IEAC
International Energy Advisory Council

DECENTRALISED ENERGY 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. 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, was the most effective way to stop diseases spreading.

Following the 'Great Stink' of 1858, the chief engineer of London's Metropolitan Board of Works, Sir Joseph Bazalgette proposed a master plan for a sewage network to serve central London which, when completed in 1865, relieved the city from cholera epidemics and the miasma pervading London at the time. Bazalgette's master planning foresight led to the 'over-engineering' of the sewer network enabling London to use the 150-year old system well into the 21st century.

But this is not the first example of master planning. For that we need to go back to the Great Fire of London 1666. Overall 80% of the city was lost providing g 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 with rapidly increasing populations and the demands of infrastructure 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 and renewable energy 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 the energy systems that are being implemented today by others, in particular by consumers, or the 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 the ever-increasing forms of distributed or decentralized energy generation, particularly renewable energy, displacing remotely generated electrons with locally generated electrons and energy efficiency. Such 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 is called 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 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 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 local renewable energy resources and 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.

100% renewable energy has already been achieved in rural areas such as the 200 bioenergy villages in Germany and Costa Rica is close to becoming the first country in the world to achieve 100% renewable energy status with 250 days being powered by 100% renewable energy in 2016. Hawaii is the first state and Copenhagen the first city to adopt a 100% renewable energy target, one of a number of world cities that have adopted a 100% renewable energy target.

DECENTRALISED ENERGY MASTER PLANNING FOR CITIES

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.

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 utility electricity and gas consumption data should be provided across the different suburbs, sub-station, voltage, gas pressure networks and existing capacities (and any planned capacity reinforcements). From this data, it should be possible to identify not only what heating, hot water services and cooling is currently provided by electricity and gas but also what heating, hot water services and cooling (particularly cooling) could be provided by thermal energy (ie, renewable heat, waste heat, renewable gas/hydrogen and/or trigeneration).

The utility network information should also identify the best locations for connection to the electricity and gas distribution networks of renewable energy generation to minimize connection costs.

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

[1] Go 100% Renewable Energy

The data from this analysis should be used to identify the electricity, gas and thermal energy consumption and greenhouse gas emissions impact over three scenarios – as existing (ie, base year), 'business as usual' and 'carbon neutrality' by the target date (ie, 2020, 2025, 2030).

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 Renewable 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 process or from an Energy Efficiency Master Plan. An Energy Efficiency Master Plan is likely to be more accurate than energy efficiency schemes, plans or assessments and can be carried out at the same time as the Decentralized Energy Master Plan.

Decentralized Energy Master Plan

The Decentralized Energy Master Plan can be carried out as three different Master Plans – Trigeneration, Renewable Energy and Advanced Waste Treatment. Depending on the technical resources available in the country that the city is located or available from overseas the three Master Plans can be undertaken using three different contractors or combined as a single contract.

Depending on the environmental policies of the city concerned, other Plans may also be undertaken such as a Decentralized Water Master Plan and/or Climate Change Adaptation Plan. A Climate Change Adaptation Plan should be carried out last so that the results of the other Master Plans can be taken into account.

Trigeneration Master Plan

A Cogeneration or Trigeneration Master Plan should be undertaken first to determine the resultant electricity, heating, hot water services and cooling demands following the application of energy efficiency savings forecast to apply by the same target date. This will also determine the cogeneration or trigeneration gas demands in addition to other gas demands in the city.

Most, if not all cities are likely to require a Trigeneration Master Plan since any significant cooling demands should be switched from electric air conditioning to

thermal air conditioning. This will have the effect of significantly reducing both electricity demand and peak power, particularly in the summer, making it much easier and more economic to deliver 100% renewable electricity to the city. Trigeneration would also provide the demand for renewable gases derived from waste resources injected into the gas grid.

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. **Trigeneration** – This chapter would set out what trigeneration is, the problems with the existing centralized energy system and why and how it can be replaced by a decentralized energy system both in terms of energy supply and security as well as reducing climate change and noxious fossil fuel emissions. This chapter to be specific to the city using local data and information.

2. **Re-Thinking the Urban Form** – Using the spatial energy demands this chapter would outline the methodology and approach to determining the different energy dense zones that would inform the decentralized energy network.

3. **The Decentralized Energy Network** – This chapter would set out the current approach to cogeneration/trigeneration in the city, determine the ideal solution for the city, set out low carbon infrastructure zones for the energy intense areas of the city centre and what the decentralized energy network would look like for the city. This would be based on the best locations for connecting the decentralized energy stations to the electricity distribution network in terms of electricity flows, fault levels, etc, rather than thermal energy mapping to minimize electricity connection costs. Thermal energy zones can be easily designed around decentralized energy station locations whereas electricity generation connection costs can be costly in terms of reinforcement or upgrading of the local distribution network if the wrong location is chosen.

4. **Performance** – This chapter would set out the measured performance of the decentralized energy network analyzed in the Master Plan, delivering renewable energy and climate change mitigation targets, air quality implications and the financial and economic viability of the Master Plan.

4. **Outside the Network** – This chapter would set out any ‘hot spot’ low carbon infrastructure zones in energy intense areas outside of the city centre and the remainder of the city, ie, suburban and non-suburban areas where small scale decentralized energy solutions would be more appropriate.

5. **Enabling the Master Plan** – This chapter would set out the enabling actions, 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 Appendices** – The Appendices would include The Trigeneration Master Plan Foundation Report and Technical Appendix and the Gas and/or Electricity Infrastructure Feasibility Study Reports. These reports would be carried out by the local electricity and gas distribution network operators.

Renewable Energy Master Plan

The Renewable Energy Master Plan should be undertaken after or in conjunction with the Trigeneration Master Plan to determine the best fit between available renewable electricity and renewable gas generation resources and the city's forecast electricity, heating, cooling and gas demands.

Since there is likely to be significantly more renewable energy resources available than would be required to meet the city's energy demands it is important to draw up a Technology Longlist of all potential renewable energy resources available that could supply the city's energy demands and test these against applicability to the city's energy profiles, existing examples and their strengths and weaknesses to determine the Technology Shortlist on which the Master Plan wouldl be based.

In terms of financial and economic viability, all renewable energy resources and technologies that are currently financially viable and/or are expected to be financially viable by the target date, ie, 2030, 2040, 2050, etc, would be included in the Technology Shortlist for the Master Plan.

In addition, only renewable energy generation that is in proximity to the city will be included in the Master Plan. This is to avoid or minimize theoretical renewable electricity electrons or renewable gas molecules from notionally supplying the city but could never reach the city. It is also to avoid investing in remote large scale renewable energy generation that could become stranded assets with the full application of energy efficiency and decentralized renewable energy generation since electricity will always flow to the nearest electricity demand.

To deliver 100% renewable energy generation it is likely that a city will require a combination of decentralized renewable energy generation inside the city and large scale renewable energy generation outside the city, hence the need for a proximity zone principle. Proximity zones are typically no greater than 250 km from the city centre. At this distance, large scale renewable electricity generation is likely to be connected to the high voltage distribution network and the waste fuels required to deliver renewable gas to the city via renewable gas grid injection is also likely to be found within the proximity zone.

For the purpose of the Master Plan, only municipal, commercial and industrial waste, forestry residues, broad acre crop residues, animal manure waste, horticultural waste, sewage sludge and existing landfill gas would be included as renewable gas feedstocks. Energy crops and native woodlands would be excluded from the Master Plan to avoid any potential land use conflicts with food crops, water use and destruction of native woodlands. Other beneficial biomass and waste, such as oil Mallee crops and bushland fire hazard reduction combustible materials could be included in the 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. **Renewable Energy Resources** – This chapter would set out why renewable energy has to replace fossil fuels and nuclear energy, technology solutions for the city, evaluating the options, Technology Shortlist and any renewable energy mining and exports potential.

2. **Re-Thinking Renewable Energy** – This chapter would set out the need to transform energy systems, securing energy, addressing back-up power and intermittency, explanation of how the cost of renewable energy is established, and carbon or similar pricing mechanism that may apply in the city, state, country or region in which the city is located, cost of carbon abatement, any financial incentives such as feed-in tariffs, renewable energy jobs, education and training and community renewable energy which could be the primary mechanism for delivering the Master Plan targets.

3. **Renewable Energy for The City** – This chapter would set out what the Master Plan is proposing, the four elements of renewable energy generation – building scale renewable electricity and heat within the city, precinct scale renewable electricity and heat within the city, utility scale renewable electricity beyond the city and renewable gases derived from waste within and beyond the city.

5. **Performance** - This chapter would set out the measured performance of the renewable energy technologies and feedstocks analyzed in the Master Plan, delivering renewable energy and climate change mitigation targets and the financial and economic viability of the Master Plan.

5. **Enabling the Master Plan** - This chapter would set out the enabling actions, 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 Appendices** – The Appendices would include the Renewable Energy Master Plan Foundation, Financial and Economic Analysis and Renewable Gases Supply Infrastructure Reports. These reports are likely to require specialist contractors or sub-contractors to undertake the work.

Advanced Waste Treatment Master Plan – The Advanced Waste Treatment Master Plan is a sub-set of the Renewable Energy Master Plan in that it identifies the municipal, commercial and industrial non-recyclable waste that can be collected within the city's local government area and converted into renewable gas for injection into the gas grid to supply a portion of the trigeneration network as set out in the Trigeneration Master Plan.

The waste that the city currently collects plus commercial and industrial waste that the city could collect within the city's local government area as part of an integrated waste collection and disposal service could reduce costs for the city and its businesses and industries. A city's waste collected and disposed of in this way is likely to generate more than enough renewable gas to supply the city's own buildings via trigeneration plus surplus renewable gas to supply other consumers within the city's local government area.

The Master Plan may also include indicative financial analysis for advanced waste treatment facility or facilities to treat the city's waste and recover recyclables and renewable gas for injection into the gas grid. The main advantages of employing an advanced waste treatment facility with advanced gasification is the small-scale nature of the technology (typically in 100,000 tonnes modules) and the lack of a tall chimney or flue since the renewable gas generated is injected into the gas grid and not burnt on site. The main disadvantage is that the advanced gasification technology is relatively new with experience in installing and operating such facilities mainly in Europe and Japan.

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. **Advanced Waste Treatment** – This chapter would set out why advanced treatment has to replace conventional methods of treatment and disposal of waste, available treatment technology options and evaluating the treatment options.

2. **Re-Thinking Waste as a Resource** – This chapter would characterize the city's waste, re-think mixed waste for energy recovery and set out additional city generated waste streams, other potential waste resources for energy recovery, resource recovery using thermal conversion, thermal conversion scenarios, renewable energy resources in mixed waste and securing a renewable gas supply for the city.

3. **Advanced Waste Treatment for the City** – This chapter would set out the renewable gases from waste and biomass within and beyond the city, what the Master Plan is proposing, determining the ideal solution for the city, a new approach to energy from waste, the city's proposed advanced waste treatment, synthesis gas, upgrading and delivery and feedstock levels available.

4. **Performance** - This chapter would set out the measured performance of the advanced waste treatment technologies, environmental benefits, delivering renewable energy and climate change mitigation targets, the financial and economic viability of the Master Plan and renewable gases from waste resources beyond the city.

5. **Enabling the Master Plan** - This chapter would set out the enabling actions, such as establishing a regulatory regime for renewable gas, 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 Appendices** – The Appendices would include the Advanced Waste Treatment Master Plan Foundation and Financial and Economic Analysis Reports. These reports are likely to require specialist contractors or sub-contractors to undertake the work.

DELIVERING THE DECENTRALIZED ENERGY MASTER PLAN

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

A City government wishing to undertake a Decentralized Energy 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 (s) 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 will 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 any associated sub Master Plans) and the City government will take the lead in terms of owning and implementing the Master Plan outcomes.
2. Master Planning specification(s). The IEAC would draft the foundation report specification(s).
3. Procurement of the Master Planning foundation report(s) 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 reports 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 Decentralized Energy Master Plan and its outcomes.
2. City government taking on the role of owning and implementing the Decentralized Energy 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 maximum amount of decentralized renewable energy that can be installed in the City.
5. Identification of the amount of renewable energy outside but in proximity to the City that needs to be installed to supplement the decentralized renewable energy to deliver 100% of the City's electricity, heating and cooling demands that can be met by renewable energy resources.
6. Identification of the institutional and non-institutional barriers, including regulatory barriers to implementing any part of the Decentralized Energy Master Plan.
7. Business models and actions required, including regulatory reform, for the City to implement the Decentralized Energy Master Plan.
8. Identification of the amount of greenhouse gas emissions that can be reduced by implementing the Decentralized Energy Master Plan and contribute towards climate change mitigation.

The deliverables will comprise:

1. A Decentralized Energy Master Plan foundation report specification by the IEAC.
2. A Decentralized Energy Master Plan foundation report by the selected contractor.
3. A Decentralized Energy Master Plan by the IEAC that will deliver 100% of the City's electricity, heating and cooling demands from renewable energy resources and 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 balance of electricity, heating and cooling demands that can be met by renewable energy resources.
3. 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 Decentralized Energy Master Plan with assistance from the City government particularly with regard to introductions to local actors and language interpretation.

The Decentralized Energy 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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