DistrictCooling2018

Efficient Energy for Smarter Cities

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The Energy Budget

A simple innovative self finance plan to reach Carbon Neutrality

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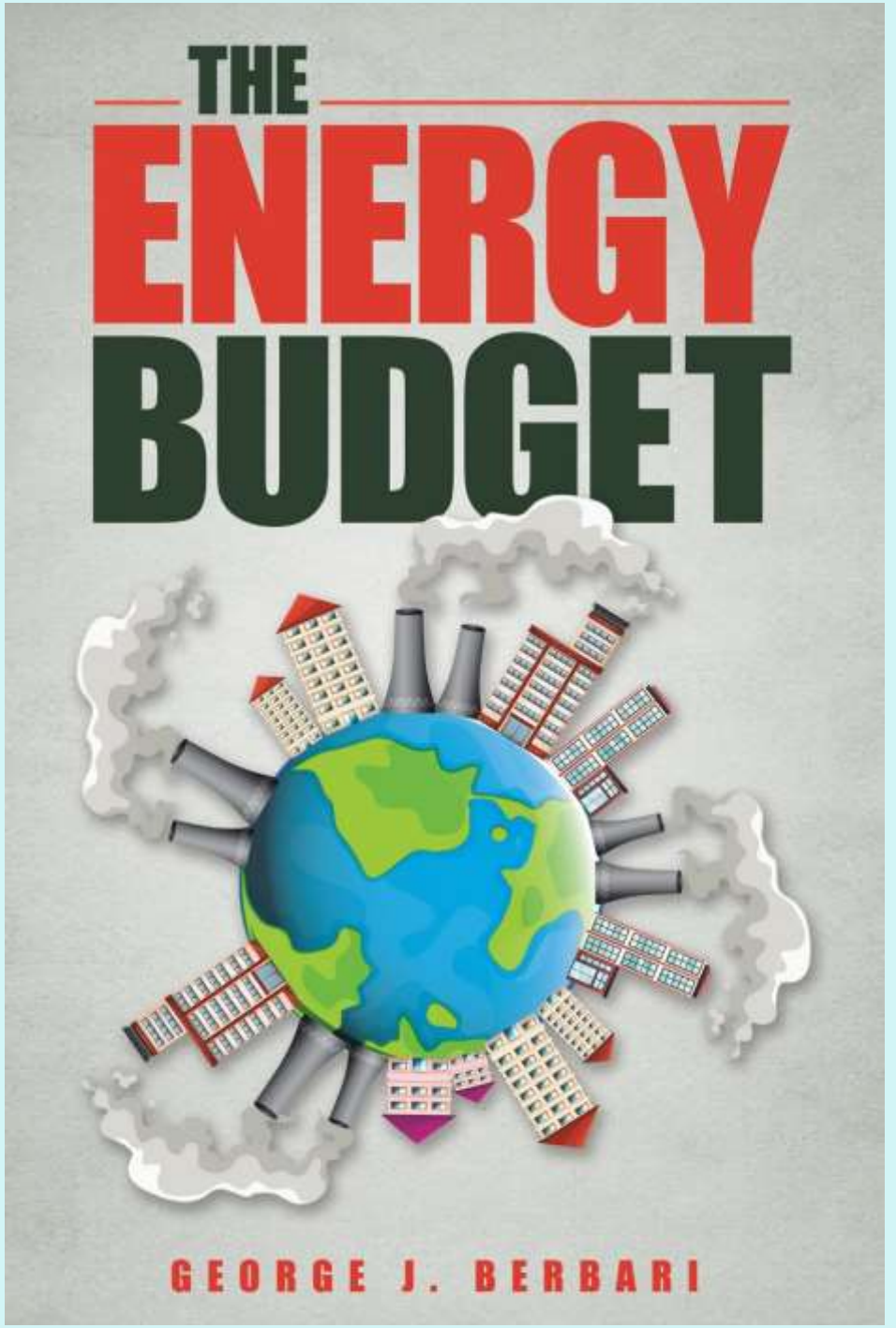

The Big Opportunity for District Energy

Integrating Renewables & Acting As An Energy Buffer & Stabilizer and creating resilient electricity & thermal micro grids

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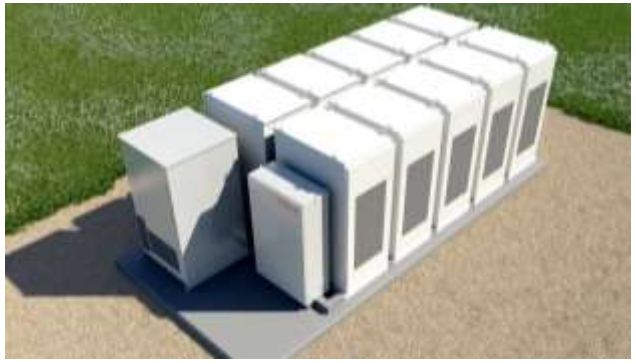
- **Renewables are on the way to become the dominant source of energy with Dubai, Abu Dhabi & Saudi Arabia latest solar PV BOO tender achieving world record lowest price of US¢ 2.99 to 1.79 / kWh respectively.**
- **60% of new power plants are either solar or wind.**
- **Traditional Gas Turbines and Combined cycle sales dropped by around 40%.**
- **Research is accelerating for Hydrogen Economy.**
- **Biomass and Bio Fuels & Natural Gas use in District Energy is growing.**

Energy Storage is the greatest future challenge with intermittent renewable power source!!!

60% of Buildings' Energy are thermal
Why the focus is only on electric storage & not thermal storage as well?

Batteries Power Pack

Price:	US $ 250 - 300/kwh
Expected Lifetime:	10 Years
Round Trip Efficiency:	88–89%
Footprint:	68–70 kwh/m^2



Stratified Chilled water Thermal Storage Tank

Several Suppliers:	US $ 18 - 20 / kwh
Expected Lifetime:	50 Years
Round Trip Efficiency:	98 -99%
Operating Efficiency:	105 – 110%
Footprint:	200 – 220 kwh/m^2

Stratified Hot water Thermal Storage Tank

US $ 8 - 9 / kwh
50 Years
98 -99%
99 – 101%
440 – 500 kwh/m^2

EU-27 District Heating and Cooling Potentials, Barriers, Best Practice and Measures of Promotion, 2012 – Extract from P12

Large scale electricity storage if it is intended to allow stored renewable electricity to be used for building heating and cooling implies extremely costly long term electricity storage for dealing with the variability (also called intermittency) of renewable energy, and again there is the issue of distributing it to the final user via the distribution grid which will need upgrading in many cases.

These issues are avoided if readily available and much cheaper thermal storage and District Heating is used.

"The Energy Budget"
Chapter 5 extracts: The Future of metering

- What is dragging us down, though, is the **fragmentation and duplication of metering and billing processes by every utility,** which is leading to waste of human energy and to high costs.
- Are we missing something here in all this? Why this massive waste of human effort? And why the proper benchmark, such as **kWh/m^2 per month or season, or thermal kWh or BTU per m^2 per month per season isn't reported?**
- My vision for the future of metering, which is endorsed by several utilities, is that there will be one **intermediate private-sector firm responsible for all the utility meters** as well as for the **billing and the collection of property tax in a jurisdiction**. The firm will report the collated figures to the local authorities concerned. **Such a structure will ensure transparency and reduction in costs**. The intermediate firm can expand its model to even include the billing and the collection of telecommunications and cable-service-related fees.

“The Energy Budget”
Chapter 7 extracts: The energy budget

- **The current model, where the utility companies are directly billing the end-users is inadequate.**
- **Should we be allowed to consume as much as we want to, as long as we are paying for them? Can that approach change without influencing our personal freedom or without limiting our choices?**
- **Each City, Town, Factory, building, Home and person shall take control on their energy consumption by creating an energy budget with specific measurable reduction targets.**
- **The city or town would adopt the global or country target and bring it down to measurable and benchmarked for every facility per m^2 and for every human being in terms of domestic water and liquid fuel usage per person.**
- **Efficient facilities and persons will benefit from base rates while inefficient facilities and persons will endure higher rates utilized as a city green investment fund.**

“The Energy Budget”

The energy budget principle: The failing Model

Indifferent City Municipality

$$$$

Electric Utility

Citizens & Institutions Consumes as much as they need
&
Trade Electricity with the Utility Company
while
the City Municipality is watching

"The Energy Budget"

The energy budget principle: the Future Model

Active City Municipality

$$$$

Energy trimming target

Energy Improvement Budget

$$$

Electric Utility

- Municipality set City Energy Budget & Slab Tariffs
- Bid out Energy bulk Purchases
- One Central Billing and Data management entity for power, water, sewage, gas, liquid fuel & district energy.
- Use the Carrot & The stick to reduce Energy Usage, create Energy Jobs and retrofit old buildings, invest in District Energy & renewables.

"The Energy Budget"
Chapter 7 extracts: The energy budget

In 2014 in the United States, electrical power was sold at a national average of US Cents 12.5/kWh. The average household consumption was 72 kWh/m^2/year while commercial consumption was 179 kWh/m^2/year . In the Energy Budget scenario, the proposed slab rates would be as per the following table:

kwh / m^2 / year	Penalty %	US ¢ / kwh
up to 50	0%	12.5
between 51 & 60	10%	13.75
between 61 & 70	20%	15
between 71 & 80	30%	16.25
More than 80	40%	17.5

In 2014, commercial and residential electricity sales in the United States were around USD 321 billion out of the USD 825 billion of total electricity sales. An increase in revenue of 15-20%, accrued through penalties, would generate an additional fund of between USD 48 billion and USD 64 billion a year, unless of course, if people consciously curbed power consumption!

"The Energy Budget"
Chapter 7 extracts: Industrial Energy Monitoring

Samples of Industrial Benchmark:

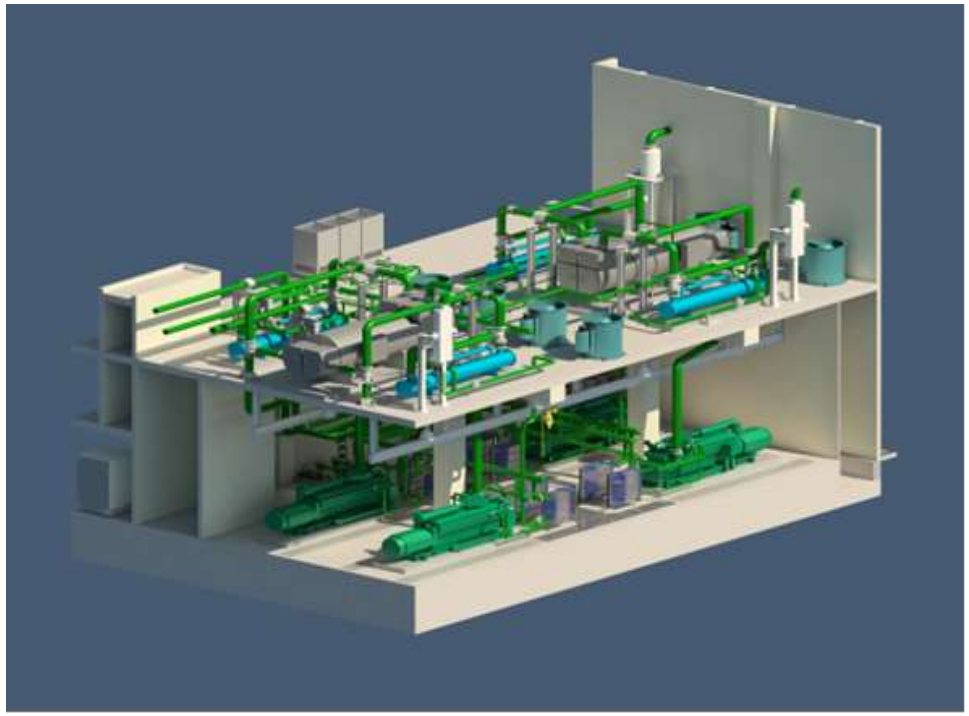
1. **Steel:** 1.8 Kg of CO_2 emission per Kg of steel produced in 2015 compared to 3.5 Kg of CO_2 emission per Kg of steel produced in 1975. Our current consumption of steel stands at 0.215 Kg / Capita / year.

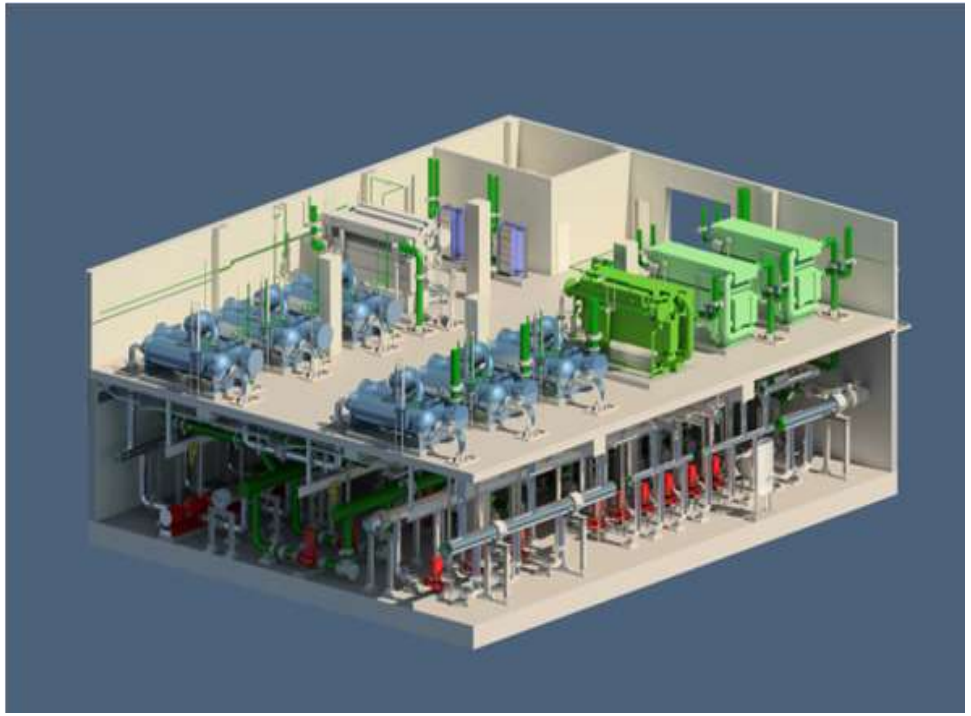
2. **Milk:** FAO estimates milk collection, processing and bottling consumes 100-120 MJ of electrical energy per tonne of milk. In Large industrial plants electrical energy is limited to approximately 65-85 MJ/tonne (to which approximately 25-30 MJ/tonne of thermal energy must be added).

“The Energy Budget”
Chapter 7 extracts: Industrial Energy Transformation

The Fastest Energy Transformation in Industries Is to adopt:

1. **Energy Monitoring per Unit Output to monitor and enforce future energy reduction.**
2. **Tri-Generation or CCHP whenever combined cooling, heating and power are required in an industry.**





“The Energy Budget”
New Chapter 8 extracts: Utopolis City case study

City Population of 2 Million People with City Municipal operating annual Budget of US $ 3 Billion in addition to US $ 1 Billion of Capital investment budget.

- **City Electricity usage: 35,252 Million kWh for residential sector 27,700 Million kwh for commercial sector and 23,860 Million kWh for industrial sector with total revenues US $ 2.472 Billion / Year.**
- **City Potable and treated effluent Water and sewage revenues are US $ 0.438 Billion / Year.**
- **Natural Gas and Distilled Fuel Revenues stood at US $ 0.603 & $ 2.628 Billion / Year respectively.**

Total Utopolis City Utilities revenue :

US $ 6.141 Billion / year or US $ 3,070 / Capita.

“The Energy Budget Version 2”
New Chapter 8 extracts: Utopolis City case study

City major action plan to reduce the energy consumption by 30% and reduced bills of US $ 1.8 Billion. The city will Maintain the same level of end-user total billing while investing 80% or US 1.44 Billion / Year in the following top four measures:

1. **Retrofit existing building to improve envelope insulation and convert to district energy by charging higher energy rate for inefficient buildings and investing part of the generated revenues to cover 50% of the conversion cost (US 600 Million / Year) (Carrot and the stick!).**
2. **Invest US $ 100 Million / year in District Energy Piping Networks.**
3. **Mandating the top 100 Factories to measure and reduce their energy use per produced unit output by 20% encouraging CHP and other measures with up to US$ 100 Million / year rebate.**
4. **Expand Bicycle and pedestrian routes with solar PV canopy with an investment budget of US$ 100 Million / year.**
5. **8 Other measures listed including Electric Charging stations, Hydrogen research, Expanding Metro, applying escalating fuel tax based on usage per person, Renewable wind and solar and organic farming, Rain water harvesting, taxing Beef & Diary product and waste sorting and recycling.**

Which Innovative City

will Implement

The Energy Budget Principles??

Copenhagen – Carbon Neutral Plan by 2025

Copenhagen has an urban population estimated at 1.26 million in 2015.

When the larger metropolitan area is considered, Copenhagen has a population of 1.99 million.

The **city proper has just 583,000 residents** with a population density of 6,800 people per square kilometer

Copenhagen – Carbon Neutral Plan by 2025

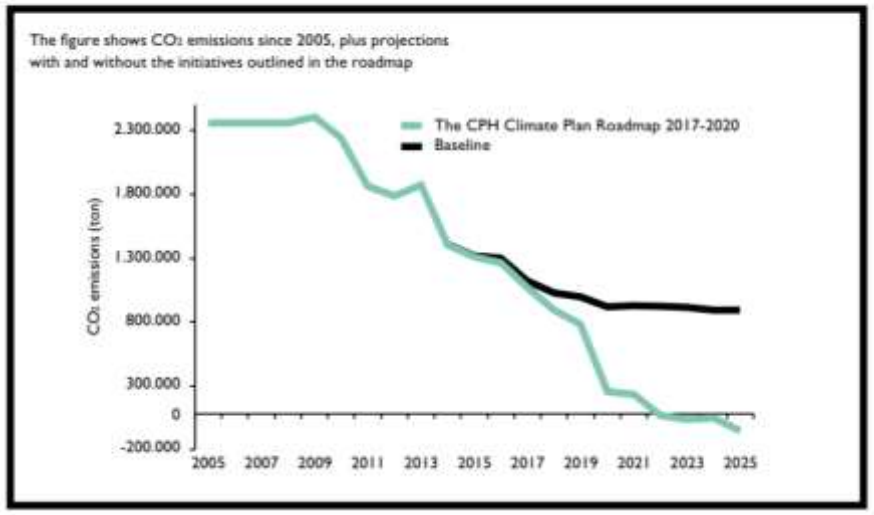
Objectives and beneficiaries

The CPH 2025 Plan involves a wide range of initiatives covering a large number of sector as well as a variety of stakeholders.

Approximately two thirds of the CO_2reduction will come from two measures:

- installation of wind turbines
- new renewable energy-based cogeneration using biomass.
- The third largest contribution comes from separation of plastic from waste to reduce CO_2 emissions from waste incineration.
- 3% of the potential still remain to be developed.

CO_2 emissions in City of Copenhagen 2005-2025



Status check

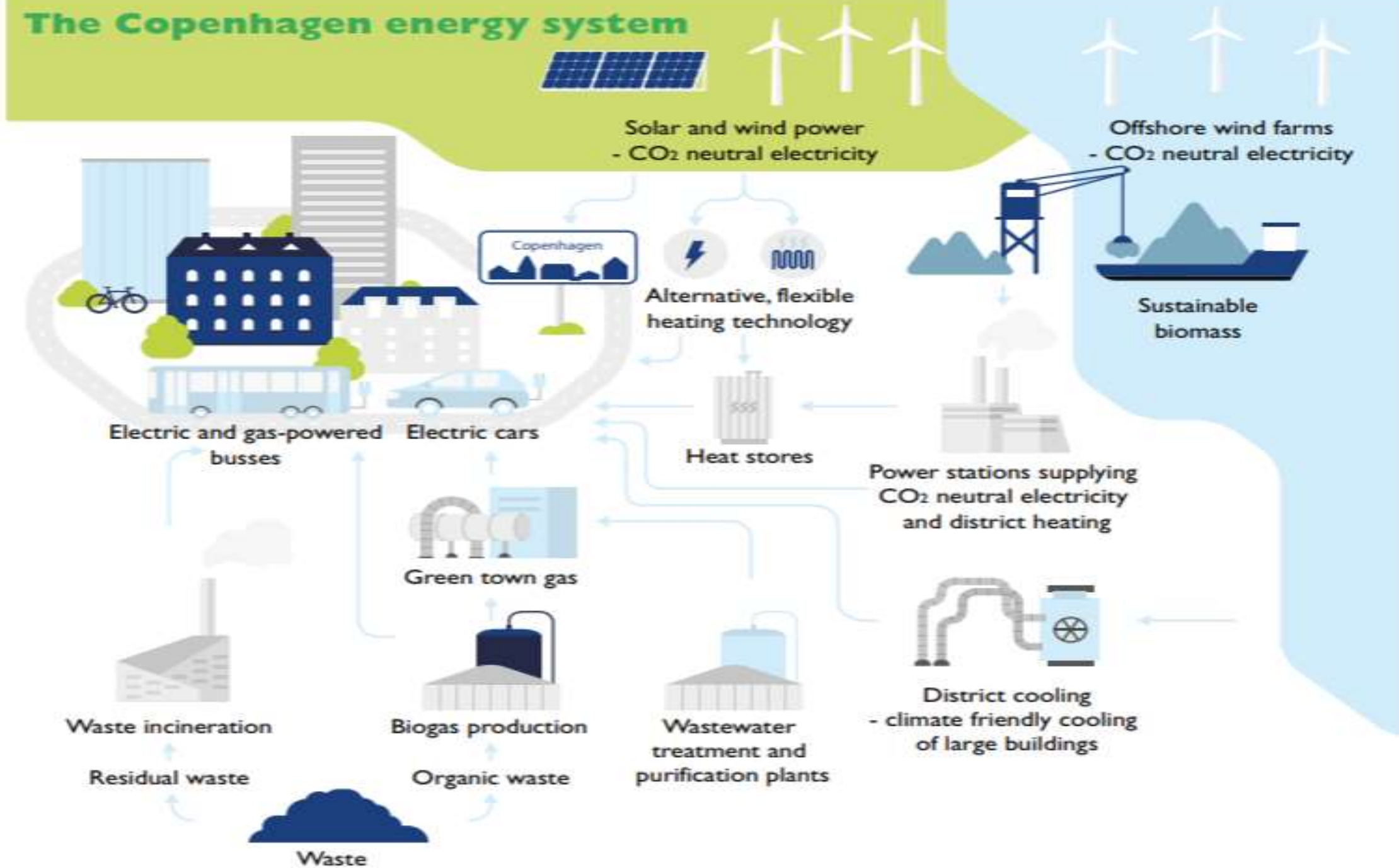
The most recent CO_2 accounts show emissions of 1.45 million tonnes of CO_2 in Copenhagen in 2015, down 38% since 2005 and 11% since 2014. At 2.5 tonnes per capita, it is one of the lowest figures for a European capital.

This reduction took place during a period (2005-2015) of 16% population growth, and was mainly attributable to the increased use of biomass in combined heat and power production, including in the Greater Copenhagen area, increased use of wind power to generate energy, and implementing initiatives outlined in the Climate Plan.

CO_2 reductions in Energy Production by 2025
Targets per main initiatives

TOTAL ENERGY PRODUCTION (TONNES OF CO_2)	741,000
Biomass in combined heat and power units - Building a new combined heat and power unit for biomass at Amagerværket - Using sustainable biomass in the district heating system	249,000
Flexible energy technology - Action plan for utilisation of surplus heat - Basis for decision-making regarding large scale heat pumps based on demo projects - Setting up heat-storage units - Testing low-temperature district heating in Nordhavn	15,000
Carbon neutral supply - Strategy for the conversion of peak-load and reserve units for district heating - Green town gas - Greater use of district cooling - Carbon neutral waste-water system and treatment - Carbon neutral water supply	89,000
Solar panels - Possibilities for investment in large-scale solar-power units	15,000
Wind turbines - Wind turbines on land in Copenhagen - Wind turbines on land outside the City of Copenhagen - Setting up near-shore wind farms - The government's offshore wind project at Kriegers Flak - Possibilities for an additional 100 MW of wind turbines	314,000
Resources and waste - Developing up a biogas strategy for Copenhagen - Establishing waste-based biogas production - Collecting more plastic - Evaluating the potential for a material recovery facility	59,000
Analysis - Fossil fuel-free Copenhagen in 2050	–

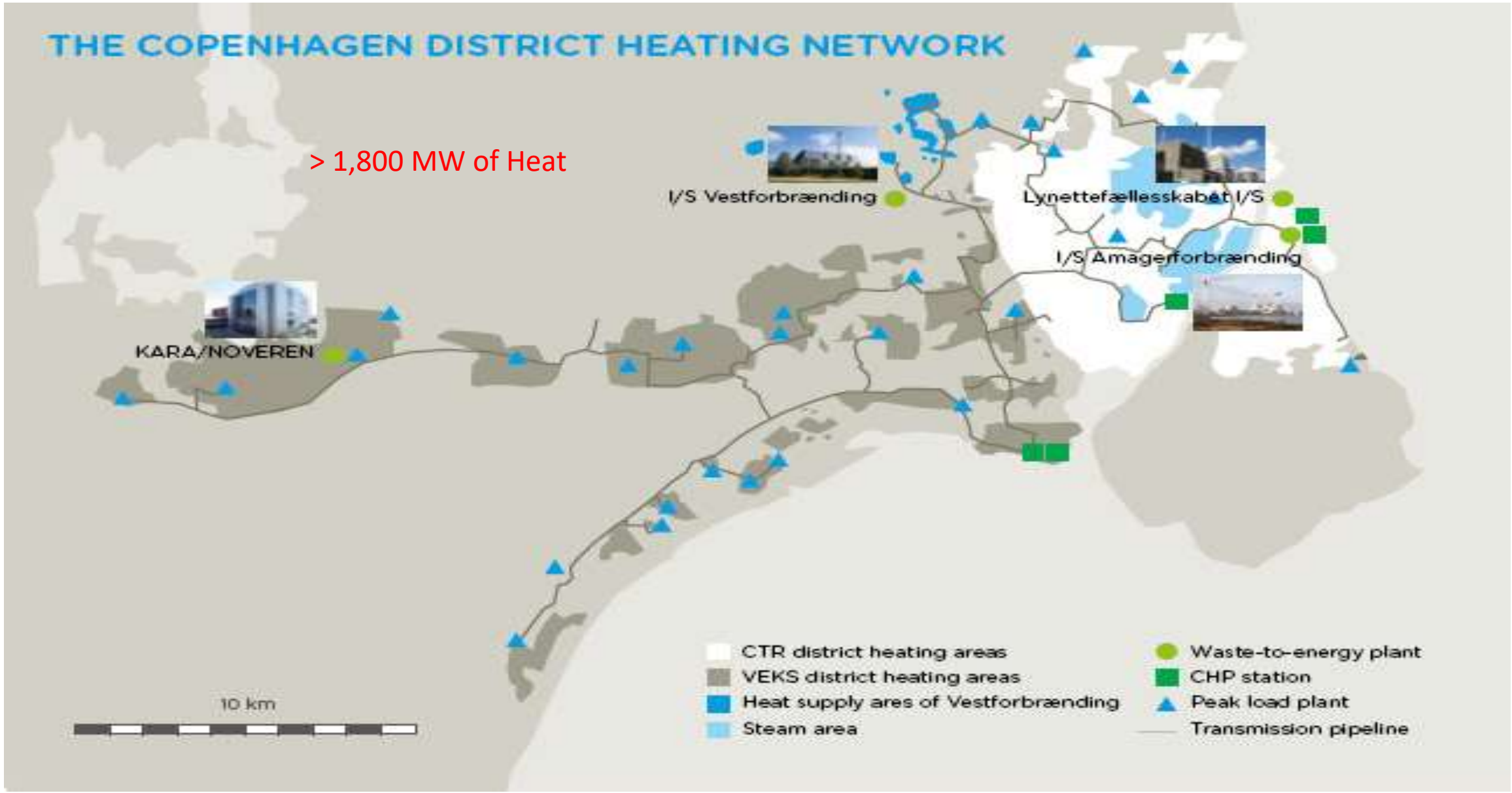
The Copenhagen energy system



Copenhagen District Energy Major Role

- 98% of Copenhagen is connected to District Heating one of the world largest, oldest and most successful systems that started in 1920's covering over 50 Million m^2 of BUA.
  - Waste heat, usually sent into the sea as a byproduct from the incineration plants and Combined Heat and Power plants (CHPs), is pumped through a 1,300 km network of pipes straight into homes.
- Copenhagen Energy opened the city's first sea water district cooling plant in 2010, a 10 MW (2,800 Ton) facility located in the historic inner city & works as follows
  - Free cooling – Seawater temperature is below $5.5^{O}C$ and cooling demand low (less than 2,400kW).
  - Combined operation – Seawater temperature is between 5.5°C and 11.5°C. Heat exchangers are used for pre-cooling of the cooled water, before it is fully cooled by chillers to the desired temperature.
  - Chiller cooling – Seawater temperature is above 11.5°C. The seawater is too warm to be used for free cooling so absorption and compression chillers provide all cooling. Free cooling exchanges are bypassed completely.
- Current status and results 2013–2016 Consumption of district heating (weather corrected) in Copenhagen in 2015 was more or less the same level as 2010 – despite population growth of 9% and approx. 1 extra million m^2 being used for housing.
- Copenhagen needs to be even better at saving on heating.

Copenhagen District Energy Major Role



Copenhagen District Energy Major Role Cont'd

Tax Incentives

In the mid-1980s the Federal Government introduced tax incentives on fuel for electricity plants. They paid less fuel tax if they used CHP (in some cases this amount equated to less than 50% tax incentive). This enabled the companies to sell heat to consumers at a lower price.

Planning regulations

In 1979, a new heat supply act was implemented which started a heat planning process in the municipalities – this enabled municipalities to dedicate a certain area to district heating and **make it mandatory for households to connect to district heating**.

Price (**¢ 8.3 / kWh heat**)

The price for district heating is highly competitive to other forms of energy. Based on average consumption of 18.1 MWh/year per home (130 m^2 in size), district heating is 11,342 DKK (**1,500 EUR**) compared to individual oil heating of 22.000 DKK (2,900 EUR). This is a saving of 10,658 DKK (**1,400 EURO**).

Hamburg, Germany

Hamburg's voters forced the city to buy back the grid in 2014 - **Municipalization of Utilities**

The consequence of this inaction has been an erosion of trust from the German public and the increasing viewpoint from citizens that large utilities, in particular, are not seriously concerned with the environmental goals of the *Energiewende*.

According to a 2009 Survey, 81% of citizens trusted local municipal utilities while only 26% of citizens trusted large corporations.

"In Hamburg, the concession for the networks was hold by Vattenfall and ran out in 2013. People then decided to regain control on the grid. So the city of Hamburg grounded a municipal utility (called "Hamburg Energie"), as a daughter of the water utility. It is now an energy provider, which focuses on producing and selling local green energy (mostly electricity but also some gas).

Medford Municipal Utilities, Massachusetts -USA

Medford Electric Utility is a municipally owned utility providing electric service to the City of Medford and portions of five surrounding townships.

The utility was formed in 1944 when the City of Medford purchased the distribution system from Lake Superior District Power Company after a lengthy debate and legal battle that began in 1935.

The utility serves over 3,292 customers with 2013 energy sales of 127,390,000 kWh and a peak system demand of 25,768 kW. Medford Electric operates approximately 50 miles of distribution line and 4 distribution substations.

Medford Electric Utility is one of more than 2,000 public, nonprofit, community owned electric utilities in the United States (82 in Wisconsin) providing efficient, low cost service.

Illinois Municipal Utilities Agency (IMUA)

The Illinois Municipal Utilties Association (IMUA) is a not-for-profit corporation functioning as a trade association for municipalities that own and operate their own electric, natural gas, water, wastewater and telecommunications systems in Illinois. It is composed of 67 municipalities, 62 associate members and 7 affiliate members.

Illinois Municipal Electric Agency (IMEA)

IMEA is a not-for-profit unit of local government created in 1984 that is currently comprised of 32 municipal electric systems and one electric cooperative from all across Illinois. Each of those communities owns and operates its own electric distribution system. Some operate local power generation plants.

Can Dubai Achieve Carbon Neutrality?

https://www.linkedin.com/pulse/can-dubai-achieve-carbon-neutrality-george-berbari/

Dewa Power Grid

- 36,527 GWh sold is at an average of 40.4 Fils per kWh (14.77 Billion AED)

- Change Current Slab Rate to 42 Fils / kwh for consumption of less than 70 kWh/m^2 / year to 52 Fils / kWh for higher than 110 kWh/m^2 / year
- Favor District Cooling with 358 Fils / kWh

District Cooling

2,500 Ton covering 20% of the City

- Increase Coverage to 80%
- Cooperative ownership of Piping Network to manage coverage expansion
- Tri-Generation
- Force offsite renewables
- Change Thermal Storage Philosophy from night time to day time storage.
- Change Rate Structure to favor end-user

Solar PV & CSP

5,000 MW by 2030

- Increase to 30,000 MW
- Allow DC to install and use DEWA Grid

Transport

Fossil Fuel Based

- EV Cars by 2025
- Join Hydrogen Council and enhance research & Production from renewables.