe

Many European countries have initiated research activities to make their cities more sustainable and energy-efficient and have gained valuable expertise in this field. The Joint Programme will leverage this knowledge by facilitating the use of common research infrastructure, intensifying exchange between high-level research players and by coordinating research activities and strategies at a European level. This joint research effort on the integration of low-carbon technologies and smart energy management at city level will provide a major scientific contribution to reaching the 20-20-20 targets as indicated in the SET Plan and meeting the ambitious long-term vision of Europe: an 80% reduction in greenhouse gas emissions by 2050.

### European leadership in R&D

Organisations involved in research and technology development must anticipate trends at an early stage in order to be able to develop future-proof solutions. The clear long-term research strategy of the Joint Programme is designed to guarantee the future leadership of European R&D in urban energy technologies and will enable European cities to act as role models for others to emulate. This joining of forces will help the European

research community strengthen its position in the field of smart cities towards other international research partners in key markets such as the USA, China or India. The Joint Programme is thus expected to act as a "one-stop shop" enabling a well-coordinated dialogue and cooperation framework in an international context. The first official review by experts from the USA, the Netherlands and Austria attested that the researchers, laboratories and capabilities involved in the Joint Programme are world-class and bring in a high level of expertise on energy system integration, especially in the areas of electrical and thermal systems.









Sub-Programme 1

## Energy in Cities

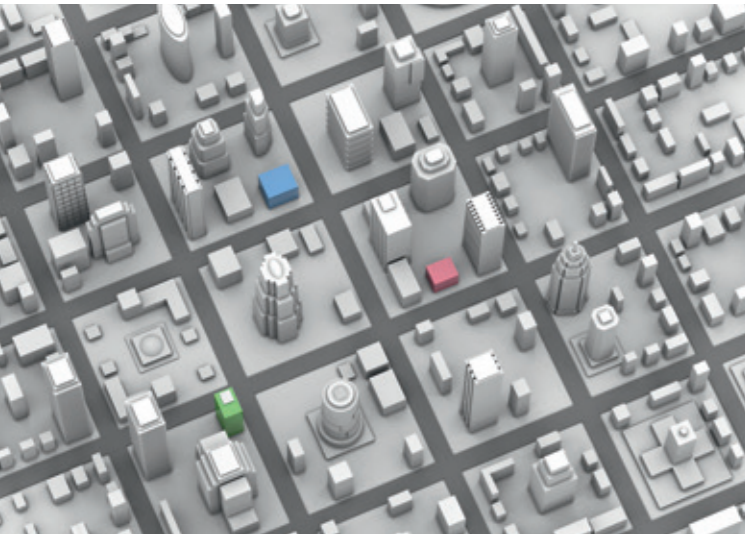
A detailed understanding of the energy performance characteristics and energy flows in urban areas is of crucial importance for the design and planning of smart energy systems. This sub-programme follows a unique integrated approach to merge urban and energy planning. The scientific tools to be developed will support cities throughout the transition process towards a low-carbon energy system – from systems analysis, vision development and pathway exploration through to experimenting, assessment and implementation.

The sub-programme will provide best practice examples of smart city visions for others to emulate. The design of integrated database structures and output interfaces will facilitate the planning of smart cities and subsequent

monitoring of their performance based on Key Performance Indicators (KPIs). Decision support and simulation tools will be developed to model economic scenarios and energy flows and thus support experts and authorities in developing urban energy roadmaps. A strong focus will also be placed on setting up a template for the implementation of the living lab concept and interaction with other smart city aspects such as mobility, waste or water.

### Work Packages

- WP 1 Examples of Smart Cities visions
- WP 2 Develop energy data system for cities
- WP 3 New decision tools for energy roadmaps and action plans
- WP 4 Develop living lab concepts
- WP 5 KPI's and progress monitoring
- WP 6 Interaction with other sustainable city aspects



Sub-Programme 2

## Urban Energy Networks

Each city has its own energy metabolism, characterised by energy production, storage and consumption with their corresponding "interconnected networks". Smart cities therefore also require smart energy grids which are able to communicate with each other to balance thermal and electrical loads depending on supply and demand. The large-scale integration of distributed renewable energy sources into existing energy grids brings up additional challenges in the development of smart urban energy networks.

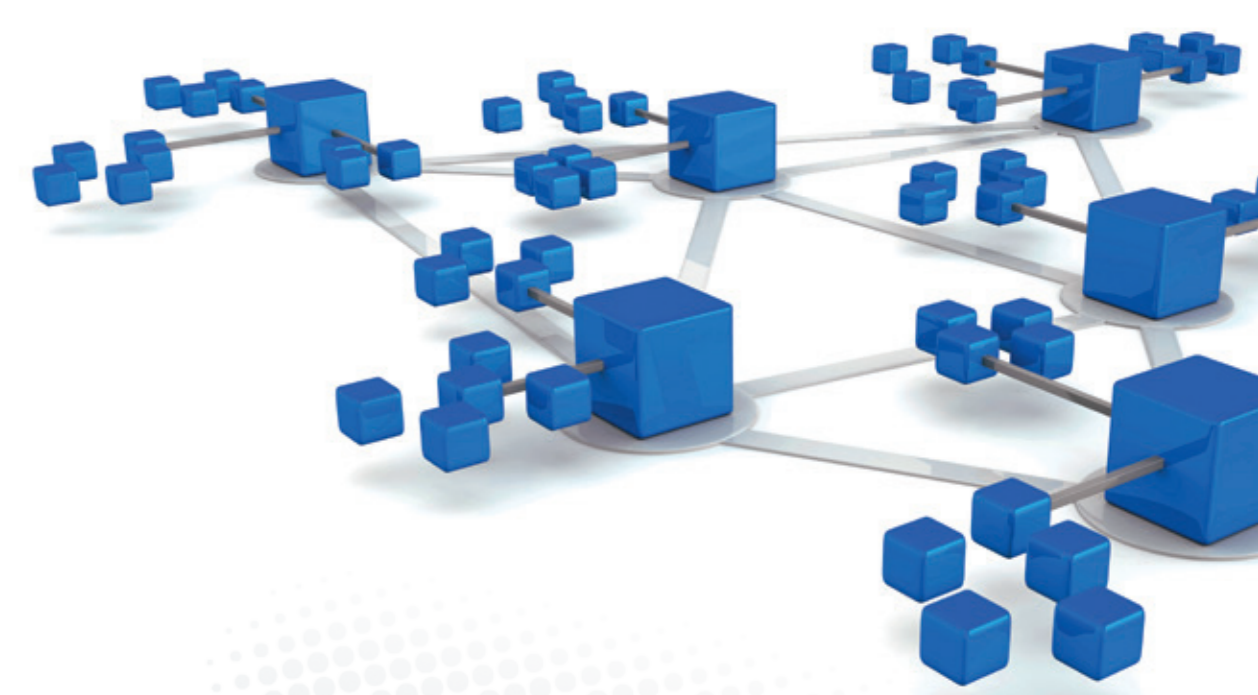
This sub-programme aims to optimise these interconnected networks by intelligent planning, design and operation, integrating all accessible sources of renewable energy and providing flexible balancing

potentials. This will be achieved by developing models for optimal management of low impact "smart energy districts" and solutions for smart integration of electrical and thermal energy production, storage and consumption at urban level (including district heating and cooling networks).

The integrated energy management systems of the future will rely on comprehensive sensor networks feeding energy-related data into a multifunctional ICT platform, which will enable a range of smart services based on real time data. The human factor will be taken into account by deepening knowledge about citizen-city interaction and its influence on energy use in order to design "human oriented technologies".

### Work Packages

- WP 1 Smart Energy Districts
- WP 2 Urban Network Integration
- WP 3 Human Factors: Citizen-City Interaction





## Energy-efficient Interactive Buildings



**Buildings account for** around 40 per cent of European primary energy demand. In tomorrow's smart cities energy-efficient buildings will make use of energy conservation measures and on-site renewables to reduce their energy demand and will play a key role as interactive elements of the urban energy system.

This sub-programme will develop and validate innovative, competitive holistic concepts, tools and demonstration cases for a new generation of buildings in the urban context. The main aim is to further increase their energy efficiency, enable coordinated exchange of energy with thermal and electrical networks while providing a comfortable healthy indoor environment to their users. Research in this sub-programme will mainly focus on distinctive fields such as design concepts for resource-efficient buildings, novel envelope materials and technologies that provide an optimal interface between the building and its environment as well as the integration of renewable energy systems into buildings. Emphasis will also be placed on innovative building and energy management, the energy interface between building and urban infrastructure ("building-to-grid"), smart interaction with the user as well as support strategies to achieve a multiplier effect within the broader stakeholder community.

### Work Packages

- WP 1 Building Design
- WP 2 Envelope Solutions
- WP 3 Energy Management and Grids Interaction
- WP 4 User Interaction
- WP 5 Support Strategies



## Urban City-related Supply Technologies

**One of the principal ideas** behind smart cities is the efficient integration of on-site renewable energy sources into buildings and networks. Energy supply technologies such as heat pumps, solar thermal, photovoltaics, energy storage units, etc. play a key role in this context. The development of smart integrated energy networks will require both new components and systems, as well as a better understanding of how to integrate distributed supply technologies into urban infrastructure in an efficient and cost-effective manner.

This sub-programme aims to develop a methodology capable of dealing with complex integration of thermal and electrical energy technologies, and enabling the design and evaluation of renewable technologies integrated at district or city level. This will require the development of an appropriate modelling and simulation framework including numerical component models and libraries and an integrated, flexible and adaptive multi-level decision support framework. In addition the city-industry interaction will be investigated to optimise



available synergies, such as the use of waste heat from industrial processes.

### Work Packages

- WP 1 Framework for Development of Multi-purpose Component-oriented Models
- WP 2 Development of Component-oriented Model Libraries
- WP 3 System Integration
- WP 4 City-Industry Interaction
- WP 5 Technology Assessment
- WP 6 Scientific Methods for Quality Assessment for Urban-related Energy Supply Technologies



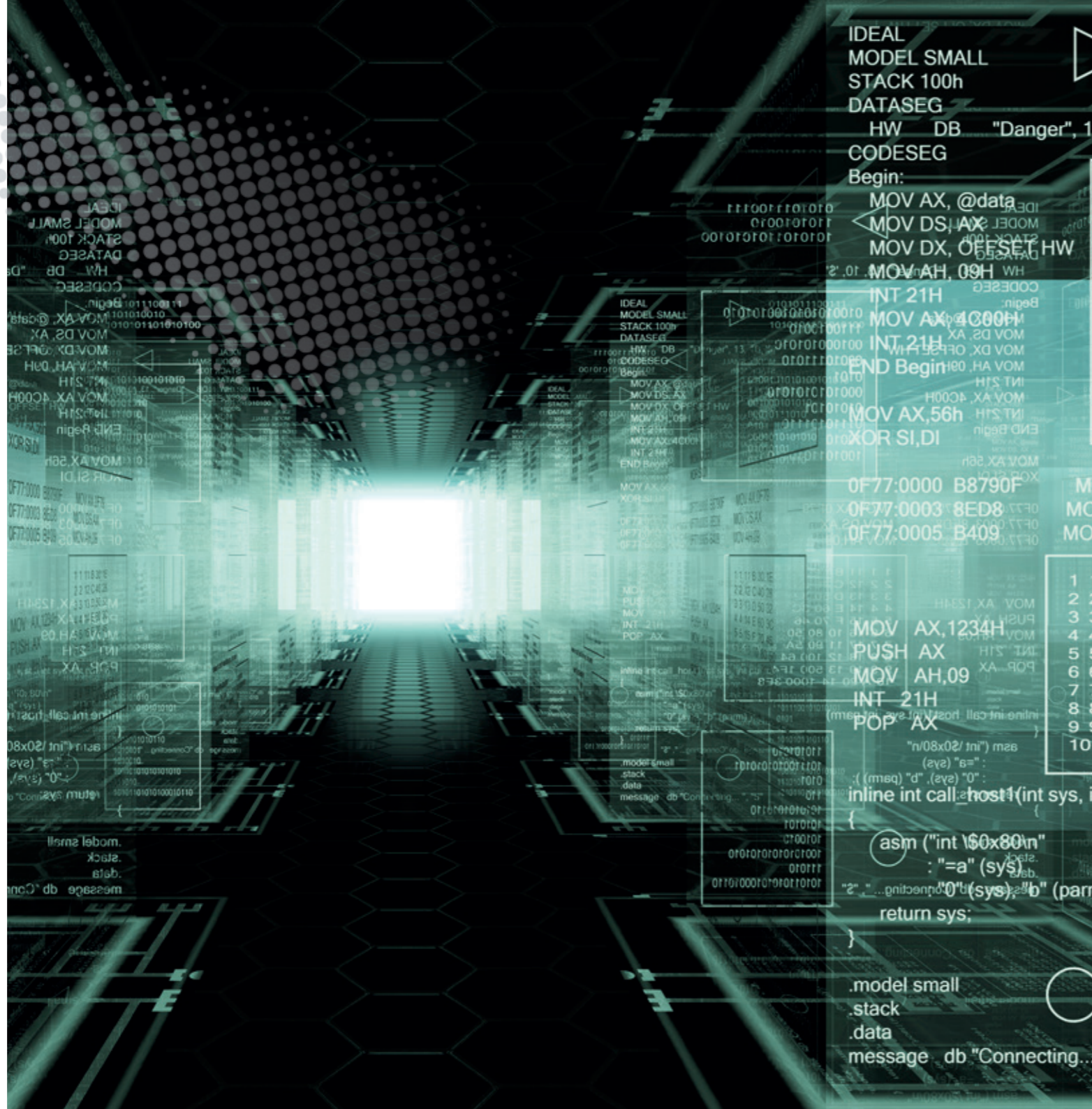


# Task Force on Simulation Platform Development

A detailed and systemic approach is required to understand, simulate and optimise the emergent properties of complex urban energy systems with a view to supporting city stakeholders in their decisions to maximise energy autonomy and thus minimise greenhouse gas emissions. This support can be provided by simulations that address and integrate all key elements of the urban energy system at appropriate spatiotemporal resolutions.

As simulation-based decision support cuts across all topics of the Joint Programme, the Task Force on Simulation Platform Development spans all four sub-programmes. Its key task is to evaluate the state-of-the-art in the modelling and simulation of urban energy systems, to identify gaps in simulation capabilities and to specify user and data requirements for future simulation tools. The overall aim is to maximise synergies and complementarities between the individual sub-programmes in this field.

It is anticipated that the Task Force will, in the future, coordinate the development of a new integrated comprehensive urban energy simulation platform to support decision making at a range of spatiotemporal scales and future time horizons.



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