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30 minutes of reading

Economic outlook

Issues and Foresight

Sustainable mobility | Connected Mobility | Biofuels and e-fuels

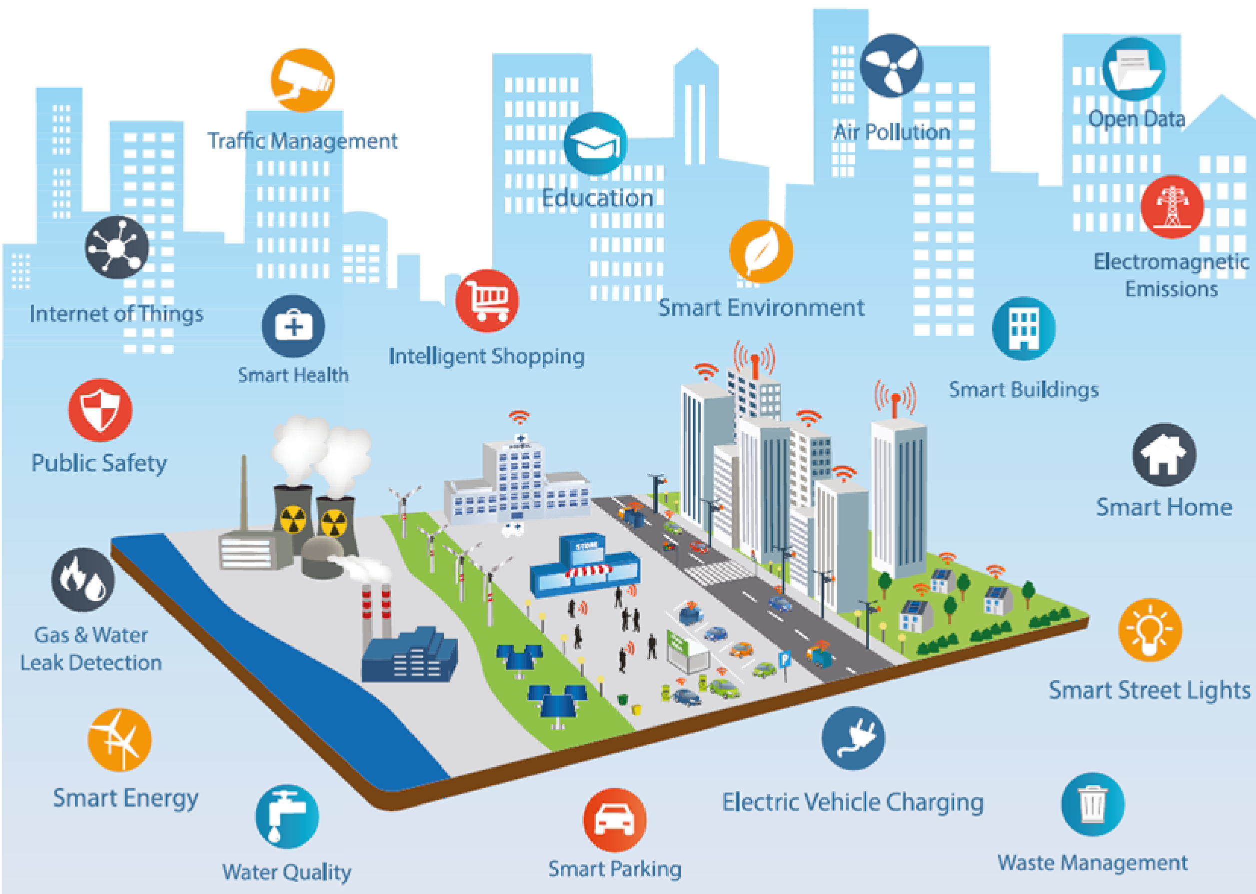
By 2025, about 58% of the world population (4.6 billion people) will live in urban areas, with this rate reaching 80% in developed countries. Urbanization poses considerable challenges, including overpopulation, climate change, environmental quality and access to energy. Urban planning must reassess how to sustainably supply the population with basic services at an affordable cost. Urban areas represent 10% of the earth's landmass, a proportion which continues to rise. Major metropolitan areas consume approximately 65% of available primary energy and count for around 70% of greenhouse gas emissions, mainly to supply energy for lighting, heating, cooling and transport. An additional challenge awaits urban areas: according to a recent WHO report[1], 92% of urban populations lack clean air to breathe. The cities of tomorrow must be configured to meet these two major challenges, climate change and worsening air quality.

FROM SUSTAINABLE DEVELOPMENT TO SUSTAINABLE CITIES

The growing awareness of our planet's ecological limitations in the early 1970s, with the publication of the Club of Rome's 1972 report entitled "The Limits to Growth", unleased the concept of sustainable development[2]. This concept subsequently led to the idea of sustainable cities, meaning a city or urban area that respects principles of sustainable development which, in addition to obvious challenges related to energy and the environment, is also concerned with its social, economic and cultural organization, for and with its inhabitants.

In 2007, Rudolf Giffinger, an expert in analytical research on urban and regional development at Vienna University of Technology, proposed six criteria to define a **Smart City**[3]: **Smart Economy**, **Smart Governance**, **Smart Mobility**, **Smart Environment**, **Smart Living** and **Smart People**.

In September 2015, the UN member states adopted the 2030 Agenda for Sustainable Development, which sets forth 17 sustainable development goals (SDG). Included among these 17 SDGs is **goal no. 11 "Sustainable cities and Communities"**[4].



Source : Adobe Stock

Fig. 1 – Smart City components

At the same time, the rise of information and communication technologies (ICT) supported the emergence of the "smart city" concept, whereby the strategic use of digital technology leads to optimized urban planning and management, with a goal of improving the quality of urban services, reducing costs and promoting the emergence of sustainable metropolitan areas (Fig. 1).

EUROPE AND URBAN DEVELOPMENT

Based on the Pact of Amsterdam[5], the **urban agenda for the European Union**[6], launched in May 2016 by the Commission, the Member States and cities, aims to strengthen cooperation among stakeholders to enhance growth, quality of life and innovation in European cities and to identify societal challenges. In the energy-environment field, key themes include the energy transition and energy consumption, air quality, urban mobility, adaptation to climate change, waste recycling, and sustainable use of soil and natural resources in cities, keeping in mind the omnipresent digital transition. Other issues related to sustainable cities remain applicable, including housing, employment and skills within the local economy.

In the field of energy, the **SET-PLAN (Strategic Energy Technology Plan)**[7] defines ten **ETIP (European Technology and Innovation Platforms)** including two related to the urban context:

- the European Innovation Partnership on Smart Cities and Communities;
- Smart Networks for Energy Transition.

Specifically with regard to Smart Cities, in June 2018, the SET-PLAN published a strategic document[8] to promote the development of **positive energy cities** in Europe by 2040, based on the development of a hundred positive energy blocks by 2025. The announced R&I budget is around €500 million for the 2018-2025 period.

The **Horizon 2020 framework program** addresses the various Smart City components through four societal challenges: energy, transport, environment, social sciences and the humanities. In the field of energy, the expansion of Positive Energy Districts is the subject of a specific appeal where projects, driven by urban entities, prepare plans for neighborhood development and technological integration (energy supply and storage, smart networks, energy efficient buildings, clean vehicles, waste management and recycling, management of digital data and ICT) at a demonstration scale.

The Joint Programming Initiative (JPI) Urban Europe was established in 2010 to address current urban challenges, with the goal of developing a European R&I hub. JPI Urban Europe currently has 13 members, including France.

FRANCE AND SUSTAINABLE CITIES

In France, the Directorate General for planning, housing and biodiversity within the Ministry for an Ecological and Inclusive Transition (MTES) prepares, manages and assesses policies related to urban planning, construction, housing, landscape, biodiversity, water and non-energy producing minerals. The Department of Housing, Urban Planning and Landscapes promotes sustainable planning for all types of areas, ensuring that planning documents and development activities meet the population’s needs and address sustainable development issues, specifically those related to housing.

The Directorate General for energy and climate within MTES organizes and promotes a number of initiatives related to Sustainable Cities[9]:

- the **Eco-District** approach;
- **EcoCities** and **cities of tomorrow**;
- the **Vivapolis** network;
- The **“Industrial Demonstrators for Sustainable Cities” (DIVD)** approach.

Part of both MTES and the Ministry for Territorial Cohesion (MCT), ***Plan urbanisme construction architecture*** **(PUCA)**[10] is an cross-ministerial agency established in 1998 to improve understanding of territories and cities, and to highlight public action. PUCA launches incentive research programs, action research and experimentation, and provides support to innovation and value creation in the fields of territorial land use, urban planning, housing, architecture and construction.

There are a wide range of initiatives, French and European programs and financial instruments to support urban development: from new concepts and technologies through their market launch, including the implementation of pilot and demonstration projects.

Starting from this premise, in coordination with MTES, MESRI[11] and MCT, the “Cities national enquiry point” (PIN)[12] was recently established in an effort to help coordinate the participation of French players in European programs on sustainable cities, in the areas of research and innovation (technology, economics, humanities and social sciences). Its operation is handled jointly by IFSSTAR and CSTB along with organizations and national networks of key players in research, businesses, local authorities, developers and urban planners, the ministries mentioned above, and the Commission General for Territorial Equality (CGET).

ENERGY TRANSITION FOR CITIES: NEED FOR INNOVATION

Energy and mobility

For the energy transition as applied to cities, the SET-PLAN has developed a roadmap setting forth a vision for Europe, based on results already achieved regarding positive energy buildings, and has developed an R&D phase followed by a demonstration at district level, intended to lead to widespread commercial deployment of new positive energy districts by 2030. The roadmap lists the technological innovations needed to achieve this goal: **high energy efficiency buildings, local renewable energies, heat and electricity storage, smart energy networks (with implementation of ICT), interaction/integration between transport and buildings** (Fig. 2).

The district concept is key to the development of sustainable cities, in the sense that it enables demonstration of technologies at a sufficient scale, as well as a collective optimization of systems and infrastructures, permitting construction of the sustainable city through replication. The district scale is also the most relevant for air quality and heat island issues, since residents directly perceive them at this level. However, transport policies must be considered on a wider scale. Before discussing these new districts, it is important to recall the current situation in cities, where a key obstacle to sustainability is the need to find solutions and funding in order to fundamentally modernize what currently exists. In OECD countries, approximately 75% of existing buildings will still be in use in 2050 [13].

Other developments arising from the SET-PLAN framework are also needed to achieve sustainable cities. These include smart, **carbon-free transport**, management of **greenhouse gas emissions** (carbon footprint) and **pollutants** (air and soil quality) as well as methods to reduce cities' environmental footprints (**waste management and recycling, circular economy**). The entire "energy-environment" value chain for sustainable cities is summarized in Figure 3.

With regard to the development of positive energy districts, the SET-PLAN identifies the need to integrate innovative solutions in order to:

- develop the potential of local renewable energies (photovoltaics, small wind turbines, wind turbines on brownfields and in industrial areas, biogas, Power-to-Gas with hydrogen and methane production, geothermal to produce heat);
- ensure maximum energy efficiency of buildings and districts: well-insulated buildings and windows, integrated photovoltaic and thermal solar systems (roofs, facades), use of smart meters;
- provide efficient and cost-effective solutions for storing heat and electricity for one day or one week, up to seasonal storage (such as storage of heat/cold in an aquifer);
- develop oversight and optimization solutions to manage intermittent renewable energy sources and optimize real-time management of several energy sectors, specifically electricity (and integration of electric vehicles), heat and gas (Smart Grid, Smart Gas Grid, Energy Management Systems, etc.);
- develop hybrid micro-networks, taking into account the possibility of integrating direct current networks;
- develop appropriate technological, administrative and commercial solutions designed to effectively integrate positive energy districts into the existing urban environment and the global energy system;
- industrialize processes to improve modularity, standardization and recycling technologies and products, in an effort to reduce costs and the environmental footprint.

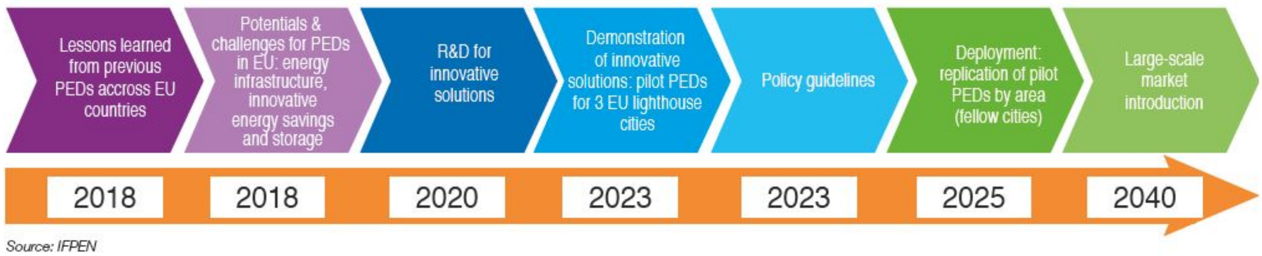
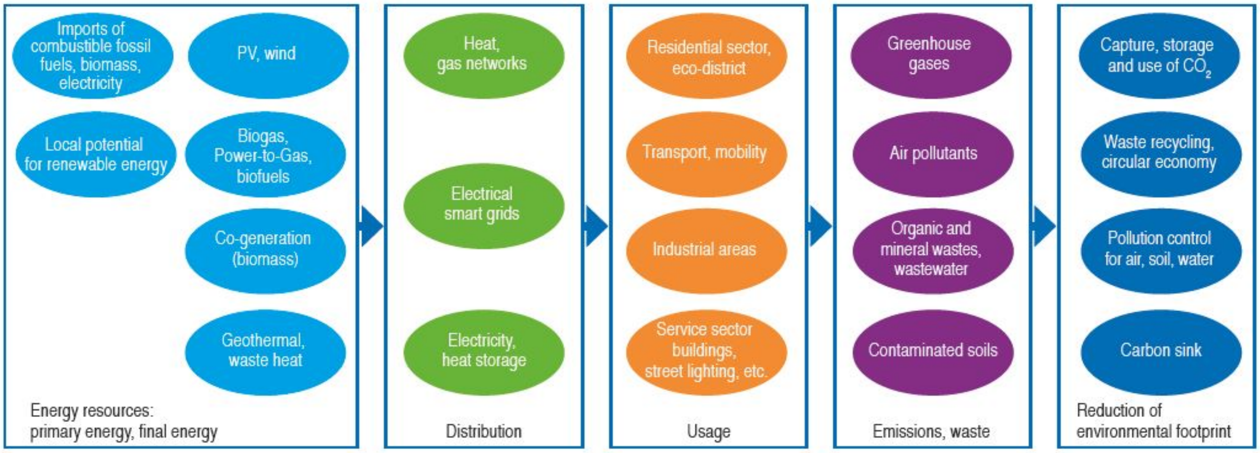


Fig. 2 – The key stages of the technological roadmap for deployment of positive energy districts (PED) in Europe (SET-PLAN 2018)



Source: IFPEN

Fig. 3 – Components of the Smart City "energy-environment" value chain

In 2014, the residential and service sectors (buildings and transport) in the 28 European Union member states respectively represented 26% and 18% of **greenhouse gas emissions**[14]. This issue is important for sustainable cities and significant actions need to be taken in these two specific areas.

With regard to transport, the goal is to reduce the climatic and environmental footprint of individual and collective transport systems. This not only involves improving the individual performance of various transport methods, but also means working at the collective organization level since sustainable cities must provide orderly transport methods. Organization of transport is the key to the equation: **multimodal**, **intermodal** and **interoperable**. These are the drivers of a new urban transport concept. Indeed, for more than a decade, the transport and mobility sector has experienced fundamental organizational change due to a two-fold revolution in technology (digitalization) and usage (new forms of transportation, autonomous vehicles, etc.)[15]. Vehicle electrification will have a two-fold impact, with a significant reduction in greenhouse gas emissions and, locally, a reduction in air pollutants. At the same time, tomorrow's cities will benefit from improved public transport technologies. During the energy transition, when combustion engines will still be in use, significant reductions in CO_2 emissions and air pollutants will be achieved through engine optimization including hybridization, and the use of new fuels such as VNG and advanced biofuels[16].

EMISSIONS, WASTE AND REDUCTION OF ENVIRONMENTAL FOOTPRINT

While urban areas generate 2/3 of the planet's greenhouse gas emissions, environmental pressures are strong in these areas, regarding air and soil quality as well as waste and wastewater management. A number of actions and innovations are needed to:

- expand the understanding, quantification and reduction of "secondary" air pollutants (such as ozone and certain fine particles) generated by primary pollutants;

- develop real-time pollution measurement and microclimatic models at the district or parcel level, using dedicated vehicles and drones;
- quantify indirect greenhouse gas emissions[17]: those generated outside the territory, but which are linked to activities taking place in the urban area - emissions related to electricity, heat and steam production, and the manufacture of inputs and waste treatment, as well as emissions linked to air travel by residents and all forms of travel by visitors;
- pinpoint contaminated urban brownfields (contaminated by hydrocarbons and/or heavy metals) then restore them;
- develop new waste collection and recycling methods, such as the **“urban mine”** (discarded household appliances containing strategic materials such as **rare earths** and base metals[18]), and **solid recovered fuels**[19] (dry fuels produced using non-hazardous waste combining wood, plastics, cardboard, etc. which may be used to produce energy).

Lastly, a significant reduction in the environmental footprint of urban areas can be achieved in the industrial sector by enhancing energy efficiency, increasing electrification of processes (when possible), pooling utilities and the circular economy, and using industrial waste heat deposits[20]. Though low in temperature (< 30 °C), wastewater can also be used to recover heat through the use of exchangers, which can help heat housing units. ENGIE estimates that the wastewater produced by 100 residents can provide heating for 10[21].

EXAMPLES OF SMART CITIES AND ECO-DISTRICTS

Singapore

A City-State recognized as one of the “smartest” and most connected cities in Asia, Singapore has a high population density, little space and few available resources. The government of Singapore was one of the first to adopt Smart City principles: a centralized government, with planning using **big data** and collaborative solutions to improve quality of life, the environment and promote economic development. Known as “Smart Nation” and launched in 2015, this program to transform Singapore encompasses five key areas:

- National Digital Identity, to enable citizens and companies to carry out practical and secure digital transactions;
- e-Payments, to enable everyone to make simple, fast, transparent and secure payments;
- Smart Nation Sensor Platform, to deploy sensors and other IoT (Internet of Things) devices to make the city safer and more livable; Smart Urban Mobility, to use digital technologies and data, including artificial intelligence and self-driving vehicles, to improve public transport;
- Moments of Life, to connect residents with government services through various agencies.

Beyond this highly technological vision, Singapore has identified the CleanTech Industry, including both energy-related and environmental aspects, as a key sector to be developed. It addresses all issues related to water resources, air quality, waste management and recycling, positive energy buildings and energy efficiency. Singapore also uses a broad mix of renewable resources – solar, wind, marine energies, fuel cells, biomass, biofuels – keeping in mind issues related to energy storage.

Amsterdam

The capital of the Netherlands (840,000 residents in 2016), Amsterdam has defined its energy strategy to 2040[22]): carbon-neutral municipal services as from 2015, 80 to 90% reduction in CO_2 emissions for the entire city by 2050, with a goal of 40% by 2025.
Several concrete actions have been implemented in this regard: climate-neutral buildings for all new construction, traffic restrictions, deployment of electric vehicles, expanded use of hydrogen for trucks, optimal use of wind and solar power and increased energy efficiency (especially for the port), development of smart grids and, lastly, the development of thermal networks to store heat and cold.

Although Amsterdam has positioned itself as a key player in the fight against global warming during the past several years, the city is also interested in sustainable economic development. In this regard, the Amsterdam Smart City platform[23] was launched in 2009 at the behest of the Amsterdam Economic Council and the electricity producer Liander. This initiative aims to launch pilot projects in the Amsterdam metropolitan area and create new partnerships among private companies, public institutions, research entities and residents.

France – IssyGrid, the first district smart grid in France

The IssyGrid project[24] was launched in 2012. This real-life laboratory aims to reduce the carbon footprint and optimize consumption, sharing resources among offices, housing units and retail stores. IssyGrid was created at the initiative of the City of Issy-les-Moulineaux (near Paris) and Bouygues Immobilier, with stakeholders encompassing all of the strategic and technical skills used to create a smart grid: Alstom, Bouygues Energies et Services, Bouygues Telecom, EDF, ERDF, Microsoft, Schneider Electric, Steria and Total. Today, IssyGrid is made up of 2,000 housing units, 5,000 residents, 160,000 m^2 of office space and 10,000 employees. Though still at the experimental stage, the project has enabled a smart grid to operate in its entirety.

France - Lyon Confluence Eco-District

A former abandoned industrial brownfield of 150 ha, the Confluence district in Lyon has undergone a deep overhaul during the past decade. Its new amenities, designed to address sustainable development requirements, make this a promising eco-district for the future[25]. The desire to transform the Confluence into a model **eco-district** is visible on many levels: **smart, carbon-free transport, positive energy buildings, wood-generated heat networks, reduced water consumption and a decline in the percentage of non-recycled waste.**

In addition, Confluence is the first sustainable neighborhood recognized by the WWF in France. We also note that Bouygues Immobilier aspires to launch a blockchain for smart grids in the district[26]. The project involves building a demonstration decentralized local network to oversee energy trading, where producers/consumers of solar energy can directly trade at the local level.

MOVING TOWARD NEW SERVICES

In addition to development of the necessary technological building blocks and their overall integration at the building, district and urban area levels, there is the question of new services to be offered, specifically for purposes of designing, planning and managing a Smart City. In a situation where each urban planning decision and each established policy has a major impact on the future of districts and cities, decision makers and urban planners must anticipate their impact, taking into account the uncertainties and complex interactions within the fields already discussed: production, distribution and consumption of energy, transport, housing, and air and soil quality. Without being exhaustive, some examples of services to be implemented include:

- decision-making support tools for urban planning, able to quantify all impacts of various strategies and scenarios over the short, medium and long term, and to optimize the system as a whole. Such decision-making support platforms are already in operation, combining physical and systemic models, optimization models and 3D modeling support[27];

- city management through the effective use of **new information and communication technologies (NICT)** – home automation, sensors and intelligent meters, digital media, information devices, etc.). Their expansion will allow better city management by gathering and analyzing key information (operation of renewable power generation facilities, real-time reporting from energy distribution networks, traffic monitoring, pollution level measurement, etc.);
- Energy Management Systems (EMS), across multiple levels: building, neighborhood, city. The EMS considers forecast data and technical parameters to more effectively manage the network components: production, storage and consumption. Associated with smart networks, the EMS enables optimal management of complex situations: the use of intermittent ENR with storage, self-use, electric vehicle charging, **vehicle-to-grid**, etc. Functionalities include monitoring, forecasts (specifically linked to the weather), production management and communication with the network operator;
- Urban geology encompasses a number of activities related to urban soil and sub-soil management, including geological modeling of the soil and sub-soil, characterization of water and geothermal resources (heat, sometimes electricity), management of geotechnical risk (cavities, fractures, etc.) and geochemical characterization of soils.

CONCLUSION

With an increasing share of the world's population, urban areas demand significant energy, materials, food and water, products, services and human capital. Their operation leads to negative impacts on a global scale, and the cities themselves also suffer from repercussions. Urban areas must change their methods of operation, with a two-fold goal of helping to achieve international goals to limit climate change, and preparing to adapt to climate change as it takes place.

Cities play an increasingly decisive role in actions to address climate and sustainability issues. Cities are naturally positioned to rise up and face the world's many energy and environmental challenges. Their human and intellectual capital, along with their economic and political power, will drive the expanded use of clean energy. The significant constraints they face make them hubs for technological and societal innovation, to accelerate transformation on a global scale. Energy and environmental issues are clearly key, to the extent that they drive (and limit) all aspects of urban development. Digitalization (sensors, Internet of Things, big data) will permit effective, optimal management of the entire urban system: as ADEME noted, "it is less about increasing the city's IQ than making it more effective across all areas[28].

However, cities and urban areas are not isolated systems; they constantly interact with the outside world, the territories or the regions where they are located. There can be no global or local efficiency without cooperation among the various regions, including agreements on energy transactions between high consumption areas and low production areas. This relationship can be ironically summed up by the saying "Smart City versus Stupid Country".

A number of challenges must be overcome to achieve a typical sustainable city. Until recently, the transformation of cities has been a slow process, but a radical transformation is now

needed. It must happen over the coming decades, but on a citywide scale it will unavoidably lead to widespread disruption, which must be managed.

According to a study by Grand View Research, the smart cities market will reach $1,400 billion by 2020. This is a tremendous opportunity, provided that funds are used to address true urban challenges (pollution, climate resilience, transport, government, etc.) without excluding the local production of renewable energy.

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