IEAC
International Energy Advisory Council

ENERGY EFFICIENCY MASTER PLAN BRIEFING

BACKGROUND

History

Master planning has traditionally been linked to architects and planners focusing on the city and the built environment but it has also been used by public health officials and social workers with often conflicting ideas of how a city should look and function. Architects and planners were concerned with aesthetics and the built environment whereas public health professionals were concerned with infrastructure and the connection between certain diseases and social conditions and the impact of the industrial revolution. Historically, they did not know precisely what the connection was but they did know how a water system should work, or where the sewage should go, or how to get waste out of a city, or how to remove pollution from fossil fuel burning, was the most effective way to stop diseases spreading and reduce illness.

The first example of master planning was the aftermath of the Great Fire of London 1666. Overall 80% of the city was lost providing a major opportunity to redesign the lost parts of the city. One such master plan was penned by Sir Christopher Wren who proposed an ambitious vision of neat blocks in a grid system and wide boulevards that would rival those of Paris. Whilst not all of the plan was implemented it did influence the design of London and other cities such as Philadelphia and the American grid system model. The plan also led to King Charles II introducing a Rebuilding Act and Building Regulations Order in 1667, the forerunner of the Building Regulations regime that we know today. Development control measures have clearly moved on since this time, not least through the introduction of town planning in the 19th century, but it is worth noting how powerful master planning can be and how it revolutionised the rebuilding of London following the Great Fire.

Master Planning Today

Whilst historic cities are often set out as examples of master planning, current master planning is a relatively recent development and faces a number of different challenges to historic master planning as cities are changing at a faster rate than ever before with rapidly increasing populations and the demands of infrastructure and energy use much of which is currently unsustainable.

There are two key types of master plan:

- A Strategic Master Plan: This may be used for a country, region, state, province or group of cities.
- A Project Master Plan: this tends to be focused on a specific site or city with definable boundaries.

More recently, master planning has been used for green infrastructure, including decentralised energy, renewable energy and energy efficiency master planning.

Utility Energy Planning

Conventional utility energy planning is the process of developing long-range policies to help guide the future of a local, statewide, national, regional or even the global energy system. Utility energy planning is often conducted by governmental organisations, large energy companies such as electric utilities or oil and gas producers. Utility energy planning is not a master plan but a plan that reflects the business interests and business models of the incumbent large energy companies and pays little or no regard to energy efficiency and the energy systems that are being implemented today by others, in particular by consumers, or the energy efficiency and energy systems that will be needed to mitigate and to adapt to climate change or the sustainable energy systems that will be needed in the future.

Current utility energy planning is based around large centralized fossil fuel/nuclear energy base load power plants with gas peaking power plants delivering electricity to consumers via large centralized transmission and distribution grids.

However, the energy systems are changing with advanced energy efficiency measures and the ever-increasing forms of distributed or decentralized energy generation, particularly renewable energy, displacing remotely generated electrons with reduced energy demands brought about by energy efficiency measures and locally generated electrons. Such energy efficiency and decentralized energy systems require a completely different and new form of energy planning, particularly for cities, than conventional utility energy planning. This new form of energy planning comprises energy efficiency and decentralized energy master planning.

100% RENEWABLE ENERGY CITIES

Cities are different to suburban or rural areas and the measures and actions necessary to transform cities into low or zero carbon cities are, therefore different to those measures or actions that may be applied to suburban or rural areas. For example, cities may have a large number of roofs for solar energy but they are at the top of tall buildings with high energy consumption, particularly air conditioning, and the roof areas represent only a relatively small part of the total energy consuming floor areas.

Cities also have high heating and cooling demands as well as night time energy demands such as leisure/entertainment buildings and street lighting. In this environment, electricity storage batteries may be useful for time of day shifting of electricity generation or for individual building electricity generation/consumption but will not improve the overall situation for the city since the scale of conventional renewable electricity generation in the city is finite, the electricity generated would be immediately consumed and not able to supply the balance of daytime electricity demands let alone night time electricity demands or for transport.

However, it is possible for 100% of a city’s electricity, heating and cooling demands to be met by a combination of enhanced energy efficiency measures and local renewable energy resources: Energy efficiency to significantly reduce energy demands and decentralized energy to supply a reduced energy footprint. Together, these will provide a more economic 100% renewable energy system than trying to meet the high energy demands of an energy inefficient city from remote generation.

100% renewable energy has become a worldwide phenomenon. Go 100% Renewable Energy[1] is a Californian initiative that has mapped so far that 59 countries, 72 cities, 63 regions/states, 9 utilities and 21 non-profit/educational/public institutions, totalling more than 1.8 billion people have adopted or committed to shifting within the next few decades to 100% renewable energy.

NET-ZERO ENERGY OR NET-POSITIVE ENERGY BUILDINGS

The combination of advanced energy efficiency measures and decentralized renewable energy technologies provide the opportunity for net-zero and net-positive energy buildings:

- A net-zero energy building produces the same amount of energy that it consumes.
- A net-positive energy building produces more energy than it consumes. Such buildings may sometimes consume energy from the grid but the energy that the building generates and exports to the grid must equal or exceed grid consumption.

A net-zero energy building can be off grid or connected to the grid but a net-positive energy building needs to be connected to the grid or to a private wire, local decentralized or community owned energy network to enable the import and export of energy. Both net-zero and net-positive energy buildings should be capable of operating in island generation mode in the event of a failure in the grid. This can be achieved by local generation, energy storage and/or load shedding.

In any Energy Efficiency or Decentralized Energy Master Plan, net-zero and net-positive energy buildings should form a key part of the city's energy policies and programs to enable self-sufficiency and to mitigate and adapt to climate change.

New buildings provide the ultimate opportunity for net-zero and net-positive energy buildings through a combination of passive energy efficiency design, energy efficiency measures, decentralized renewable energy technologies and energy storage but existing buildings can also be retrofitted with most of these measures, particularly at times of major refurbishment and renewals. These measures can be effectively incorporated in new and existing buildings by the use of mandated city planning and building regulatory policies and controls.

ENERGY EFFICIENCY MASTER PLANNING FOR CITIES

Decentralized energy master planning is covered by a separate Decentralized Energy Master Plan Briefing whilst energy efficiency master planning is covered by this Energy Efficiency Master Plan Briefing.

This Master Plan Briefing is based on a Project Master Plan for a city with definable boundaries. A Strategic Master Plan for a country, region, state, province or group of cities will be similar but based on a much wider area.

[1] Go 100% Renewable Energy

Spatial Energy Demands

As a first step a city will need to establish the city's Local Government Area (LGA) electricity, gas and thermal energy demands. Ideally, this should be based on the city's land use and floor data reconciled against metered electricity and gas consumption data provided by local electricity and gas network operator(s). This will enable the spatial diagnostics of the city's electricity, gas and thermal energy demands to be identified.

The layer of information should provide the following results:

Layer A:	Land Use and Floor Space
Layer B:	Utility Electricity and Gas Consumption Data
Layer C:	Building by Building Electricity Consumption
Layer D:	Building by Building Gas Consumption
Layer E:	Building by Building Thermal Energy Demands (Heating, Hot Water Services and Cooling)
Layer F:	Land Use, Energy and Greenhouse Gas Emission Analysis

The data from this analysis should be used to identify the electricity, gas and thermal energy consumption and greenhouse gas emissions impact over five scenarios - baseline efficiency levels, existing policies and programs, new policies and programs, cost-effective technologies and emerging technologies - by the target date (ie, 2025, 2030, 2040).

Energy Efficiency

Energy efficiency is one of the cheapest ways of reducing greenhouse gas emissions which in combination with decentralized energy can provide the pathway to a 100% renewable energy future. However, recent improvements in building materials and energy efficiency technologies such as LED lighting and more efficient domestic and commercial appliances and equipment shows that energy efficiency can deliver far more reductions in energy consumption than previously thought.

Energy efficiency should be applied to the spatial energy demands with a particular focus on reducing or displacing electricity consumption and peak demand since this will make it easier and more economic to apply renewable energy to the resultant energy demands. Care should also be taken not to double count energy savings and/or greenhouse gas emission reductions through applying energy efficiency savings to electric heating or cooling which may be replaced by cogeneration, trigeneration, solar thermal, geothermal and/or waste heat as part of the Decentralized Energy Master Plan.

Energy efficiency savings may be taken from a known national, state or city energy efficiency scheme or plan, assessed energy efficiency as part of the Decentralized Energy Master Planning or from an Energy Efficiency Master Plan process. An Energy Efficiency Master Plan is likely to be more accurate than energy efficiency schemes, plans or assessments and can be carried out separately or at the same time as the Decentralized Energy Master Plan.

Energy Efficiency Master Plan

The content of the Master Plan would comprise the following:

Foreword – This would normally be written by the City Mayor or other leading politician in the city in conjunction with the lead author of the Master Plan.

Unlocking the Master Plan – This would summarize the results of the Master Plan.

1. **Energy Efficiency Opportunities** – This chapter would set out what energy efficiency is, sufficiency versus efficiency, the case for energy efficiency, energy productivity, the cost of energy, rising heat (climate change impacts), meeting the 2°C target (United Nations Framework on Climate Change), resilience, energy security (with energy service security being the ultimate goal), smoothing the peaks, job creation, the introduction of intelligent or smart primary energy services, technology shortlist, new builds and passive energy efficiency. This chapter to be specific to the city using local data and information.

2. **Re-Thinking Energy Efficiency** – This chapter would set out the changing energy patterns, the future of energy efficiency, policies and programs.

3. **Energy Efficiency for the City** – This chapter would set out the city and its people, the stock model (spatial energy demands), energy service need assessment (eg, what temperature and air change occupants of buildings are comfortable with), defining the mid-tier, baseline year energy and emissions, future scenarios over five scenarios – baseline efficiency levels, existing policies and programs, new policies and programs, cost-effective technologies and emerging technologies – and what the Master Plan is proposing.

4. **Performance Measures** – This chapter would set out the energy intensity improvements achievable through energy efficiency measures to the target year (s), tracking the target or targets, financial and economic viability with the well-being of citizens as key criteria for measuring success.

5. **Enabling the Master Plan** – This chapter would set out the barriers to energy efficiency, addressing the barriers, implementing the Master Plan, priority principles and actions and the enabling actions required, such as removing regulatory and institutional barriers, to deliver the full outcome of the Master Plan.

6. **Case Studies** – This chapter would set out national and/or international case studies relevant to the Master Plan.

7. **Technical Appendix** – The Technical Appendix would comprise the Energy Efficiency Master Plan Foundation Report.

STAKEHOLDER CONSULTATION

The Technology Shortlist and future scenarios should be developed in consultation with stakeholders from government, the building sector, energy sector and community groups to ensure a detailed and practical understanding of both current and potential future energy performance and to verify the modelling.

The consultation with stakeholders should also identify enabling actions required to remove any regulatory or institutional barriers to any part of the Master Plan, even if this is contrary to any state or federal policy or program, taking account of governance and jurisdictions.

The final draft Master Plan should be put out for public consultation and any accepted amendments made as a result of the public exhibition to be incorporated into the final Master Plan prior to formal adoption by the city.

TECHNOLOGY SHORTLIST

The Technology Shortlist should identify a range of energy efficiency technologies applicable to the city being master planned. Technical opportunities and assumptions listed in this section are sector averages only and may not be representative results for individual buildings.

The technologies listed below are commercially available today. Energy efficiency opportunities will continue to grow and new technologies emerge over time as the market for energy efficiency technologies evolves.

- **Appliances –** Minimum energy performance standards have had a key impact on reducing energy consumption in recent years and improving such standards should be one of the key actions in enabling the Master Plan. However, appliances exceeding the minimum energy performance standards are available and economic today.

- **Building Energy Management Systems (BEMS) –** BEMS provide great opportunities to reduce energy consumption and improve comfort. They also optimize energy use and identify equipment failure or unusual patterns of energy use.

- **Domestic Hot Water** – Substantial energy savings can be achieved by the replacement of hot water systems with heat pump or solar boosted systems.

- **Heating, Ventilation and Air Conditioning (HVAC) –** HVAC upgrades for existing systems typically include treatments such as replacing plant, improving and tuning controls systems, BEMS, retro-commissioning and power factor correction. Solar thermal and hydronic (water) delivery of heating and cooling will reduce grid energy electricity and gas consumption as will zonal HVAC systems. Energy efficient HVAC for new systems can be provided with these measures from the outset.

- **Lift Upgrades –** Lift upgrades typically include using the right combination of gearing, roping and pulleys, high energy efficiency and properly sized motors, regenerative drives, frequency converters with automatic standby functions, energy efficient transformers, components and equipment and lighting.

- **Lighting** – Lighting is a major energy use in buildings and street and public lighting and considerable savings can be made by energy efficient lighting design and replacing existing fluorescent and halogen lighting with light emitting diodes (LEDs), or metal halide lighting with induction lamps. LED dimming drivers which reduce energy consumption are also available and are of particular benefit for daylight linking for open plan offices, car parks and industrial buildings where natural daylight is available.

- **Metering** – Dedicated sub-meters and smart metering can help with reducing energy consumption with the provision of data and avoidance of waste energy.

- **Pool Equipment** – Significant energy savings can be made by adjusting set point temperatures, improved controls, high energy efficiency pump motors, variable speed drives, solar thermal, heat pump and heat recovery systems.

- **Time Switches and Sensors** – The simplest form of energy saving is switching off a service when it is not required. These controls typically include time switches, sensors, movement detectors, smart thermostats and smart device control such as mobile telephones and tablets.

- **Variable Speed Drives (VSD) Controls for Motors** – Significant energy savings can be made through the use of VSD control of motors such fans, pumps and other drive motors.

- **Voltage Reduction** – It is possible to reduce voltage for plant and lighting systems and even desktop computers (software enabled) to reduce energy consumption without affecting performance.

- **Water Saving Measures** – Reducing hot and cold water consumption can reduce heating and pumping energy consumption for very little cost.

The above Technology Shortlist is not exhaustive but an indication of typical cost-effective energy efficiency technologies available today.

PASSIVE ENERGY EFFICIENCY

Passive energy efficiency principally comprises passive design and other measures to reduce energy consumption by passive design and utilizing natural sources of heating, cooling, ventilation and daylight.

The importance of passive design cannot be overstated. Good passive design suitable for the climate effectively locks in thermal comfort, natural ventilation and lighting, low heating, cooling and electricity bills, and reduced greenhouse gas emissions.

The most economic time to achieve good passive design in a building is when initially designing and constructing it. However, renovations and retrofitting also offer cost effective opportunities to implement passive design and energy efficiency measures.

The passive design and energy efficiency measures listed below are commercially available today.

- **Design for Climate** – Good passive design ensures that the occupants remain thermally comfortable, naturally ventilated with minimal auxiliary heating, cooling, mechanical ventilation and electric lighting in the climate where they are built.

- **Orientation** – At the time of construction, orientating a building on its site to take advantage of climatic features such as the sun, cooling breezes and natural daylight will make the building more comfortable for occupants and reduce energy consumption.

- **Shading** – Shading buildings and outdoor spaces reduces summer temperatures, improves comfort and saves energy. Shading can include eaves, window awnings, shutters, solar shading devices and louvres, pergolas and planting. However, shading should be designed not to block winter sun.

- **Passive Solar Heating and Cooling** – Passive solar heating and cooling keeps out summer sun and lets in winter sun ensuring that the building envelope keeps heat inside in winter and allows built up heat to escape in the summer.

- **Natural Ventilation** – To be effective, passive cooling techniques need to cool and ventilate the building and the occupants in it with elements such as air movement, evaporative cooling and thermal mass.

- **Thermal Mass** – High density materials such as concrete, bricks and tiles have high heat storage capacity or high thermal mass. Lightweight materials such as timber have low thermal mass. Good use of thermal mass moderates' indoor temperatures by averaging day-night temperature extremes.

- **Air Tightness** – Air leakage accounts for 15-25% of winter heat loss in buildings and can contribute to significant loss of coolth in the summer where air conditioning is used. Sealing buildings against air leaks can increase comfort in buildings while reducing energy consumption.

- **Insulation** – Insulation acts as a barrier to heat flow and is essential for keeping buildings warm in winter and cool in summer. A well-insulated building provides year-round comfort, reducing heating and cooling bills by up to 50%. Typical retrofit and renovation measures can include roof, cavity wall and even floor insulation.

- **Glazing** – Glazing can be a major source of unwanted heat gain by up to 90% in summer and heat loss by up to 40% in winter. These thermal performance problems can be largely overcome by selecting the right glazing systems for the climate and orientation taking account of the size and location of window openings. Typical retrofit and renovation measures include double, triple and quadruple glazing with or without argon gas filling depending on the climate and orientation.

- **Light-Coloured Roofs** – Lighter coloured roofs reduce ambient temperature levels and can reduce the amount of energy required to artificially cool a building. They can also play a role in mitigating the urban heat island effect in cities.

- **Daylight** – Daylight techniques such as skylights can make a major contribution to energy efficiency and comfort. They are an excellent source of natural light, admitting more than three times as much light as a vertical window of the same size, improve ventilation and reduce lighting electricity consumption during daylight hours. Solar tubes also bring daylight into darkened corridors, hallways and other rooms without windows and can be easily retrofitted.

NEW BUILDS

New buildings and major renovations represent a significant opportunity for energy efficiency. For example, new commercial buildings could use between 60% and 70% less energy on average than code-compliant designs. Best practice design for energy efficiency minimizes energy consumption for the whole building system. Designs that make use of passive design and energy efficiency techniques reduce the need for the building system to consume energy in the supply of thermal comfort, ventilation, light and other services.

Such techniques for new builds and major renovations can be implemented cost-effectively to the point that on-site renewable energy can generate as much energy as the building uses leading to zero net energy and zero carbon buildings.

DELIVERING THE DECENTRALIZED ENERGY MASTER PLAN

The International Energy Advisory Council (IEAC) provides master planning project management services to help cities deliver Energy Efficiency Master Plans.

A City government wishing to undertake an Energy Efficiency Master Plan must take ownership of the Master Plan and commit to actioning the outcomes. The IEAC will then enter into a partner agreement with the City government.

The City government will act as the client and procurement agency for the Master Plan foundation report and take the lead with marketing and public relations with help and advice from the IEAC. The IEAC will also draft the necessary Council reports for authorizations and adoption of the Master Plan throughout the project. The Master Plan activities and the roles the IEAC, City government and selected contractor (s) will take comprise:

1. Establishing the contract between the IEAC and the City and agreeing the workshare and the proportions of the budget that would cover the workshare commitments. The IEAC will take the lead in designing and completing the Master Plan and the City government will take the lead in terms of owning and implementing the Master Plan outcomes.
2. Master Planning specification. The IEAC would draft the foundation report specification.
3. Procurement of the Master Planning foundation report by a competitive tender process. The investigative and foundation report work would be undertaken by local specialist engineering consultant(s) and/or university supervised by City government project manager(s) with input from the IEAC along the way to ensure the correct outcome to enable the Master Plan to be drafted. Master Plan foundation reports can take 6 to 12 months to complete depending on the jurisdiction or energy district covered.
4. The City government will accept the best tender(s) based on the recommendation of the IEAC.
5. Completion of Master Plan foundation report and submission to the IEAC.
6. Completion of draft Master Plan. The IEAC would draft the Master Plan ready for public exhibition. The City government will authorize the draft Master Plan and place the draft Master Plan on public exhibition.

7. Following public consultation, the draft Master Plan will be amended by the IEAC, as necessary. The IEAC will then submit the final Master Plan to the City government for adoption.

The expected Master Plan outcomes will comprise:

1. Identification of partners and any co-partners to deliver the Energy Efficiency Master Plan and its outcomes.
2. City government taking on the role of owning and implementing the Energy Efficiency Master Plan.
3. Identification of the maximum amount of energy efficiency measures that can be installed or implemented in the City.
4. Identification of the institutional and non-institutional barriers, including regulatory barriers to implementing any part of the Energy Efficiency Master Plan.
5. Business models and actions required, including regulatory reform, for the City to implement the Energy Efficiency Master Plan.
6. Identification of the amount of greenhouse gas emissions that can be reduced by implementing the Energy Efficiency Master Plan and contribute towards climate change mitigation.

The deliverables will comprise:

1. An Energy Efficiency Master Plan foundation report specification by the IEAC.
2. An Energy Efficiency Master Plan foundation report by the selected contractor.
3. An Energy Efficiency Master Plan by the IEAC that will significantly reduce greenhouse gas emissions.

The performance indicators will comprise:

1. The amount of electricity, heating and cooling demands that can be reduced by energy efficiency measures.
2. The amount of greenhouse gas emissions that can be reduced.

Business Model

The business model for implementing the project will be a City partner agreement between the IEAC and the City government. The IEAC will undertake the fundamentals of the Energy Efficiency Master Plan with assistance from the City government particularly with regard to introductions to local actors and language interpretation.

The Energy Efficiency Master Plan will be undertaken by a local specialized contractor (which may include sub-contractors) and the City will own and implement the Master Plan once it has been adopted by the City.

Allan Jones MBE
President/Chair
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