# Optional Sectoral Module
# ENERGY

In a resilient city, the energy system offers a secure supply of power that ensures the continuity of services in the event of disruptions (*robust*). It has spare capacity to provide power to the city under any circumstances, especially to ensure continuity to the functioning of critical infrastructure like hospitals and government buildings (*redundant*). The planning for and design of energy infrastructure is informed by an integrated risk assessment taking major shocks and stresses into consideration (*reflectiveness*). A resilient energy system provides access to electricity to all societal groups, and embraces both centralized and decentralized approaches as appropriate (*inclusive and redundant*). Management of the energy system, including decisions regarding distribution and pricing, is inclusive of local departments and stakeholders (*coordinated and inclusive*).

| TOPIC | GUIDING QUESTION | APPLICABLE RESILIENCE QUALITY | RELARIONSHIP TO RESILIENCE QUALITY |
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| Institutional Capacity | Who manages the city's energy planning? What is the city's degree of influence/control over power utilities? Do power utilities have collaboration channels in place for emergency situation (e.g., agreement on sharing excess demand, etc.)? | Coordinated | Close coordination among utilities and between utilities and the city can improve planning and accelerate response in case of disruption. Ability to exercise influence/control over power utilities helps the city ensure continuous supply to critical systems. |
| Institutional Capacity | Does the city have updated data on energy consumption across sectors? | Reflective | Maintaining an overview of energy consumption across sectors allows the city to manage health and environmental impacts of energy use. |

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| Regulatory Framework | Is there a regulatory framework in place to reduce risks in the energy system, and potential cascading impacts (e.g., loss of economic productivity, disruption of critical services such as hospitals, etc.) | Robust | A regulatory framework for the city's energy system can be used to mitigate climate, and other risks, by making sure these are integrated into infrastructure updates and new design requirements. To better manage risks to the city's energy system, regulations can require diversification of energy generation and supply, as well as establishment of back-up generating systems for critical services. |
| Finance | What are the funding sources for the energy system and is the supply of energy financially sustainable (i.e., does it achieve cost recovery)? | Robust | A financially healthy energy sector with diverse and reliable sources of funding helps to ensure continuity in service provision. Cost recovery in the power sector implies a sustainable management, where revenues from electricity sales recover operational expenses at the very minimum. |
| Finance | Is contingency financing available for energy supply infrastructure and service delivery? | Redundant | A contingency fund covers unexpected damages to energy infrastructure/facilities, accommodates sudden demand increase and/or changes in energy prices. |
| Planning | Do building and zoning codes prevent the siting of critical energy infrastructure in hazard exposed areas? Are the building and zoning codes enforced? Are new developments obliged to integrate power supply in their design? | Robust | Enforced zoning codes help prevent siting of critical infrastructure in exposed areas, thus avoiding service disruption in the event of a disaster. New developments should consider the conditions of the area's energy supply to avoid overload, incorporate power supply as part of the design, and smart technologies for reducing consumption. |

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| Planning | How has the city's energy infrastructure and equipment been impacted by past disasters? Has this experience informed design and siting of new infrastructure and equipment? | Reflective | Past experiences can help cities understand vulnerabilities and strong points in their energy system, as well as the effects that specific events can have on the city's energy system. |
| Planning | Have previous disruptions informed improvements in technology and substantial changes in the energy system (e.g. flood-proofing of substations, undergrounding critical overhead lines, replacement of wood poles with steel, equipping grids with smart grid capabilities, etc.)? | Reflective | Technologies that promote equipment robustness can be used to prevent disruptions during disaster events. Knowledge about system vulnerabilities can be used to make improvements to avoid repeating previous failures. |
| Planning | Does the city have contingency plans for major failures within the energy sector? | Robust | Contingency plans help utilities and the city prepare equipment and procedures for when disasters occur, which helps accelerate the response and minimize the impact. |
| Access | Is there a mismatch between energy demand and energy supply? How much excess capacity is there in the city's energy supply? | Redundant | Excess capacity can prove useful when a portion of the energy system is impacted by a hazard, but could also represent inefficiencies in the energy system. Regular monitoring of energy consumption can reduce these inefficiencies while making sure the energy system can provide continuous services during disaster events. |

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| Access | Do all areas of the city and all socio-economic segments of the population have 24-hour access to electricity? Are there areas in the city that are more vulnerable than others to power blackouts? | Inclusive | Lack of electricity can have adverse impacts on other sectors (health, manufacture, etc.). Efforts should focus on providing predictable electricity access to all populations in the city, as well as prioritizing critical infrastructure, such as hospitals, public-transportation, etc. |
| Generation | Is the city's energy supply diversified in terms of type (e.g., coal, solar, hydro) and source (private, public, imported)? How are different system types distributed across the city? Who is the main provider? Does the city have control over main energy sources? Are there rules and incentives in place to encourage distributed generation? | Redundant | An energy sector with diverse technology and sources is better equipped to address disruptions in energy supply. Reliable and distributed energy supply has a better chance of providing sustained, uninterrupted electricity if a localized disaster occurs. |
| Generation | Is the city's energy supply vulnerable to price shocks and political instability? What percentage of the city's energy supply is dependent on foreign fuels? | Robust | Economic and political changes can impact fuel supply and therefore electricity generation. This includes changes within the country or at an international level, especially if the city heavily relies on foreign fuel imports. |
| Generation | Could climate change or known natural hazards affect the balance of different types of energy generation assets? In what way and where? | Robust | Calculating the potential impacts of future weather events allows the city to prepare and avoid over-reliance on energy generation assets vulnerable to climate change, such as hydropower. |

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| Generation | Do businesses, industries, residences, and key energy consumers (e.g. hospitals, fire stations, shelters, etc.) have back-up energy generator capacity with fuel/battery storage in the event of a power outage? What is the proportion of commercial / residential / institutional buildings served by own energy generation? | Redundant | Own energy generation or back up generation can be critical for facilities that rely on electricity to deliver basic services. Minimum levels of services need to be maintained in case of power outages. This serves as additional capacity for the energy system. |
| Demand | Will the anticipated effects of climate change have a significant impact on local energy demand (e.g. increased demand for heating/cooling)? Have future demand changes been incorporated into energy system design? | Reflective | Ability to assess the impacts of climate change on energy demand allows the city to adapt the design of its energy system, including use of new infrastructure, sources and technologies, to best accommodate future demand. |
| Demand | Does the city promote energy reduction among industrial, commercial, or residential consumers by means of education, community training and awareness raising campaigns? Has the city made any efforts to increase energy efficiency in public buildings? | Reflective | Successful energy reduction programs can lessen the pressure on limited energy sources, something that is particularly important in face of increasing number of energy consumers. Energy retrofitting of public infrastructure and buildings is an opportunity for cities to increase durability and resiliency of its assets. |
| Demand | Do utilities have authority and capacity for demand side management (e.g. load shedding, financial incentives, etc.)? | Robust | Demand side management can help reduce demand during peak hours and reduce the need for investments in networks and/or power plants for meeting peak demands. |

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| Vulnerability | What proportion of electrical assets is exposed to hazards? To what degree of hazard intensity can the electricity provision in the city remain functional? What proportion of electrical energy user accounts is exposed to hazards? [Lens 3 – CRF 7] | Robust | In case of prolonged events, it is useful to know the total capacity of facilities that can continue to function, as well as the coverage that can be achieved with these. To increase reliability of electricity supply, exposure of electrical user accounts should be minimized. |
| Safety | Does the city provide electrical safety recommendations to it citizens, both regarding risky household wiring and illegal connection to distribution networks? | Robust | Making citizens aware of electrical safety procedures is important for ensuring their well-being and maintaining undisturbed distribution channels. |
| Distribution | Could climate change or known natural hazards affect the performance of energy distribution networks (e.g. robustness of power-lines)? In what way and where? | Robust | If the effects of repeated weather events can be predicted, the city can improve the design of distribution systems to better withstand their impacts. |
| Distribution | Is the design of the power distribution network compartmentalized enough to deal with faults on the line? Can the utilities isolate critical parts of the network and keep these running despite failure in other parts of the network? | Robust | A compartmentalized network helps ensure continuous supply despite failure in one part of the network. Compartmentalization also provides more time for response. |
| Transmission & Distribution: | Does the city know its total transmission and distribution losses and the reasons for these (e.g. inefficiency, theft and pilferage, etc.)? Are there any efforts/strategies for limiting losses from the transmission and distribution systems? | Reflective | Transmission and distribution losses are unavoidable, but keeping them to a minimum can have considerable effects on demand and costs. Transmission and distribution losses create demand for excess capacity that would otherwise not be needed. |

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| Distribution (natural gas) | Is the city's gas distribution done through piping or by using gas trucks to deliver tanks/ charge stationary tanks? What proportion of gas user accounts is currently exposed to hazards? To what degree of hazard intensity can the gas provision in the city remain functional? | Robust | Since gas itself can be a hazard, knowledge about a city's gas distribution helps identify vulnerabilities. It is useful to identify the degree of hazard events that can disrupt gas supply and how many people such a disturbance will affect. |
| Distribution (fuel) | What proportion of major fuel distribution stations in the city are exposed to hazards? To what degree of hazard intensity can the major fuel distribution stations in the city remain functional? | Robust | Evaluating the level of stations' exposure helps assess fuel accessibility during disaster events. In case of prolonged events, it is useful to know which fuel distribution facilities can continue to function, as well as the coverage that can be achieved with these. Lack of fuel can have cascading impacts on functions which depend on fuel for mobility (e.g., ambulances, fire trucks etc.) |
| Distribution (fuel) | Does the city have its own network of gas station and mobile fueling trucks to bypass the retail liquid fuels market in case of supply chain breakdown? | Redundant | Sustained fuel availability is required for mobilizing aid and providing basic transportation options. |