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LOS ANGELES CCAP: A STRATEGIC COURSE OF ACTION TO ACHIEVE CARBON NEUTRALITY BY 2050[1]

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1 INTRODUCTION

This Climate Change Action Plan (CCAP) was created to address climate change issues confronting the City of Los Angeles (Los Angeles or the City). Los Angeles faces serious risks and

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adverse impacts to the health, safety, and welfare of its residents, environment, and economy from climate change (LOS ANGELES, 2014; UNIVERSITY, 2013; WILLIAMS et al., 2015). In Los Angeles, climate change is expected to worsen air pollution, triple the number of extremely hot days above 95º F, and increase wildfires during the next 30 years, presenting grave public health issues such as increased respiratory diseases, poor water quality, and illnesses and deaths caused by heat and vector-borne diseases (LOS ANGELES, 2014). Climate scientists have suggested that human activities will continue to contribute to extreme weather and drought in California in future years (National Oceanic Atmospheric Administration - NOAA, 2015, citing Belmecheri, 2015). The City's coastal infrastructure is at risk due to anticipated sea level rise, namely, the City's wastewater management, stormwater management, and potable water systems, and City roads (UNIVERSITY, 2013). Moreover, coastal flooding could have an adverse impact on the economies of beach communities in Los Angeles, accounting for $16.5 billion in expenditures in 2012 (UNIVERSITY, 2013, p. 2). In order to mitigate those risks and impacts, this plan presents various pathways for Los Angeles to achieve carbon neutrality by 2050.

The CCAP identifies the City's carbon inventory and proposes plans for reducing and eliminating carbon dioxide (CO_2) emissions to zero by 2050. The City's main sources of emissions will be examined, and strategies will be suggested to reach target reductions over the next 33 years in six public and private sectors, namely, buildings, transportation, waste, land use, and energy systems and energy supply. As indicated below, the production and supply of energy for use in buildings and transportation present the largest opportunities for reductions in CO_2 emissions in Los Angeles. The CCAP will therefore focus mainly on and provide a more detailed analysis of the strategies for reduction and elimination of emissions in connection with the production and supply of energy

for buildings and transportation, notwithstanding the importance of the other sectors.

2 EMISSIONS INVENTORY AND TARGET REDUCTIONS

In 2007 the City conducted a study comparing levels of CO_2 emissions in Los Angeles in 2007 with 1990 (LOS ANGELES, 2007). According to that study, Los Angeles had reduced emission levels by 7% from 54.1 million metric tons (MMT) of CO_2 in 1990 to 50.3 MMT in 2007, notwithstanding an increase in population of about 12.5% (LOS ANGELES, 2007, p. 1-2). Transportation represented the largest source of CO_2 emissions in 2007, accounting for 47% of the total (LOS ANGELES, 2007, p. 1). Building energy consumption was the second largest source of emissions, generating 32% of the total (LOS ANGELES, 2007, p. 1). The remaining sources of emissions were from industrial fuels (12%), natural gas, residential (6%), and natural gas, commercial (3%) (LOS ANGELES, 2007, p. 1). In light of those levels and sources of emissions, the CCAP provides for a one-third reduction of CO_2 emissions based on 2007 levels every 11 years until 2050 and will focus on strategies to transition from fossil fuels to clean renewable sources of energy for Los Angeles in order to achieve carbon neutrality by the proposed deadline.

3 PLAN, STRATEGIES, AND ACTION TO ACHIEVE CARBON NEUTRALITY

The pathway to carbon neutrality proposed in this plan is predicated on broad strategies to reduce carbon emissions in connection with the City's buildings, transportation, waste, land use, and energy systems and energy supply. These strategies rely on the transition from fossil fuels to renewable energy for homes, businesses, and transportation. The plan identifies options for

emission reductions such as buildings designed to reduce and conserve energy through construction and retrofit projects, vehicles powered by electricity, and electricity generated from solar, wind, and geothermal energy.

The plan also suggests higher density design to reduce vehicle traffic and encourages alternative modes of transport and movement of persons by mass transit, bicycling, and walking. Appropriate land use for management of waste will also be discussed, along with reduction of heat islands and increase of carbon sinks by planting trees and vegetation and other land use plans. Investment in infrastructure to implement the plan will also be considered, although specific policy strategies to achieve carbon neutrality, such as carbon pricing, cap-and-trade programs, financial incentives, financing, and building code regulations, are beyond the scope of this plan.

3.1 BUILDINGS

Green design will play a critical role in emission reductions for new construction. Efficient designs can also reduce energy consumption. Retrofitting existing building stock will be crucial to achieve net zero carbon emissions. On-site electricity production through rooftop photovoltaic (PV) or geothermal systems will contribute to reductions of carbon emissions. Off-site electricity must be generated and supplied from clean renewable sources such as wind, solar, or geothermal in order to achieve carbon neutrality by 2050.

3.1.1 COMMERCIAL, INDUSTRIAL, AND RESIDENTIAL BUILDINGS

Several actions can be taken to reduce or eliminate carbon emissions in the City's building stock. Leadership in Energy and

Environmental Design (LEED) certification offers one possibility to achieve some of the highest standards in the design, construction, operation, and maintenance of new and existing buildings (UNITED STATES, 2016). Energy Star certification would also assist individuals and businesses conserve energy and address climate change issues through the purchase and installation of energy efficient products and construction of energy efficient buildings (UNITED STATES, 2016). Green building materials using recycled materials and manufactured without harm to the environment would also have a positive impact on climate change. Heat pumps, air conditioning systems, furnaces, appliances, electronics, lighting, and other equipment should also meet or exceed the energy efficiency specifications established by the LEED and Energy Star programs.

A well-sealed building envelope, together with insulation and energy efficient doors and windows, could also decrease GHG emissions, conserve energy, and reduce energy costs (UNITED STATES, 2016). About one-sixth of all electricity generated in the U.S. is used to air condition buildings (UNITED STATES, 2016a). Cool roofing materials such as those certified by Energy Star have the potential to reduce peak cooling demand for electricity by 10-15% (UNITED STATES, 2016a). Building tops can be covered with solar panels to meet energy needs and any remaining roof space can be dedicated as a green roof to provide environmental benefits such as reducing stormwater runoff and urban heat island effect (UNITED STATES, 2011).

Retrofits will be necessary to achieve energy efficiency in existing buildings. Large high use structures should be considered at the outset of the plan for upgrades. Commercial and industrial retrofits could start with structures 30,000 square feet or larger and should be undertaken at the earliest possible opportunity within the first 11 years of the plan. Larger residential structures could be the first selected for remodeling. All structures could be subject to

upgrade by either the seller or buyer in connection with real estate sales or refinancing transactions.

At least one-third of the building stock should be retrofitted each 11 years to meet the 2050 deadline. A whole building concept should be employed. As with new construction, existing buildings should be insulated, sealed, and caulked to ensure against air leaks in the building's envelope. Heat pumps, air conditioning systems, furnaces, appliances, electronics, lighting, and other equipment should be upgraded to achieve maximum energy efficiency. Solar installations should be considered to provide power for energy needs and appliances such as water heaters. Cool roofing material would also serve to regulate building temperature and reduce energy use and would provide a potentially maintenance free substrate on the surface of which solar PV panels could be installed. A green roof could also be installed on appropriate roof configurations. Each site should be appropriately landscaped to provide carbon sinks. For that purpose, drought resistant trees, shrubbery, and vegetation with high carbon sequestration potential should be planted.

Systems must be designed and constructed on all properties, both public and private, to capture, retain, and store rainwater flowing off buildings, parking lots, or other impervious surfaces for subsequent on-site use. Water must be conserved and recycled due to the perennial threat of drought and water shortages confronting Angelenos.

Although detailed policy considerations are beyond the scope of this plan, incentives and tax breaks such as government guaranteed loans, property assessed loans, low-interest financing, property tax reductions, tax credits, green bonds, and rebates could be used to assist businesses and residents with their retrofit projects. Accelerated depreciation could also aid businesses. Utility cost savings would also serve to offset and expedite return on such investments and possibly provide a positive cash flow. Environmental returns would be immense.

3.2 TRANSPORTATION

A transition from fossil fuels to renewable energy sources to power motor vehicles must occur to meet carbon neutrality in Los Angeles by 2050. The right combination of political and economic forces will be required to reach critical mass. This appears to be a tangible possibility. On the legislative front, California has codified into law one of the most ambitious environmental bills in U.S. history. Specifically, the Global Warming Solutions Act of 2006, California Assembly Bill 32 (AB 32), requires California to reduce GHG emissions to 1990 levels by 2020, and to a level 80% below 1990 levels by 2050 (AB 32, 2006). On the economic front, in a study conducted by Bloomberg New Energy Finance (BNEF), energy analysts forecasted that electric vehicles (EV) will be able to compete economically with internal combustion engines by mid-2020 (BNEF, 2016). BNEF also forecasted that EV sales will reach 41 million by 2040, or 35% of light passenger vehicles (BNEF, 2016) According to BNEF's estimates, EV's will represent 25% all vehicles on the road by 2040, resulting in a reduction of 13 million barrels per day of crude oil consumption, but using 2700 terawatt-hours of electricity (BNEF, 2016).

Collin McKerracher, who is a lead advanced transportation analyst at BNEF, stated: "At the core of this forecast is the work we have done on EV battery prices. Lithium-ion battery costs have already dropped by 65% since 2010, reaching $350 per kWh last year. We expect battery costs to be well below $120 per kWh by 2030, and to fall further after that as new chemistries come in." (BNEF, 2016). Salim Morsey, another BNEF senior analyst and author of the study, stated: "Our central forecast is based on crude oil price recovering to $50, and then trending back up to $70-a-barrel or higher by 2040. Interestingly, if the oil price were to fall to $20 and stick there, this would only delay mass adoption of EVs to the early 2030s." (BNEF, 2016).

According to Business Finance News, Tesla Motors has already established a network of charging stations called "Superchargers" and "Destination Chargers" in various parts of the world to recharge EV batteries in less than an hour (BUSINESS, 2016). Tesla plans to sell at least 500,000 EVs annually by 2020 (BUSINESS, 2016). Other EV manufactures are also expected to be competitive by that time (BUSINESS, 2016).

Technological advances are also being realized in aviation. Within the past two years, an airplane circumnavigated the planet without the use of fossil fuel (BORA, 2016). Solar Impulse was the first aircraft to travel around the earth (BORA, 2016). The airplane ran on solar power during the day and battery-stored power during the night (BORA, 2016). This is encouraging news and holds promise for air travel using clean renewable energy. Until that time, federal agencies can play a major role in reductions of aircraft emissions through regulations and guidelines designed to garner emission reductions through efficiencies in design and other practices, which can benefit the City's busy international airport.

For purposes of this plan, it is assumed that vehicles will be powered by clean renewables, most likely electricity produced by batteries, by 2050, given the previously mentioned political and market forces. Consequently, it would be a better use of public funds and resources to invest in technology with the greatest assumed likelihood of success. Los Angeles should therefore capitalize on the aforesaid legislative and economic momentum by continuing to make significant investments in EV infrastructure. There should be parking spaces throughout the City capable of supporting EV power and recharging supply and clearly marked to inform the public that EV charging is available at those locations. Charging stations should be installed in all municipal property and other public facilities or venues. The installation of charging technology should be encouraged and eventually mandated in all new construction and retrofits for the

City's building stock, so that such technology is nearly ubiquitous within the City's limits by 2040.

The City should also consider investing in mass transit powered by renewables such as solar cells and batteries. Los Angeles should also encourage ride sharing and discourage single occupancy vehicles trips. Consideration should be given to tiered parking pricing within the City to encourage multiple passenger rides and green technology transportation. Los Angeles should also continue with its efforts to make City streets one road for all, vehicles, cyclists, and pedestrians, with appropriate street markings and signs, to reduce traffic, pollution, and carbon emissions.

3.3 WASTE

Methane (CH_4) is generated in municipal landfills when waste decomposes, and landfills are the third largest source of CH_4 in the U.S. (UNITED STATES, 2016b). CH_4 is the second most pervasive GHG generated in the U.S. from anthropogenic sources and represents about 10.6% of all GHG emissions from human activities (UNITED STATES, 2016b). The impact on climate change of CH_4 emissions is 25 times greater than CO_2 over a 100-year period (UNITED STATES, 2016b).

All the City's waste can and should be managed to reduce emissions to zero within the next 10 years. CH_4 emissions must be reduced to zero within that timeframe. The City is currently unsure of the exact amount of CH_4 emissions related to daily, intermediate, and final cover of waste materials (BOGNER; SPOKAS; CHANTON, 2010). The City extracts CH_4 from landfills and uses it as a source of energy (CALIFORNIA, 2016). In order to transition to clean renewable energy, the City must discontinue use of CH_4 as a power source. The City must find and use safe and clean methods of CH_4 extraction, trapping, and storage. Further research and investigation

are recommended in order to achieve such objectives.

All the City's waste should be recycled. Los Angeles already uses separately color-coded and marked bins for general waste (black), recyclable materials (blue), and garden materials (green) (LOS ANGELES, 2016). The City should institute a similar system for commercial and industrial properties, with varying size bins to meet its customer's needs.

The City should partner with residents, businesses, educational centers, and other organizations to create collection centers. Those centers could be used to deposit and collect used and reusable items, canned foods, and other goods for recycling and distribution. This could be another source of food and other items for individuals who need public assistance.

3.4 LAND USE

Reductions in carbon emissions can be anticipated through land use design and density. Reductions in vehicle travel will certainly result in reductions in emissions. Higher density urban development is conducive to walking, cycling, and mass transit (UNITED NATIONS, 2013). The planning, design, and development of self-contained communities can minimize adverse impacts on the environment. The City should promote development near existing streets and existing commercial and retail centers in order to minimize travel. Residences should be located within short distances of basis public services whenever possible. The City should also support efforts to promote local agriculture and businesses to reduce the environmental costs of shipping food and products from long distances. Residents should also be encouraged to grow some of their food.

The City should also promote efforts to improve air and water quality and reduce emissions at the City port. Coastal development

should be discouraged unless new projects meet design specifications to prevent water intrusion. All new coastal construction and retrofits must be designed and constructed to prevent water intrusion and mitigate against flooding. All outdoor lighting and traffic signals can be powered by solar panels and use energy efficient lights which do not damage the environment.

The City should also identify and establish programs in new and existing neighborhoods to develop carbon sinks by planting drought resistant trees, shrubs, and vegetation. Los Angeles should also plant up to one million trees and create up to 20 new parks each year on municipal property for the life of the plan and beyond to enhance the City's capacity for carbon capture and sequestration.

3.5 ENERGY SYSTEMS AND ENERGY SUPPLY

Clean renewable energy will be required to achieve carbon neutrality by the proposed deadline. To that end, the harvesting of wind, solar, and geothermal energy is contemplated by this plan to meet all the energy needs of Los Angeles by no later than 2050. These renewable resources are vast and can provide clean energy for countless future generations.

3.5.1 RENEWABLE ENERGY SYSTEMS AND ENERGY SUPPLY

Further advancing clean energy in California, the State Legislature passed the Clean Energy and Pollution Reduction Act of 2015, Senate Bill (SB) 350, to increase California's renewables portfolio standard (RPS), mandating production of energy for California from renewable sources such as wind, solar, biomass, and other alternatives to fossil and nuclear electric generation, from 33% by 2020 to 50% by 2030 (SB 350, 2015).

The City owns its water and power company, the Los Angeles Department of Water and Power – 2015 LADWP (2015). In 2015 LADWP supplied more than 25 million megawatt-hours (MW) of electricity to 1.4 million residences and businesses in Los Angeles (LOS ANGELES, 2015, p. 4). LADWP will be required to assume a prominent role in the transition to clean energy in order to achieve plan objectives. LADWP currently plans to replace over 70% of its existing sources of power with clean energy alternatives during the next 15 years (LOS ANGELES, 2015, p. 5). The transition will require substantial investments to rebuild local power plans to transition from coal to renewable energy sources (LOS ANGELES, 2015, p. 5). By 2030, LADWP plans to eliminate coal as a source of power supply to Los Angeles, with an energy resource mix by that time: renewables (40%), cleaner burning natural gas (34%), nuclear (7%), hydro (4%), and energy efficiency accounting for the balance (15%) (LOS ANGELES, 2015, p. 6).

In 2014 LADWP began construction on the Barren Ridge Renewable Transmission Project (LOS ANGELES, 2015, p. 8). This project will provide up to 2,000 MW of additional power to access wind and solar power to meet California's RPS goals (LOS ANGELES, 2015, p. 8). In 2014 LADWP commenced construction on the Beacon Solar Project (LOS ANGELES, 2015, p. 8). This project will provide 250 MW of solar power. The power company has received approval for the Manzana Wind Project, which will provide 39 MW of wind energy to LADWP (LOS ANGELES, 2015, p. 8). LADWP will also receive 34 MW from the Heber-1 Geothermal Project beginning in 2016 (LOS ANGELES, 2015, p. 8). As of 2014, there were over 15,000 customer-installed PV systems connected to LADWP's grid (LOS ANGELES, 2015, p. 9).

There are obviously significant challenges and opportunities to produce and supply enough clean electricity from renewable sources to meet the needs of Los Angeles and achieve carbon

neutrality by 2050. There is reason for optimism. According to at least one study, there is sufficient space on the rooftops of homes in Los Angeles for 5,500 MW of solar PV panels (ENVIRONMENT, 2013). This is enough electricity to power 1.3 million residences (ENVIRONMENT, 2013, p. 2). Based on recommendations by that study, this plan supports the goal of installing 1,200 MW of local solar power generation by 2020 (ENVIRONMENT, 2013, p. 1-2). This would reduce annual emissions of over 1.1 million metric tons of pollutants and save 435 million gallons of water annually (ENVIRONMENT, 2013, p. 1). It is estimated that installation of 1,200 MW of solar power by 2020 would create about 32,000 jobs (ENVIRONMENT, 2013).

Apart from the immense environmental benefits from installation of additional solar power generation capacity, significant amounts of money could be saved. For example, with incentives, the Los Angeles Unified School District's investment in a solar energy system was estimated to save it about $800,000 per month (ENVIRONMENT, 2013). With continued incentives, Los Angeles consumers could expect reductions of their electric bill to zero or near zero (ENVIRONMENT, 2013).

In an interdisciplinary MIT study, its authors concluded that currently available solar panel technology is all that is necessary to supply the world with many terawatts (TW) of clean solar power by 2050, and, although further research may improve the efficiency of solar panels, current technology in solar panels is sufficient to supply the entire world's energy needs (AMATYA et al, 2015).

In a report analyzing the impact of removal of fossil-fuel subsidies on energy markets and climate change, the International Energy Agency (IEA) estimated that worldwide fossil fuel subsidies were $493 billion in 2014 (IEA, 2014). The fossil-fuel subsidies amounted to more than four times the incentives for renewables including solar, wind, and biofuels (IEA, 2014). The IEA report

estimated that renewables will account for almost one-half of the global increase in generation of electricity by 2040 (IEA, 2014). The report also indicated that globally wind power will provide more than a third of the growth in renewable energy, with hydropower representing about 30%, and solar power 18% (IEA, 2014).

According to other forecasts, the costs of lithium-ion batteries have already significantly decreased due to technological advances, making night-time storage of solar PV and wind power economical (AHMED, 2014, citing Seba, T). It is estimated that battery costs will decrease to $200 kWh by 2020 and to $100 kWh by 2024 or 2025 (AHMED, 2014, p. 3). This would mean that as early as 2020, for about $15.30 per month, a consumer could have eight hours of battery power storage to shift from day to evening usage and not be required to pay peak prices (AHMED, 2014, p. 8). In 15 years, based on current growth trends, total global solar capacity is estimated to be 56.7 TW, which is equivalent to 18.9 TW when converted to conventional power loads (AHMED, 2014, p. 9). This would be sufficient to meet worldwide energy demand projected to be 16.0 TW (AHMED, 2014, p. 9). With the assumption that solar continues to increase based on trends, the energy infrastructure will be entirely solar powered by 2030 (AHMED, 2014, p. 10). After 2020, on-site rooftop generation of solar power will be cheaper than energy generated by traditional fossil fuel plants even if such plants operational costs were assumed to be zero (AHMED, 2014, p. 10). The cost to produce wind power is also rapidly dropping, will be cheaper than all other sources of energy except solar, and is expected to complement solar at night and during the winter within the near future (AHMED, 2014, p. 10). According to Professor Seba (*apud* AHMED, 2014, p. 11)

> We are on the cusp of the largest disruptions of industry and society since the first industrial revolution. Large, centralized,

> top-down, supplier-centric energy is on its way out. It is being replaced by modular, distributed, bottom-up, open, knowledge--based consumer-centric energy. The transition has already started, and the disruption will be swift. Conventional energy sources are already obsolete or soon to be obsolete.

Other individuals and groups are equally optimistic. For example, Greenpeace International estimated that the amount of energy that can be accessed by current technology meets global demand many times over (TESKE et al, 2015). In an article entitled *Carbon-Free and Nuclear-Free*, Dr. Arjun Makhijani stated in 2007 that available wind resources in 12 Midwestern and Rocky Mountain states are equal to about 2.5 times the electricity produced in the U.S. (MAKHIJANI, 2007).

In Los Angeles, it will be necessary for residents and businesses to partner in conjunction with the City to ensure a smooth transition from fossil fuels to renewables. On-site solar projects have the most promise for an expeditious conversion to renewables. As noted by LADWP, "'distributed generation' functions like mini power plants that generate right where it's being used." (LADWP, 2015). LADWP's electrical grid is aging and not established to support large scale renewable energy use (LADWP, 2015, p. 5). To augment electricity customer's on-site mini power plants, the City must establish the capacity to store energy when the sun is not shining and the wind is not blowing. This will allow bi-directional energy flow in order that buildings and power stations can both produce and use such energy.

As noted, improving battery technology may transfer this function largely to residents and businesses in the future. This transition will, however, require at least a few years. In the interim, the City can therefore play an important role in facilitating that transition. Although Los Angeles currently derives its renewable

energy from solar, wind, geothermal, and other sources, the best prospects for exponential growth in renewable energy between now and 2050 are solar and wind, with wind complementing solar, as noted above.

4 CONCLUSION

Los Angeles can achieve carbon neutrality by 2050. The pathway to carbon neutrality will rely on smart grids powered by renewable resources and vehicles powered by batteries. Solar power, complemented by wind power technology, has the best prospect of providing all the clean renewable energy needs of Los Angeles by 2050. The City's building stock can achieve zero emissions by employing the highest standards in green design, construction, operation, and maintenance of new and existing buildings. Retrofits will be necessary to achieve energy efficiency in existing buildings, thereby reducing emissions. Higher density neighborhoods built closer to commercial and retail centers will promote alternative methods of transport and movement, including walking, cycling, and mass transit. The City can benefit from appropriate land use planning such as recycling water, recycling waste, and increasing carbon sinks by planting trees, shrubbery, and vegetation, green rooftops, and constructing new parks. In short, the City, its residents, and businesses have an excellent opportunity to provide a model to share with other communities throughout the U.S. and abroad to achieve carbon neutrality by 2050 and benefit the earth for generations to come.

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