European Green Capital Award – Frankfurt am Main's application **Environmental indicator 12 Energy performance**	
Question 1 (max. 1,000 words)	Present details of the original and/or most recent Action Plan, including any relevant disadvantages or constraints resulting from historical and/or geographical factors which may have influenced this indicator area negatively. Make reference to: 1. Energy consumption and the performance of municipal buildings per square metre; 2. The development and goals for a renewable energy share of all energy (heat and electricity); 3. The strategy of renewable vs non-renewable mix as well as the renewable energy mix (different renewable energy sources) dynamics for the coming two decades; 4. Integration and performance of renewable energy technology in municipal buildings and homes; 3. Development of compatible and integrated district systems and the facilitation of more sophisticated city-wide control.
	Frankfurt – Energy Efficiency City Frankfurt's energy efficiency policy emphasises energy saving (especially in buildings), highly efficient energy production and increasing the share of renewable energies. Through the city's power supply company Mainova AG, Frankfurt has been able to carry out model projects and promotional programmes for renewable energies from an early date. Frankfurt's housing association (ABG FRANKFURT HOLDING GmbH) owns a comparatively high proportion of homes in the city. This is both a challenge and springboard since residential buildings have a particularly high savings potential. **Approaches and plans** Frankfurt resolved to **construct low-energy buildings** and extend electricity cogeneration as long ago as in 1991. The city's "**Guidelines for cost-efficient construction**" (2005, revised annually) are among Europe's most demanding and detailed municipal building and procurement rules. New buildings must be constructed according to passive house standards and passive house components must be included in refurbishment work. **Link** With its **Energy and Climate Protection Concept** (2008), Frankfurt aims to reduce CO_2 emissions by more than 40% by 2025 (see "Local contribution to global climate change"). **Link** In 1992 the City Council adopted a policy of cooperating with banks and investment companies through its **"Energy Forum Banks and Offices"** initiative. Since then, many projects for energy-efficient offices and low-energy high-rises have been completed. The city's "**High-rise framework plan**" (2008) requires new high-rise buildings to demonstrate primary energy needs of below 150 kWh/m²a, with at least 50% coming from renewables.

1. Municipal energy management in urban buildings

In 2010 energy consumption in municipal buildings was 105 kWh/m²a for heating and 34 kWh/m²a for electricity.

A **municipal energy management** system was introduced in 1987 with the aim of gradually lowering energy and water consumption in the 2,500 municipal buildings in as efficient a manner as possible.

All new buildings and refurbishments in the city must comply with the "Guidelines for cost-efficient construction" (see above).

Energy consumption values and costs for all municipal properties over the past few years and the quarter-hourly load profiles for more than 1,000 meters are published online.

Link

Municipal housing

In 2005 ABG decided that all new buildings would be consistently constructed as passive houses (heating energy need < 15 h/m^{2}a). The company substantially pioneered the launch of passive house technology in multi-storey homes. Frankfurt now holds the European record for buildings constructed to passive house standards.

2. Renewables: use, production and expansion prospects

Germany's allocation mechanism (Renewable Energy Act) means that all electricity users have the same share of power from renewables – around 20% in 2011. Nationwide figures are approximately 10% for heating sector and 6% in for fuel. In total, renewables account for 10% in Germany.

For Frankfurt, a distinction needs to be made between the share of renewables used in the city and the share generated in the city area.

Figure 1: Use, share of renewable energies in Frankfurt (2011)

Share of total final energy consumption	7%
Share of total energy consumption (Germany's allocation mechanism)	20%
Share of total heat supply	4%
Share of total primary energy consumption	5%

Figure 2: Electricity generation from renewable energies in Frankfurt's city districts (2011)

Waste incineration, biogenic share	100 GWh
Bioenergy plants	103 GWh
Photovoltaics (12 MW)	10 GWh
Hydropower	25 GWh
Total renewable electricity generated in Frankfurt	238 GWh

In line with Federal requirements, the aim is for renewables to provide approximately 40% of the electricity needed by 2020. Some 25% is produced in the city of Frankfurt and 75% regionally or supraregionally.

Figure 3: Electricity generated from renewable energies in Frankfurt's city districts (outlook for 2020)

Waste incineration, biogenic share	100 GWh
Bioenergy plants	103 GWh
Other biomass plants	140 GWh
Photovoltaics (50 MW)	50 GWh
Hydropower	25 GWh
Wind energy	20 GWh
Geothermal energy	10 GWh
Total renewable electricity generated in Frankfurt	approx 450 GWh

3. Renewable energy mix

Investment in efficient and renewable power generation: Mainova AG plans to invest up to €500 million by 2015 in

- wind farms in Frankfurt, the region and supraregionally,
- a stake in a highly efficient gas and steam power plant (combined cycled), and
- expanding district heating and constructing a biomass heat plant with CHP.

This will lead to a significant annual reduction of 550,000 tonnes in CO_2 emissions (approximately 10% of all energy-related CO_2 emissions in Frankfurt).

By 2015 the share of carbon-neutral electricity generation is to increase to 20% and the share of electricity generated from renewables to 15%. The aim is for 100% of power to be generated by the city's own plants and no longer by nuclear and large coal-fired power plants.

The share of cogenerated electricity (> 25%) and heat in the district heating network (just under 90%) is to be maintained.

4. Renewable energies in municipal buildings

The "Guidelines for cost-efficient construction" stipulate that when new municipal buildings are constructed and roofs renovated, consideration should always be given to the possibility of installing solar power systems.
If no municipal system is installed, the roof area must be made available to investors at no extra cost.

Heat is to be provided from regenerative energy sources or cogeneration. Renewables such as solar power or geothermal probes should be used for active cooling purposes.

	5. District systems **Combined heat and power (CHP)** CHP is a vital part of the city's energy planning. Frankfurt has three major CHP-based district heating networks (coal, natural gas, waste). The waste-fuelled power plant in Frankfurt's Nordweststadt district has been extensively modernised and its capacity extended to four waste lines, each with a thermal output of 63 MW and an annual waste incineration capacity of 525,000 tonnes. Mainova's three major production plants have been graded "highly efficient". Compared with separate power and heat generation, they save between 18.3% and 21.6% of primary energy. District heating has a very good primary energy factor of 0.54 (normal heating: approximately 1.1-1.3). It easily satisfies statutory heating market criteria (Renewable Energy Heat Act and Energy Saving Ordinance). A systematic search for sites and investor consulting resulted in 186 decentralised CHP plants (5 kWel - 10,000 kWel). In some cases, plant design was linked to urban development planning. Connection to 2 of the 15 district heating networks is compulsory, thus ensuring that all buildings are connected. CHP is increasingly linked to the use of bio-energy. Four CHP plants use energy from biomass - old wood (10 MWel), domestic biowaste (500 kWel), industrial biowaste (4 MWel) or sewage sludge (4 MWel). **Virtual power plant** In 2011 ABGnova GmbH, a subsidiary of ABG and Mainova AG, launched a project in which three home-based power plants with a central control system are turned into a "virtual power plant". **Electronic electric meters** Mainova AG offers private customers a "smart meter" so that they can monitor their power consumption online (PC, smartphone) and make greater use of lower-tariff periods.
Question 2 (max. 800 words)	Details of targets achieved or not to date (within the last 5-10 years). Provide a review of how both situations occurred and lessons learned. Make reference to: 1. Increasing the energy performance of municipal buildings; 2. Maximising and prioritising the use of renewable energy technology in municipal buildings and homes; 3. Measures to improve the city's overall energy demand performance.
	European passive house capital Over 1,500 apartments and over 150,000 m² of passive houses have been built in Frankfurt (including schools, day nurseries and sports halls). The first office building to use passive house technology was completed in 2011. Its power comes from renewables only (wood pellets, photovoltaic equipment). Municipal buildings and new property built by the municipal housing companies have fulfilled the European EPBD criteria since 2010.

Anyone purchasing municipal plots of land is obliged to build passive houses.

New ABG property is built entirely in accordance with passive house standards (1,000 homes already built; 1,500 under construction or planned).

Over ⅔ of ABG's 50,000 residential units have been thermally insulated. Two 1950s buildings have been upgraded to passive house standards; one older building has been turned into an "energy-plus building" with solar thermal systems and a vegetable oil heating plant.

Apart from solar heat and power plants, heat pumps, district heating power plants fuelled by rapeseed oil and biomethane and wood pellets are used.

For some ABG apartments, rents include heating as so little heat is needed that it is unnecessary to impose charges based on use.

ABG saves around 23 million litres of heating oil annually through thermal insulation and passive house construction, i.e. around 52,000 tonnes of CO_2.

1. Municipal buildings

Despite increased use of technical equipment and IT, **municipal energy management** has cut power consumption by 4.4%, heating energy consumption by 28%, water consumption by 13% and CO_2 emissions by 22% since 2000.

In 2010 the ratio of energy management costs (approximately €4.6 million) to savings (€15.8 million) was 1:3. €91.4 million has been generated since 1990.

Figure 4: Energy and water consumption in city-owned properties

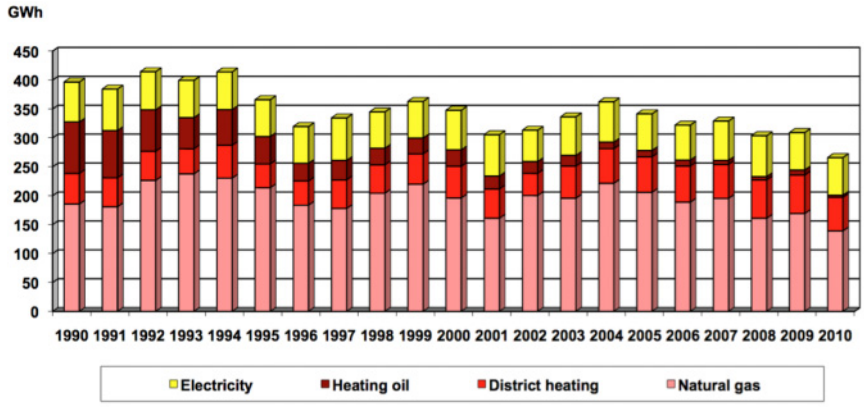

Figure 5: Development of specific heating energy and electricity consumption in city-owned buildings in Frankfurt

Heating energy

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Unit
145.8	122.2	135.2	140.7	152.8	145.3	136.6	136.3	121.7	127.6	104.9	kWh/m²a

Electricity

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Unit
35.7	37.4	28.3	34.9	36.4	33.1	31.6	35.5	36.9	33.8	34.0	kWh/m²a

	Specific heat energy consumption fell from 146 kWh/m²a (2000) to105 kWh/m²a (2010), a saving of 28% over 10 years (2.8 % per annum). Despite greater use of electrical equipment, specific electricity consumption fell from 35.7 kWh/m²a (2000) to 34 kWh/m²a (2010), a saving of 5% over 10 years (0.5 % per annum). **2.** **Photovoltaics** Frankfurt has 700 solar power plants with 12,000 kW peak power output. Several plants have been established with public participation. **Heating** Eight solar collectors (total surface: 119 m²) operate in municipal properties and two solar absorbers heat the water in open-air swimming pools (2,012 m²). Two wood chip and ten wood pellet boilers with a total thermal capacity of 2,063 kW and two geothermal plants (heat capacity: 800 kW, cooling capacity 600 kW) are also in operation. **Electricity** The city owns 27 photovoltaic plants on its properties, with an actual or planned total 218 kW peak output. There are also 33 plants funded from external sources with a total 3,300 kW peak output. Since 2008, 50% of the city's remaining electricity needs have been met from renewable sources, with the rest generated by CHP. **Link** **3.** **Ecology and the economy** ÖKOPROFIT, a joint project of Frankfurt am Main and regional enterprises, demonstrates the compatibility of environmental responsibility and the pursuit of profit. The aims are to protect natural resources, to reduce emissions and waste, and to cut operating costs by using energy and raw materials more efficiently. Since 2008, 32 Frankfurt-based companies have participated in ÖKOPROFIT, saving nearly €820,000 and 3,200 tonnes of CO_2. **Industry** CHP has considerably reduced CO_2 emissions in the Höchst Industrial Park. The gas turbine power plant run by the operating company Infraserv Höchst produces approximately 320,000 MWh/a of power. The waste heat (520,000 MWh/a) is used to generate steam. Thanks to the energy mix, specific CO_2 emissions of companies relocating there are 20% lower than at sites that buy electricity in from external sources. Since 2011 Infranova Bioerdgas GmbH has used sewage sludge and organic waste to produce raw biogas and upgrades it to natural gas quality; around 80,000 MWh/a are fed into the public gas network.

	Energy efficiency in non-municipal buildings Since 1995, several of the most energy-efficient office buildings in the world have been built in Frankfurt. In the **Commerzbank** high-rise**,** energy consumption has been cut by more than 30% compared with initial plans thanks to windows that open, natural air-cooling, adjustable and efficient lighting and absorption cooling from district heat. The **Helvetia building** is Frankfurt's first low-energy office building with concrete core temperature control and triple-glazing. **KfW's** East Arcade is the first low-energy office building without active cooling and won the "Green Building" architectural award. The main building and the West Arcade (2010) have achieved even better standards (< 120kWh/m²a primary energy consumption). **Link** Upgrading the twin **Deutsche Bank towers** cut energy consumption by 55%, CO_2 emissions by 89% and water consumption by 75%. The "green towers" are connected to Mainova's district heating network and are LEED certified (platinum). In Frankfurt, the average **heating energy requirement in residential buildings** has dropped from 170 kWh/m²a (2000) to 145 kWh/m²a (2010) (source: Techem, energy performance indicators 2010).
Question 3 (max. 800 words)	Plans to meet or revise key targets for the future and the proposed approach to achieve these.
	Climate road map In 2011, Frankfurt set itself the target of converting the power supply to renewables by 2050. This climate road map is to be prepared with the support of scientific experts and public participation in the period from 2012 to 2014. Frankfurt sees the following concept as potentially successful: • 35% of today's needs will be cut (energy-saving measures, greater efficiency), • 20% of today's needs will be met by renewables from within the city area, • 45% of today's needs will be met by renewables from within the region and beyond. **Extending the passive house strategy** ABG will be extending its passive house strategy - with three aims: • To develop the cost reduction potential in refurbishment and passive house construction for comparatively low rents and social acceptability • To further develop passive house technology in multi-storey homes • Knowledge transfer of passive house expertise for other housing developers, building contractors, planners, architects and municipalities Over the next four years, ABG will be investing an annual €250 million in new building and refurbishment.

	More than 90 new city-owned buildings are being planned or are already being built as passive houses. Refurbishment will include passive house components. The use of passive house standards and local energy generation in redeveloping the former university site in the Bockenheim district as a "culture campus" will make it a zero emission zone. The Höchst district will be the site of the world's first "passive house" hospital. A passive house high-rise is being planned for the Gateway Gardens construction area near the airport. The redevelopment of Frankfurt's historical centre close to the cathedral will be of international significance. Passive house standards are to be used as far as possible. Town twinning arrangements (e.g. Guangchou, Yokohama, Arab countries, Barcelona) are also useful for disseminating knowledge of energy-efficient buildings, particularly high-rises. **Energy-plus construction** The city authorities will be investigating the cost-effectiveness of the energy-plus construction method in three model projects. Over the year, these buildings produce more energy than they consume. **Refurbishment of existing buildings** Existing buildings offer the greatest saving potential. It is already standard practice to use passive house components when renovating buildings that are less architecturally significant. There are also plans to increase the energy efficiency of listed buildings and those of great architectural value. The Energy Agency has issued well-received **"Guidelines for the energy-saving renovation of Gründerzeit buildings"**. High-profile projects are intended to demonstrate the compatibility of reducing heating needs by 50% and preserving historical monuments, e.g. through interior insulation, small-paned windows and controlled ventilation with heat recovery. The 1970s Heinrich Lübke estate is to serve as a model for **large social housing estates**. Since December 2010, ABG, in cooperation with the University of Vienna and the Fraunhofer Gesellschaft, has been modernising it to increase energy efficiency. The residents are very closely involved in the planning process and special importance is attached to sustainability from the social, construction and ecological points of view. A new district centre is being built to encourage residents to shop locally. A building comprising offices, 40 apartments built to passive house standards and ground-floor shops is to be constructed on the site of the present shopping centre. Frankfurt has submitted the Heinrich Lübke estate refurbishment as its application for the Eurocities Award. This project was Frankfurt's first nomination – in the participation category.

Green IT lighthouse project

DE-CIX, one of the most important internet exchanges in the world, is based in Frankfurt, which today ranks second in Europe for data centre density. Internet exchanges with high electricity consumption and the associated CO_2 emissions present a challenge for green IT.

The city authorities' IT components alone emit approximately 9,000 tonnes of CO_2 per annum, at an annual cost of €2.4 million.

"Green IT" is intended to halve municipal IT electricity consumption and CO_2 emissions within five years.

The EU Services Directive will be implemented concurrently. Most services will be easily accessible electronically, grouped together via integrated service hubs ("single point-of-contact") and made available in a legally dependable manner.

Planned measures:

- Consolidating all server capacities in a new computer centre in the Department for Information and Communication Technology
- Procuring only highly efficient, high temperature resistant hardware components
- As far as possible, natural cooling of network and server components
- Strictly user-dependent business management by activating all energy-saving options, scheduled client shutdown and switch-off of all peripherals
- Shutdown of server capacities no longer required owing to consolidation

Thirty computer centres of various sizes can be closed.

The plan is for service-oriented architecture to establish an administrative contact point for all enquiries and applications.

IT infrastructure consumption values have been precisely recorded (14,200 MWh/a). Additional load profile meters should improve precision, enabling real-time monitoring of the results.

Figure 6: Electricity load at the computer centre

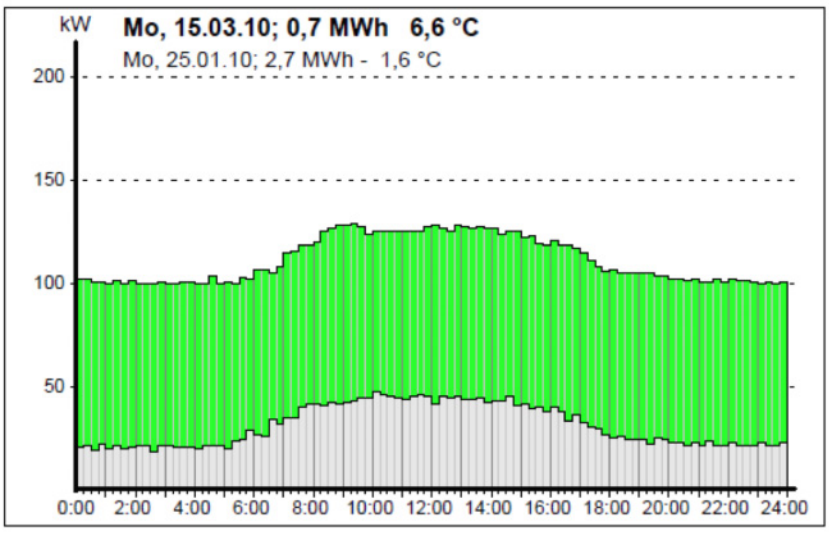

	Figure 7: Thermal image of server use in the new computer centre