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The City of San Francisco, CA Climate Mobilization

Draft Technical Implementation Plan – Phase 1

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Note: This is an example document that is intended to demonstrate the kind of mobilization plan that a city like San Francisco, CA will utilize to engage in an 8-year rapid emissions reduction program. All values in this document are subject to change as better information about local conditions are provided by government officials in the development of a formal implementation plan.

PREFACE.

Dramatic advances in low-cost solar, battery storage and electric vehicle technologies offer an opportunity for the City of San Francisco to slash community-wide greenhouse gas emissions to net zero by 2025. By initiating a World War II-intensity climate mobilization this year, the City can achieve this imperative while greatly boosting the regional economy, securing economic and environmental justice for all citizens, and positioning San Francisco as the leader of the global mobilization required to restore a safe climate.

This document outlines a set of steps that could be taken to drastically reduce fossil fuel use, achieve regional food and water security, and begin the process of drawing down excess carbon from the atmosphere.¹ These extraordinary measures go far beyond what is being implemented or considered in any American city, and — if successfully delivered — could draw international interest, acclaim, and investment, while generating hundreds of thousands of new jobs.² With globally averaged temperatures projected to breach catastrophic levels within the next 10 years, the time is right for Citizens to launch the global climate mobilization.³

As in America's home front mobilization of the 1940s, the San Francisco climate mobilization will require strategic market interventions and investments in workforce development to accomplish tremendous feats of production.⁴ Highlights of the proposed mobilization include a comprehensive "Victory Gardens" distributed agriculture program, a Copenhagen-style city bike network, the development of electric shuttle, bus, and autonomous vehicle public transportation fleets, and the creation of city-owned manufacturing facilities to produce key efficiency, storage, and alternative energy technologies. Furthermore, the proposed broad range of investments in

new infrastructure and city services would substantially increase the City’s commitment to energy and transportation democracy.

This San Francisco Climate Mobilization draft plan is designed to work in concert with other sustainability, infrastructure and environmental and social justice programs, while providing a commensurate response to the dramatic intensification of the climate emergency in recent months. In addition to providing robust stakeholder feedback on this draft technical implementation plan, it is our hope that community leaders can develop companion plans and visions to ensure that the San Francisco climate mobilization effort secures justice for all Citizens.⁵ Like America’s World War II mobilization, which was motivated in part by a vision of a world governed by the Four Freedoms⁶ and a Second Bill of Rights⁷, the San Francisco climate mobilization must be guided by our highest ideals.

INTRODUCTION.

This preliminary technical implementation plan provides a concrete vision of the first phase⁸ of the emergency decarbonization of the City of San Francisco. It details policy and implementation schedules for six key sectors — Energy, Transportation, Industry, Food, Water, and City Services. However, it is not comprehensive and does not address critical areas and issues, including workplace safety standards, prevailing wage provisions, housing affordability and supply, and public engagement strategies to enlist all Citizens in the mobilization, as well as the pressing need to remove carbon from the earth’s atmosphere on a tremendous scale.⁹

For the purposes of this plan, the term “net zero emissions” relates to all embedded emissions associated with energy use, transportation, water consumption, and food production. While this plan does not produce a complete elimination of fossil fuel consumption and greenhouse gas emissions associated with consumption (i.e. air travel, meat and dairy consumption, and embedded emissions associated with the production of imported goods), it does slash emissions to such an extent that the simultaneous deployment of extensive regenerative agriculture carbon sequestration activities utilizing biochar and composting feedstocks could successfully drive the San Francisco economy to net zero emissions by the end of the year 2025.¹⁰

Future phases of the San Francisco Climate Mobilization plan will focus on achieving a complete zero greenhouse gas emissions economy across all sectors as well as a massively scaled-up carbon removal (or drawdown) effort. These herculean efforts will be necessary in order to restore safe, late Holocene, climate conditions.¹¹

EXECUTIVE SUMMARY.

The San Francisco Climate Mobilization draft technical implementation plan provides a framework of implementation activities to achieve net zero greenhouse gas emissions within the City of San Francisco over an 8-year timeline.¹² The proposed rapid transformation of The City's emissions profile is directed by local government intervention in key industry sectors, in the tradition of the whole-of-society mobilization that took place in the United States during World War II.¹³

This plan adopts best practices for similar renewable generation production and efficiency achievements from Germany¹⁴ and Canada.¹⁵ Multiple technical resource projections were utilized to ensure feasibility of all proposed developments and labor-force needs.

To achieve 100% renewable generation capacity, this plan proposes the utilization of 70% of all qualified rooftops¹⁶ within The City of San Francisco to receive rooftop solar panel installations, for a cumulative distributed solar power generation of 840 MW of new installed rooftop DC capacity.

The development of large-space, grid-scale solar systems are also required to meet both current electricity demand and additional load requirements as a result of fuel-switching from fossil fuel consumption in residences and gasoline in the transportation sector. The cumulative installed capacity needs for grid-connected solar in the plan is 546 MW of new installed grid-scale solar generation capacity. New wind resource development is also needed to provide energy during off-solar peak periods. This plan proposes that the City of San Francisco site 638.8 MW of installed AC wind generation capacity, using new 110-meter hub turbines in areas identified by NREL to have a gross wind capacity factor of 34% or higher.¹⁷

Due to the variable nature of renewable energy generation, and the need for continuous supplies of electricity, this plan proposes 8,442 MWh of total installed energy storage capacity. This energy storage need is met by the enrollment and average daily supply of 1,018 MWh of Vehicle-to-Grid resources,¹⁸ 4,052 MWh of new Li-Ion grid-connected battery storage¹⁹ and 3,372 MWh of new, municipally-owned Compressed Air Energy Storage (CAES) infrastructure with associated thermal energy storage systems for increased efficiency gains.²⁰

Rapid and deep reductions in The City's electrical energy use are provided through an aggressive deep-energy efficiency retrofit program that installs city-produced mini-split (ductless) and rooftop heat pump systems, retrofits of all natural gas, fuel oil and conventional electric residential water heating systems with heat pump water heaters, and installs blown-in cellulose rooftop insulation. These and other efficiency measures are projected to reduce the residential electrical load by 222.4 GWh per year.²¹ As a result of thermal energy capture-and-storage systems associated with distributed CAES operations, additional savings to large-scale commercial end-users are estimated to be 87.2 GWh per year.²²

City-wide natural gas and/or fuel oil consumption must also be switched to electrical power-supplied appliances to achieve a zero net greenhouse gas emissions system and to improve in-home air quality.²³ To achieve this goal, The City contracts government-owned, contractor

operated (GOCO) manufacturing facilities for the production of heat pump water heaters that eventually replace every standard electric and natural gas water heating appliance.²⁴ The installation of electric stoves and water heat systems are incorporated into the residential deep-energy efficiency retrofit program. The plan projects a need for 384,380 standard electric and fossil fuel supplied water heaters and 326,790 gas range replacements in city homes and businesses.

Additionally, the plan projects an increase of 216,360 new plug-in electric vehicles²⁵ and an operational fleet of 39,190 fully autonomous (AV-5) ride-sharing taxis.²⁶ These vehicles are projected to increase city electricity demand by 1,922 GWh per year by 2025.

To achieve community-wide carbon neutrality, the plan includes comprehensive municipal composting of food and yard wastes²⁷ that are combined with regionally-sourced biochar feedstocks²⁸ and utilized within a distributed agriculture program modeled after the popular “Victory Gardens” project of World War II. This system works to develop 89,740 new front- and backyard gardens in the City.²⁹ To achieve a targeted 56% reduction in all imported vegetable produce, the City of San Francisco also develops green-roof gardens in locations not deemed suitable for solar installation.³⁰ To achieve significant reductions in greenhouse gas emissions resulting from water transport and storage in San Francisco, and to facilitate the local production of food, the “Green Gardens” project also develops greywater and rooftop catchment and storage systems in participating households.³¹ Additional rooftop solar-powered water vapor condensers, rapidly entering the market, are installed to attain the targeted reduction in city water system consumption by 20%.³²

Workforce development activities to assist in the direct implementation of these sweeping transformations are expected to create 117,570 new jobs in addition to the significant growth projected in the manufacturing and services sectors. The rapid reduction of fossil fuel expenditures, seen as a net-regional loss of economic resources, are instead applied locally and retained within the City’s economic system.³³

Finally, the resulting benefits of radically improved air quality, reduced commute congestion, climate resiliency and community interdependence will result in significant increases in economic, environmental and social justice within The City of San Francisco.³⁴ These benefits, once achieved, will reduce expenditures associated with endemic poverty and health care costs, and upon completion will move us closer to a society free from want or fear.

METHODOLOGY.

To develop a working model of a rapid greenhouse gas reduction plan, assessments were made for the technical feasibility of all processes and activities within the plan to determine their qualification for adoption. Heavy reliance was made on previous energy and water efficiency program designs and process implementation strategies in the United States and Canada. Peak load, total annual renewable energy generation and energy storage needs were determined using regional-specific consumption profiles of cities and counties and adjusted for key demographic and economic profiles. Satellite rooftop solar feasibility surveys³⁵ were used to determine technical potential for distributed power generation. If location specific data was not obtainable, a reasonable proxy location was selected by latitude, population and economic characteristics. Analysis of industry projections of Li-Ion battery storage,³⁶ solar power system,³⁷ and electric vehicle production³⁸ were used to develop likely implementation scenarios over the scoped 8-year project implementation cycle. Household appliance and energy consumption surveys of the City of San Francisco provided by the Energy Information Administration³⁹ were used to determine natural gas and fuel-oil appliance saturation use in residences as well as household electric consumption. The development of all program administrative activities were derived from experience in program implementation and taken from working knowledge of the World War II mobilization strategies initiated by the U.S. Federal Government.

ENERGY.

Policy Activities	Completion Date
Identify and secure <i>storage & staging facilities for bulk-purchased distributed solar power equipment</i> . Begin bulk purchase / sale program to preferred solar installation vendors. ⁴⁰	2019
Planning Department to identify most common single-family building types and develop <i>pre-approved solar system configuration building plans</i> for streamlined construction. ⁴¹	2020
Complete <i>preferred vendor selection process</i> for the identification of private solar power equipment installers to perform residential and small commercial <i>rooftop solar power installations under “cost-plus” contracting</i> and benefitting from municipal equipment storage / staging and delivery services.	2020
Develop <i>Time of Use (TOU) & Time of Supply (TOS) Feed-in Tariff</i> to support distributed energy generation, distributed energy storage solutions and Vehicle-to-Grid (V2G) operations. ⁴²	2020
<i>Lobby state government officials for legislation directing the State of California to act as the sole-sourced lender providing subsidized, very low-interest or zero interest loans for a residential on-bill financing program</i> that performs residential deep-energy efficiency, appliance fuel switching, and renewable generation retrofits. ⁴³	2020
File and successfully pass special-use bond for the development of <i>City-owned Green Bank</i> to finance energy generation and storage infrastructure developments. ⁴⁴	2020
Develop <i>power grid adaption plans for saturated solar energy generation</i> , including necessary storage infrastructure placement needs, distribution requirements and grid stability issues. ⁴⁵	2020

This level of government intervention, not seen since the World War II mobilization effort, will be required to achieve a rapid transformation of the energy sector. The development of incremental “cost-plus” bulk contracting of goods and services, identification of preferred vendors, and utilization of public funds to identify and promote key sector activities would constitute a distinct change from the current approach to economic development.

The bulk purchases of solar generation equipment and reduced cost of transport, warehousing and staging are proven market assist activities that worked to cut incremental installation costs in Germany. During Germany’s *Energiewende* transformation of the past decade, such increased gains in efficiencies of scale drove per unit installation costs 20% below those in the United States, even as average wages and benefits paid to laborers were higher. To produce an effective and timely transformation of the energy sector, similar activities must be engaged by the City of San Francisco.

To support the wide-scale adoption of energy generation infrastructure, monumental changes to the electric power grid must be engaged. The integration of distributed solar with variable voltage and frequency outputs and associated energy storage infrastructure must be met with regional load forecasting to ensure continued grid stability. New switchgear and other distribution infrastructure will need to be put into place. It is recommended that this transformation be performed on a region-by-region basis to prevent the over-commitment of resources and to allow for a smooth transition to a renewable energy-powered grid.

Implementation Activities	Completion Date
Identify <i>workforce training and development</i> needs, begin process for providing training / scholarships for workforce to meet the needs of the City’s solar installation goals.	2019
Develop <i>workforce training and placement</i> with preferred program vendors for City deep-energy efficiency retrofit and appliance fuel-switching programs.	2020
Begin operation of <i>Government-owned / Contractor-operated (GOCO) solar panel & associated technology manufacturing facilities</i> for low-cost stock supply to solar saturation project. ⁴⁶	2021
Contract for <i>deep-energy efficiency residential and small commercial retrofit program</i> offerings that utilize subsidized low-interest or zero-interest on-bill financing. Retrofits offered include: Attic blown-in cellulose insulation, ductless & rooftop heat-pump HVAC, heat-pump water heating, low-cost water conservation, air sealing measures and natural gas-to-electric appliance retrofits. Opportunity provided to preferred vendors contracted on a pre-determined cost-plus basis. ⁴⁷	2021
Contract for ‘ <i>solar parking</i> ’ retrofits to large parking facilities to increase vehicle charging during solar peak hours and to increase participation in Vehicle-to-Grid (V2G) program. ⁴⁸	2021

Complete siting and land-lease, and begin construction of new <i>110-meter hub height wind-power generation resources</i> with 34% or greater gross capacity factor. ⁴⁹	2021
Complete construction of <i>Government-owned / Government-operated (GOGO) manufacturing facilities</i> for the production of low-cost ductless and rooftop heat-pump HVAC and heat-pump water heating systems. ⁵⁰	2021
Identify and contract construction for <i>all city-owned structures to implement rooftop solar, green roofs & deep energy efficiency retrofits</i> (i.e. ceiling & wall insulation, ductless & rooftop heat-pumps, heat-pump water heaters, rooftop water collection, greywater collection etc.).	2021
Begin siting and construction of <i>municipal compressed-air energy storage (CAES) systems</i> with related thermal energy capture for increased system efficiencies.	2022
Achieve <i>840 MW DC of installed rooftop solar</i> generation capacity.	2025
Achieve <i>546 MW DC of installed grid-scale solar</i> generation capacity.	2025
Achieve <i>638.8 MW AC of new wind power generation</i> in the form of 110-meter hub turbines with annual resource capacity of 34%. ⁵¹	2025
Achieve <i>8,442 MWh of cumulative energy storage capacity</i> – including V2G program participants, Li-Ion battery and municipal compressed air energy storage (CAES) facilities.	2025
Achieve <i>9% reduction in annual large-commercial electricity consumption</i> . ⁵²	2025
Achieve <i>30% reduction in annual residential electricity consumption</i> . ⁵³	2025
Achieve <i>100% reduction in residential & large commercial natural gas consumption and fuel-oil</i> .	2025
Provide training and full-time <i>employment opportunities for 78,380 City residents</i> for energy efficiency retrofit and solar saturation installation programs.	2025

These implementation activities follow the blueprint established during the World War II home front mobilization of using public funds to determine the most efficient product and mass-producing it on the scale necessary to achieve victory. The engagement of an all-out mobilization

with a rapid increase in training and employment opportunities for the public will produce large economic gains for The City.

Increased electrical power generation needs associated with the electrification of transportation and residential fuel-switching from natural gas and fuel oil are considered in the projections of renewable generation growth as are energy storage needs required to meet the variable nature of these energy sources. Current projections of electric vehicle usage projections attributed a slightly lower annual load requirement per electric vehicle than this assessment⁵⁴ and these additional energy demands were largely offset through deep-energy efficiency retrofit activities.

The utilization of distributed compressed air energy storage systems as the primary method of energy storage is a new development that is selected for this plan due to significant regional benefits above the emergent Li-Ion battery systems. The ability to scale this resource by providing additional storage and charging facilities allows greater flexibility for grid-system operators. This system also uses readily-available proven technology that can be developed locally for additional regional economic benefit. The increased system efficiencies associated with the use of cold exhaust air for the production of ice for day use by large commercial buildings is a currently viable technology.⁵⁵ Heat is also captured during the compression cycle phase of operations to produce additional efficiency gains in configurations similar to the thermal energy storage system being developed for the Los Angeles International Airport⁵⁶ as well as through the direct offset of heating and other heat-process loads. The majority of large-commercial energy use reductions are associated with this additional savings potential.

This plan utilizes satellite-based rooftop solar potential assessments to achieve 70% solar penetration of qualified city rooftops with an average solar system capacity of 4.8 KW DC per roof. To meet energy demands, installed grid-connected systems on open-space and public-use space locations with significant additional capacity installed in outlying regions, will also be required. A significant increase in installed wind generation capacity to alleviate some off-peak power generation needs and to reduce the total system energy storage requirements will also be built. This wind power is produced by newer, 110-meter hub-height wind turbines situated in favorable locations identified by the National Renewable Energy Laboratory wind resource maps to have an associated annual gross capacity factor of 34% or greater. This wind resource is projected to have a 10% peak demand coincidence and provide energy supply during the hours when solar generation is not possible.⁵⁷

Deep-energy retrofits provided by program implementers should be staffed by local workforces who work within their own communities with additional regional and state incentives provided for the training and employment of residents from identified disadvantaged communities. The City should explore policies that target disadvantaged communities and take advantage of grants and incentives directed toward economic development within these communities.⁵⁸ If feasible, new manufacturing facilities that use energy derived from non-fossil fuel sources, resulting in very low air-quality impacts, should be sited in city areas that would benefit from local economic development and the new jobs that would result.⁵⁹

TRANSPORTATION.

Policy Activities	Completion Date
Identify key transportation corridors and infrastructure needs to develop a <i>vibrant park & ride system of autonomous electric shuttle, electric-powered busing, PEV ride share and walk / bike path infrastructure.</i>	2020
Identify <i>key city center and shopping districts</i> to be targeted as <i>Vehicle Exclusion Zones</i> with park & ride access points, autonomous electric shuttle services and bike-and-walk path access. ⁶⁰	2020
Identify and select a standardized PEV bi-directional charging system with user identification communication protocols for operation of <i>Vehicle-to-Grid (V2G) feed-in tariff.</i> ⁶¹	2020
Complete licensing and regulatory process for <i>on-call autonomous vehicle taxi fleets.</i> ⁶²	2021
Establish a <i>docking tariff schedule for fossil fuel powered freight transport</i> within city limits that increases to peak per-trip cost at 2025. ⁶³	2021

The use of liquid fossil fuels for transportation generates the majority of greenhouse gas emissions in most regions and is the primary source of non-industrial air pollution harming the health of many Citizens. The City Climate Mobilization plan incorporates recent developments of lower-cost Li-Ion batteries and the emerging disruptive technology of fully-automated electric vehicles operating through a municipal taxi fleet with ride-sharing options to generate the bulk of emissions reductions for the entire city.⁶⁴ This strategy works well with the associated solar power energy build-out that will generate a large amount of excess energy during peak solar between the hours of 10 a.m. and 4 p.m. A rapid build-out of inductive charging platforms will need to be sited and constructed to prepare for the deployment of this technology in the latter half of program implementation.

The adoption of electric biking, park-and-walk systems and autonomous trolley and shuttle services will be necessary to facilitate the development of “vehicle exclusion” zones within major city centers. To speed the adoption of new electric vehicle freight transport, per-trip docking fees are applied to fossil-fuel delivery vehicles with a scheduled ramp-up through 2025.

These new electric freight vehicles are scheduled for production in 2018 and projections of per unit and per mile operational costs are very favorable compared to traditional diesel-powered transport.

Finally, the identification of a consortium of integrated bi-directional charging platforms to be adopted by city codes for household and public installation will streamline the communication development needs for a vibrant Vehicle-to-Grid (V2G) and smart-charging system that will allow stored energy accumulated during the peak solar hours to be made available during off-peak hours with significant benefits to both grid operations and ratepayers. The subsidized installation of these systems through government retrofit projects, as part of the larger deep-energy efficiency retrofit program, will work to greatly increase the accessibility and market adoption of plug-in electric vehicles by households.

Implementation Activities	Completion Date
Site and begin construction of <i>inductive charging platforms</i> at electric busing and autonomous trolley and shuttle loading zones. ⁶⁵	2020
Identify siting and begin construction of <i>park & charge concierge parking facilities</i> for solar-peak vehicle charging for registered participants in the municipal V2G feed-in tariff; provide park-to-door shuttle service for participants.	2020
Contract for subsidized PEV standard <i>V2G charging system installation in single- and multi-family residences</i> with subsidized low-interest or zero-interest on-bill financing. ⁶⁶	2021
Explore the development and operation of <i>municipally-owned autonomous vehicle shuttle fleet</i> (GOGO or GOCO).	2021
Establish <i>first vehicle exclusion zone</i> in city center or shopping district.	2023
Begin siting and construction of <i>inductive charging stations for autonomous vehicle fleet operations</i> . ⁶⁷	2023
Complete the installation of <i>167,870 in-home V2G bi-directional electric vehicle charging systems</i> . ⁶⁸	2025

Establish a <i>fully operational city-owned 39,190 autonomous electric vehicle ride-sharing fleet</i> with inductive charging capability and 200+ mile battery life. Implement voluntary ride-sharing option to increase customer participation at reduced per-mile costs ⁶⁹ with a target of 30 daily trip offsets per vehicle.	2025
Establish a <i>fully operational city-owned 2,530 autonomous electric ride-sharing shuttle fleet</i> to operate as a Mobility-on-Demand (MOD) platform for short trips and within vehicle exclusion zones. ⁷⁰	2025
<i>Reduce gasoline consumption by 90%.⁷¹</i>	2025
<i>Reduce diesel consumption by 95%.⁷²</i>	2025

To facilitate the rapid transformation of the transportation sector away from fossil fuels and toward renewable energy, the City must engage in sweeping changes in land-use and public transportation infrastructure. The ideal of a “car-free city” has typically been found only in futuristic science fiction novels. With the advent of affordable electric-powered private and public transportation technologies in recent years, this goal can now be achieved.

The operation of a fully autonomous (AV-5) vehicle fleets within the City of San Francisco should be viewed as a sweeping new paradigm in the transportation sector that is akin to the development of the first gasoline-powered car. These vehicles will move effortlessly through traffic to pick-up passengers and deliver them safely to their destinations, allowing additional passengers along the way to reduce shared per-trip costs to consumers. They are projected in future years to reduce urban private vehicle ownership rates by up to 60%.⁷³ These vehicles have the ability to track electric system resource availability and can be dispatched to provide spot-charge and discharge-to-grid capability to increase regional grid stability of operations.⁷⁴ During peak solar periods, and in the absence of riders, they automatically navigate to inductive charging stations to maintain full battery capacity in between trips. Due to the heavy demand on these vehicles’ batteries, early scheduled replacements will be necessary. Upon replacement, these second-life batteries will be assembled and re-configured for use in the Li-ion battery grid storage program.

The development of viable walk / bike pathways — likely through elevated structures and dedicated lanes as found in Copenhagen and other European cities — will facilitate the adoption of standard and electric bicycle⁷⁵ use in the City of San Francisco. The associated development of park-and-ride, park-and-walk / bike systems will help to reduce traffic congestion and contribute to increases in public health and well-being. To produce the additional regional electric transport capacity needed for a vibrant system of public vehicle exclusion zones, City of San Francisco should engage with vehicle manufacturers to develop local manufacturing facilities to produce autonomous trolley and shuttle vehicles for use by citizens for short trips and within vehicle exclusion zones.⁷⁶

Finally, to increase the adoption rates of privately-owned plug-in electric vehicles, the City of San Francisco should develop municipal parking / shuttle services for daily commuters that allows them to park in regionally dispersed park, charge & ride facilities. These parking structures will be concierge-operated, allowing for each car to receive a full charge during peak solar hours while providing park-to-door busing or shuttle services for customers continuing on to their place of employment. As an additional incentive, these customers may receive free or discounted electricity if they are registered in the vehicle-to-grid program.⁷⁷

INDUSTRIAL SECTOR.

Implementation Activities	Completion Date
Develop and successfully implement an <i>aggressive incentive program</i> with grant-funding for the <i>implementation of flywheel energy storage, solar power generation, fuel-switching and energy efficiency retrofits for industrial accounts.</i> ⁷⁸	2020
Develop and complete qualification for <i>promotional brand “Made Green in San Francisco.”</i>	2020
Work with industrial accounts to <i>identify specialized industrial electrification retrofits</i> (i.e. RF heating and electric heating of molten salts) to replace current fossil fuel thermal processes. ⁷⁹	2023
<i>Reduce industrial sector fossil fuel energy consumption by 100%.</i>	2025

Central to industrial activity within the City of San Francisco are high-temperature processes that currently require fossil fuels for production. After the development of clean air regulations in the 1970s and beyond, these environmental restrictions forced many manufacturers to leave the region. The San Francisco climate mobilization draft implementation plan provides significant resources in the form of subsidized loans and benefits to manufacturers who switch to electricity-sourced operations for these process needs.

The use of flywheel energy storage technology for processes that require short pulses of high energy use are already utilized by many specialized facilities as a way of offsetting expensive demand charges. Including this technology within the framework of distributed power generation will produce significant reductions in electrical distribution loading and associated line-losses for many manufacturers.

The ramping up of government-owned manufacturing facilities for products required by the mobilization effort will increase the trained workforce in the manufacturing sector in the City of San Francisco. This regional benefit coupled with aggressive development incentives directed toward disadvantaged communities with new geographically dispersed and vibrant public transit networks and combined with a nationally recognized “Made Green in San Francisco” manufacturing label, will attract significant additional new manufacturing facilities to the City of San Francisco. These good-paying local jobs will provide substantial benefits to their local communities.

FOOD & WATER PRODUCTION.

Policy Activities	Completion Date
Establish <i>multi-bin waste collection ordinance</i> for all waste collection locations, including curbside pick-up (landfill, paper, recycle, food & yard waste). ⁸⁰	2018
Develop workforce training and placement program for <i>City Green Gardens municipal workforce program</i> .	2019
Begin registration and support for the creation of <i>food collective Community-Sourced Agriculture (CSA)</i> supply, collection and delivery processes. ⁸¹	2020
Identify municipal building rooftops that do not qualify for solar panel build-out and begin construction of <i>green roof garden placement</i> .	2022

Vital to a successful implementation of a zero emissions strategy is the consumption of locally-generated foods. This process takes all municipally-generated compost and combines it with regionally generated biochar for active carbon sequestration and increased soil vitality. Additional benefits of the production of this soil amendment for public use are reductions in landfill transport and increased baseload power generation using captured biogas. Other public benefits include regional economic gains, increased consumption of fresh produce, a natural reduction in meat consumption that occurs with a constant supply of vibrant and healthy, low-cost, locally grown foods, and the increased interdependency of communities through trade, CSA program collection, packaging and delivery operations and farmers’ market platforms.⁸²

Implementation Activities	Completion Date
Develop <i>municipal compost production facilities with biogas capture</i> for electric power generation. ⁸³	2019
Launch City ‘ <i>Green Gardens</i> ’ <i>development workforce program</i> .	2020
Contract for <i>greywater capture & storage with associated rooftop rainwater capture & low-cost solar powered atmospheric condenser system installations</i> for homes participating in front- and backyard gardens program. ⁸⁴	2020
Contract with <i>regional biochar generation facilities</i> utilizing forestry and agricultural feedstocks for power generation and biochar supply for inclusion in municipal compost system as soil amendment. ⁸⁵	2021
<i>Achieve 56% reduction of imported city produce.</i> ⁸⁶	2025
<i>Achieve 20% reduction in draws from municipal water systems.</i> ⁸⁷	2025
Provide training and full-time employment opportunity for <i>39,190 City residents in City ‘Green Gardens’ municipal workforce</i> .	2025
Successfully develop an additional <i>89,740 front- and backyard gardens with associated water capture and greywater use systems</i> .	2025

To establish a vibrant Green Gardens program, The City will need to develop a recruitment and training program for workforce development. This team of individuals, operated by local contractors, will work to develop household atmospheric water capture technology using solar-powered dehumidifiers and grey-water and rooftop water catchment systems. They will also contract to develop subsidized backyard and front-yard garden spaces with deliveries of municipal agricultural feedstocks, plot development, and irrigation system installations. Within the City of San Francisco a target of 56% of all consumed produce generated locally will also greatly reduce greenhouse gas emissions associated with the production, transport, and display of these foods.

In addition to distributed backyard agriculture, The City should also perform green roofs retrofits of municipal buildings that do not receive full sunlight for solar power generation. These rooftop gardens will provide clean space, reduce cooling loads and generate additional revenue for The City.

Several global studies of cost-effective greenhouse gas mitigation activities have pointed to the use of regenerative agriculture as a primary solution to drawing down dangerous greenhouse gases from the atmosphere.⁸⁸ By feeding the soil, the development of vibrant soil cultures drives carbon deeper into the earth.⁸⁹ When implemented as part of a rapid decarbonization strategy, this necessary activity will work to help remove excess greenhouse gases from the earth’s atmosphere and bring the City of San Francisco toward a net zero — or even a net negative — emissions profile.

CITY SERVICES.

Implementation Activities	Completion Date
Explore the potential development of <i>Compressed Air Energy Storage (CAES) as a municipal service for off-solar peak power generation with capture of exhaust gas for thermal energy storage and chilled water production for large commercial service.</i> ⁹⁰	2018
Negotiate purchase agreements for delivery of electric vehicle fleet (refuse collection, municipal busing and maintenance vehicles) with <i>targeted 100% conversion of municipal fleet.</i> ⁹¹	2023
Implement a “ <i>No Emissions Left Behind</i> ” policy for replacement of all fossil fuel-powered hand-held and construction equipment with Li-Ion battery powered systems, including battery trailers for large industrial vehicles. <i>Require contracted construction firms to replace fossil fuel fleets with electric vehicles by 2025.</i> ⁹²	2023
Complete <i>construction of vibrant municipal CAES production and high-pressure air delivery service</i> with associated capture of cold exhaust air for large-commercial thermal energy storage. <i>Achieve 3,372 MWh of total CAES storage capacity.</i>	2025

The use of electric-powered industrial vehicle fleets is currently cost effective for the City of San Francisco and the replacement of these vehicles early in the climate mobilization plan cycle will provide a concrete example of the City’s commitment to providing a viable climate future for all citizens. Similarly, the recent development of cost-effective battery powered hand-held equipment will lead to significant reductions in noise⁹³ and air pollution⁹⁴ impacts upon municipal employees.

The development of a new municipal service of high-pressure air to large-commercial clients would be the end-result of the development of a vibrant, distributed CAES system. This infrastructure development should be viewed as part of the larger societal transformation of climate mobilization. The utilization of this energy storage resource for necessary off-solar peak power generation will provide, as an additional benefit, great reductions in cooling load demands for medium- and large buildings.

CONCLUSION.

If successfully implemented, this draft technical implementation plan could transform the City of San Francisco's economy to net zero greenhouse gas emissions by 2025 and set the stage for a global mobilization to restore a safe climate. This plan for the first phase of the San Francisco Climate Mobilization is a continuing work-in-progress and must be further developed through robust stakeholder and community feedback.

ADDENDUM (A NOTE FROM THE AUTHOR).

Subsequent to the development of this draft implementation plan in the Spring of 2017, a growing coalition of local governments that wish to affirm our Nation's continuing commitment to the international goals of greenhouse gas emissions reductions has formed. To date, over 50 cities and towns in our country have made commitments to achieving reductions in emissions that are equal to, or better than, the Paris Climate Accords. Some entire states have passed binding resolutions that are even more aggressive. This trend is sure to continue as the current targets within the Paris Accords are widely viewed as inadequate to achieve the intense policy shifts away from fossil fuels that will be required to prevent climate change that is both irreversible and catastrophic. In response to this shift in climate priorities by local communities, the Rocky Mountain Institute has released its *Carbon Free Cities Handbook*. This resource contains many of the policies outlined within this document and provides case studies of cities and communities that have already moved forward in their implementation. This resource may be downloaded here: <https://www.rmi.org/carbonfreecities/>

This work provides additional support for many of the policies contained within this draft demonstration plan and it should be used by local TCM chapters and elected policymakers who wish to lead their own communities toward policies and actions that will soon catalyze into a national movement to effectively address the urgent national threat that is climate change.



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NOTES.

Preface

1. Current UN International Panel on Climate Change carbon budget analyses show that we will overshoot 1.5°C and, when carbon cycle feedbacks from warming soils (Crowther 2016) and precipitation regime shifts (Page 2002) (Jiménez-Muñoz 2016) are included, have likely surpassed the current carbon budget available to prevent 2°C of globally averaged warming. The growing consensus among climate scientists is that some form of atmospheric CO₂ extraction and sequestration will be required. For more information see: (Peters and Geden 2017)
2. (Höhne 2015) This assessment of national benefits from projected COP-21 voluntary reduction targets finds that the U.S. goals would produce 470,000 new jobs with significant benefits in reductions of pollution, health care costs and fossil fuel purchases. The per-capita emissions reductions and sustainable-city developments within this localized plan are more comprehensive and operate within a much shorter timeline than the national targets offered by the Obama Administration under the Paris Climate Accords. This results in greater job creation rates, on a per-capita basis.
3. (Pearce 2017)
4. For a comprehensive analysis of U.S. efforts during the national mobilization to defeat global fascism see: (Wilson 2016)
5. For a detailed analysis of the implications of future climate impacts on disadvantaged communities as well as the economic and environmental justice advances obtained through focused urban mitigation and adaption activities see: (Jabareen 2011)

6. (Roosevelt, Annual Message to Congress on the State of the Union 1941)
7. (Roosevelt, Annual Message to Congress on the State of the Union 1944)

Introduction

8. As the City of San Francisco moves toward a sustainable zero-carbon emissions economy the growing impacts of climate change will require intense adaption and CO₂ drawdown efforts. These activities will require separate implementation plans. This draft mobilization plan sets the stage for these critical activities with the engagement of civic leaders, the development of energy and transportation democracy platforms as well as increasing city resiliency and sustainability through the development of new infrastructure and city services.
9. Examples of other areas omitted are the development and implementation of pricing structures governing imported goods according to their embedded greenhouse gas emissions in production and transport, Hyperloop and electric high speed rail construction, and automated electric vehicle freight transport. These necessary activities are outside of the influence of any single-city and will likely be incorporated within larger regional or national climate mobilization projects.
10. The development of regenerative agriculture as a means to offset current greenhouse gas emissions is fundamental to restoring a safe climate. (Rodale Institute 2014) The adaption of biochar as a secondary feedstock has been demonstrated to increase soil fertility and to greatly extend the retention of carbon in soils. (Bolan 2012) The specific application of this strategy toward urban agriculture environments results in increased soil fertility, local resiliency, regional economic development and

improvements in groundwater retention and aquifer recharge. (Rhodes 2017)

11. (Marcott 2013) This ground-breaking research document showed that globally averaged temperatures are currently above 66% of the entire span of temperatures that has occurred during the current interglacial period, called the Holocene. This work shows that as globally averaged temperatures exceed 1.5°C, we will pass the maximum temperature experienced during the previous 11,300 years. Projections of future temperature increases indicate that it is very likely that we will exceed the previous interglacial maximum temperature (MIS-5e) of 2.5°C above pre-industrial that occurred 123,000 years ago.

Executive Summary

12. This timeline assumes an immediate engagement by the City of San Francisco with necessary ramp-up to eventually achieve full mobilization from all sectors of the local economy. It includes the projected development schedules of emergent technologies and resources within an aggressive implementation schedule that is analogous to those activities that occurred during the re-tooling of the U.S. manufacturing sector to meet the production and resource demands during WWII.
13. (Wilson 2016, 59-91)
14. (Seel 2013)
15. (Econoleur 2016) also: (Henwood 2015)
16. (Google 2017) This satellite survey of potential rooftop generation includes full-sun and partially-shaded roofs and includes rooftop orientation in its analysis. Cumulative solar potential for the City of San Francisco is projected to be 80% of all rooftop space. It is expected that some percentage of this total will be considered unfeasible and this mobilization plan projects that 70% of all rooftops will be

developed for distributed energy generation. It should also be noted that this tool uses current solar panel efficiencies in their analysis. As solar panel research and development continues, panel efficiencies will continue to increase, therefore this total rooftop solar potential is conservative. Additional solar panel efficiency gains may also be achieved by incorporating micro-CAES generated cold air for single-pass cooling of rooftop solar panels. See: (Moharram 2013) and 22 below.

17. The location for large-scale wind farm development can be identified through wind-resource maps provided by the National Renewable Energy Laboratory. (National Renewable Energy Laboratory 2014)
18. Vehicle-to-Grid (V2G) operations allows private electric vehicle owners to provide excess stored electricity to power their home or to sell back to the grid during the evening power demand peak at favorable rates. It is assumed that 20% of vehicles with this capability will provide a small portion (15 kWh) of their daily battery storage potential each evening. These individuals charge their vehicles during the solar-peak and either did not use their vehicles that day or have a short daily commute. For more information on the use of V2G and impacts on battery performance see: (Dubarry 2017) While this operation will likely lead to somewhat reduced battery life, current industry demand for batteries allows individuals to resell their used batteries on the second-life market for use by electric utilities where they will be configured into grid-scale storage platforms or private markets where they can be used in behind-the-meter (powerpack) residential and commercial storage solutions. For current industry projections of the use of second-life car batteries for grid-scale storage see: (Martin 2016)
19. These grid-scale battery storage platforms are similar to the currently operating 80 MWh Mira Loma substation storage facility

provided by Tesla to Southern California Edison and was completed in January, 2017.

20. This energy storage system makes up the majority of total energy storage potential for this mobilization plan. This integrated system of distributed compression, storage and power generation facilities will be installed at large-commercial and industrial sites that require significant electricity consumption for heating, heat-process, cooling, refrigeration and chill-water loads. In these locations, the use of thermal energy storage (hot and cold), combined with high-efficiency turbine pneumatic drive motors to generate electricity is projected to provide a total energy storage and utilization system efficiency of up to 68%. In addition, the use of very cold exhaust air provided during the power-generation cycle will be extremely valuable in later phases of climate adaption where projected future heat-waves will become life-threatening and require the deployment of community cooling centers distributed throughout the city. Upon the development of a standardized design, this system can be locally mass-produced and installed by local trade unions providing additional benefit to the local economy. For a detailed explanation of this system and its operations see: (Kim 2012) Section 3.4 Trigenation Micro-CAES System.
21. These efficiency gains represent 30% of total residential electricity consumption through the implementation of traditional efficiency measures that are known to have a simple pay-back period of 10 years or less. Case studies demonstrating more extensive deep-energy efficiency retrofits, with resultant efficiency gains of 50-90% have been performed. See: (Green Building Advisor 2015) Additional savings will be achieved through program applications to small commercial buildings.
22. For conservatism, this estimated savings potential only considers large-commercial HVAC cooling loads, additional energy savings from the capture of heat and cold in a trigeneration micro-CAES applied facility will produce savings that may be very significant, including a potential 7% increase in rooftop solar panel generation efficiency. (Moharram 2013) This study analyzes the benefits of water-cooling for increased solar panel efficiency gains. This mobilization plan identifies single-pass air-cooling of solar panels as a more appropriate, lower cost retrofit.
23. (Logue 2014) “The simulation model estimated that—in homes using natural gas cooking burners without coincident use of venting range hoods—62%, 9%, and 53% of occupants are routinely exposed to NO₂, CO, and HCHO levels that exceed acute health-based standards and guidelines.”
24. Heat pump water heater systems are a standard measure for utility industry energy efficiency programs with incentive offerings that range between \$200 (Southern California Edison) and \$750 (Efficiency Maine). Depending on regional conditions and installation environments the increased efficiency of these systems yields a breakeven per-unit cost that is calculated by the National Renewable Energy Laboratory to be between 150% and 200% of the current market price for many models. (Maguire 2014)
25. This is a significant portion of the 26 million cumulative electric vehicle sales projected worldwide through 2025 by OPEC. (Shankleman 2017) Increased rates of EV adoption can be facilitated through city-sponsored programs that provide financing mechanisms, partnerships with electric vehicle manufacturers for bulk purchases and the availability of low-cost day-use charging facilities for individuals registered as Vehicle-to-Grid (V2G) program participants. Similar market facilitation projects are currently being offered in Northern California by Sonoma Clean Power. See: (Kovner 2017)
26. Driverless autonomous vehicles (AV-5) are currently operating in some parts of the United States though they are required to

- have a driver for emergency operations. The California Department of Motor Vehicles released their proposed rules for AV-5 vehicle operations on April 25, 2017. The state has licensed 27 companies to test vehicle operations and fully-operational AV-5 vehicles are expected to be on public roads in many states by 2021. (Lienert 2017)
27. In 1999 the Halifax Regional Municipality (HRM) implemented a 4-bin waste collection protocol for all points of refuse pick-up. In addition, they partnered with local food industry to streamline the pickup of food waste from all sources. With a population of 400,000, HRM currently generates 53,000 tonnes of compost per year with plans to expand to 70,000 in coming years. (Panacci 2017)
 28. Regionally sourced biochar facilities may process farm and forestry waste stream products very cost-effectively for use as agricultural amendments. In addition, waste-heat from this process may be used in a combined-heat and power (CHP) system to generate net-zero carbon electricity which is then sold at peak demand to the electric power grid. (Gaunt 2008)
 29. Included in this estimate of installed gardens are urban community and school gardens. Similar to the Victory Gardens program, significant resource will be provided to citizens to design, develop, deliver, implement and maintain these plots. A minimum size requirement to qualify for this additional assistance will incentivize increased food production and environmental benefits, though private citizens may have access to soil delivery for personal use if excess resource is available.
 30. (Blackhurst 2010) In addition to producing food, green-roof projects also provide clean space for building occupants, reduce building cooling loads, slightly reduce urban heat-island effects and help to reduce storm water runoff.
 31. The additional cost of grey-water retrofits for capture and use in the Green Gardens program will likely reduce participation for this part of the program. Consideration must also be made to ensure sufficient water flow is provided for transport of solids to wastewater treatment facilities. The use of greywater and storm-water runoff, combined with the use of rooftop solar condensers will increase water flows to the ground water table for aquifer recharge.
 32. New developments in the chemistry of Metal-Organic Frameworks (MOFs) promise a cost-effective solar powered source of potable water through the capture of atmospheric water vapor. These systems produce potable water for in-home use and, if used within an extensive urban farming program, allows a portion of irrigation water vapor that is released through plant evapotranspiration to be recaptured, effectively recycling part of this water continuously within regional areas. While this technology is not currently available on the market, the City of San Francisco can provide research funding to assist in its development and eventually produce this equipment for mass distribution within the Green Gardens program. See: (Sanders 2017)
 33. In 2013 the Energy Information Administration determined that 4% of U.S. total pre-tax household income was spent annually on the purchase of gasoline. (Energy Information Administration 2013) Using household census bureau data, a reasonable estimate of \$1.04 billion dollars is spent by city residents annually on the purchase of gasoline. This estimate of total household costs is regionally adjusted based on local gasoline prices provided by the EIA. (Energy Information Administration 2017) Similar estimates of residential non-electric heating and cooking fuel expenditures for city residents are \$241 million dollars per year.
 34. A 2016 report from the American Lung Association of California (Holmes-Gen

2016) found that \$24 billion was spent annually on health care costs as a result of air pollution from fossil fueled vehicles in the 10 states studied. These costs, if applied to the total combined population within the study yields a per-capita cost of \$263 per person annually. If this per-capita average value is then applied to the City of San Francisco, city residents have a total annual expenditure of \$229 million dollars of hospitalized health care impacts due to fossil fuel vehicle use.

Methodology

35. (Google 2017)
36. (Green Tech Media 2017)
37. (Solar Energy Industries Association 2017)
38. (Cooper 2017)
39. (Energy Information Administration 2015)

Energy

40. This strategy of local government market intervention is consistent with the rapid deployment goals of a society that has determined that it is under a direct threat. These types of government market interventions were very successful in reducing per-unit installed costs of rooftop solar in Germany. (Seel 2013)
41. This streamlining of siting and permitting was performed by the Sacramento Municipal Utility District (SMUD) to reduce administrative hurdles for rapid solar adoption. Upon initiation of its *Solar Pioneer* project, these and other innovative solutions helped to reduce per-unit installed solar costs to half of the national average. For an excellent summary of these and other innovative implementation assists currently being engaged by municipal utilities to streamline the rapid adoption of rooftop solar power, see: (Farrell 2016)

42. Many states offer a residential Net Energy Metering (NEM) program that allows a homeowner to only offset energy consumption with rooftop solar. The sale of this electricity in these programs can only be applied toward the charges associated with power consumption, the homeowner does not receive any additional payments for the value of excess power supplied to the power grid. In effect, these programs restrict homeowners to size their rooftop solar systems to only meet their home's current demand. Therefore, these programs are intended to limit solar rooftop developments and do not unleash the power of the market to rapidly reduce community-wide greenhouse gas emissions. They also provides a negative incentive for landlords to invest in solar when their tenants pay the rental unit's electricity bill. The San Francisco Climate Mobilization plan proposes that a new NEM/FIT hybrid be developed that provides direct support to home and business owners to maximize their rooftop solar buildouts. This program simply credits the consumer's bill based on the total volume of energy provided, at the time of supply, with rates based on the cost of electricity at the time the power was generated and supplied to the grid. No restrictions are made on how much additional energy may be sold to the grid. This will allow private investments to help offset the public cost of climate mobilization. In addition, a variable Time-of-Use/Time-of-Supply tariff that targets a much higher rate during the period of peak demand will promote voluntary reductions in energy use during peak-demand periods, increase participation in the City operated Vehicle-to-Grid program and lead to additional investments in behind-the-meter energy storage (powerpack) systems for homes and small businesses. The provision of subsidized loans for rooftop solar construction and on-bill financing mechanisms that allow homeowners to pay down these loans over time will allow rapid entry into the solar market by all home and small business owners. This is the most feasible, low-cost method to rapidly scale up

solar power generation within The City and will lead to a rapid expansion in the local solar market, providing job growth and economic expansion over a period of several decades, while rapidly reducing the City's GHG emissions profile. For more information and analysis on the use of variable feed-in tariffs to increase community-scale energy storage see: (Parra 2017)

43. Loan guarantees for residential customers have been developed in multiple states to help secure low-interest financing for energy efficiency projects. However, these programs fall far short of what is required for a rapid transformation of the regional power grid away from fossil fuels. Within the province of Nova Scotia, subsidized loans have been provided at low or zero interest for efficiency program activities and these loans were paid through an on-bill attachment, usually at monthly values lower than the cost of electricity that would have otherwise been consumed. For more information on best practices for energy efficiency program delivery see: (Energy and Mines Ministers' Conference 2016)
44. Already adopted by several U.S. municipalities, the creation of a Green Bank/Infrastructure Bank provides economic return through the funding of cost-effective energy efficiency and alternative energy projects. By securing this financing mechanism, stability of operations going forward can be ensured through uncertain future levels of state and national support. A viable funding system also helps to secure additional bond revenue and, in future years, may allow an opportunity for city residents to provide economic support for the climate mobilization via their own market choices. The Yale University's Center for Business and the Environment has recently initiated a new project providing case study analyses of green bank designs and operations. See: (Shub 2017)
45. For a detailed description of private and public sector adaption strategies that will

facilitate the development of a distributed energy electric power grid see: (Rocky Mountain Institute 2011) also: (SAIC 2012)

46. "During all of World War II, the U.S. government would spend close to \$20 billion (\$301 billion 2017 dollars) on manufacturing facilities and machinery, more than double the amount invested by the private sector." (Wilson 2016, 61-62). For comparison, this value of direct investment represents the total cost of 60 brand new Tesla Gigafactories. However, economies of scale and other efficiencies generated under such a massive program would reduce the per-unit costs of construction far below the \$5 billion that was spent by Tesla to build their flagship facility. It is estimated that, within a streamlined national-scale manufacturing mobilization, this level of funding could produce over 100 Gigafactories and would generate enough new Li-ion battery production to allow the transition of the entire world to renewable energy. The Government Owned/Government Operated (GOGO) and Government Owned/Contractor Operated (GOCO) system of market transformation are consistent with efforts in the U.S. during WWII to provide high volumes of necessary goods and services, at least cost, during mobilization. Within the context of the existential threat of climate change, every effective means must be engaged to help secure victory. The contracting of necessary municipal services managed within government owned facilities is commonplace and these activities should be seen as an extension of this current practice. Securing manufacturing and service delivery through GOGO systems will be necessary to meet the maximum demand in a timely manner and at least-cost.
47. The administration of energy efficiency programs by vendors selected through an open-bid process and reimbursed on a cost-plus basis is the industry-standard for publicly-owned utility demand-side management programs. Within the standard

- delivery contract, a schedule of approved measures with their per-unit installed reimbursement rates ensures these measures are extensively deployed in a cost-effective manner.
48. The rapid buildout of electric vehicle public charging facilities will be necessary to facilitate that increased adoption of EVs in the private sector. Many of these facilities will be in the form of City operated solar-parking lots that are designed as concierge-operated park & charge facilities with solar canopies that provide shade to parked vehicles and generate electricity. Electric vehicles that register and participate in a city-managed V2G program are offered at reduced costs of parking and charging. These facilities will assist in shifting electric vehicle energy demands to the mid-day solar peak and increasing the supply of stored electricity during the evening period of peak demand through the V2G program. For examples of cities that have incorporated solar parking canopy facilities see: (Matasci 2017)
 49. In addition to wind turbine siting and construction, extensive transmission infrastructure must also be scoped and constructed. In the event that regional wind-resource availability is low, partnerships may be formed with a partner city and sited remotely.
 50. These systems are extremely cost-effective for the San Francisco area (Maguire 2014) and their manufacture and delivery through government owned mechanisms is consistent with a rational response to an existential threat. (Wilson 2016, 59-91)
 51. This amount of additional wind resource at high-yield locations will provide large volumes of energy during times when solar power generation levels are low. Besides being the least-cost energy resource available (Lazard 2017), this generation from wind resources will reduce the need for energy storage of the daily power produced through solar buildouts.
 52. This value represents savings associated with the use of trigeneration micro-CAES exhaust air for thermal capture and storage for use in HVAC operations of large-commercial buildings. Additional savings associated with other thermal energy capture uses (i.e. refrigeration, chill-water, heating etc.) and from the industrial sector makes this a conservative estimate.
 53. More aggressive deep-energy retrofit programs have achieved residential energy efficiency gains of 50-90%. (Green Building Advisor 2015)
 54. For example, the Los Angeles Department of Water and Power Integrated Resource Plan (IRP) assumes only 8,125 driving miles annually per electric vehicle, this work assumes 10,000 miles per year. Current IRPs generally use a per-mile electricity consumption value that is determined using multi-year field-test results of Tesla Model S performance. It is very likely that future electric vehicle designs will be more efficient than these models. Therefore, this is a conservative (higher) estimate of electricity demand for electric vehicles in future years.
 55. (ASHRAE 1997)
 56. (Williams 2015) For conservatism, potential energy savings from this aspect of thermal energy capture are not included in this assessment.
 57. (Los Angeles Department of Water & Power 2016)
 58. (OEHHA 2016)
 59. It is estimated that aggressive GHG mitigation strategies will employ 4.5 million people in the United States by 2030. (Bezdek 2014) This study analyzes the impact of renewable energy generation and energy efficiency program delivery for the electric power sector. It does not include

workforce needs required for GHG mitigation strategies applied to the transportation sector and to develop urban sustainability (food, water, land use). Therefore these estimates of new job creation are conservative (low).

Transportation

60. The implementation of vehicle-exclusion zones in cities is rapidly being adopted all over the globe. (Garfield 2017) In addition to providing significant reductions in the emissions of GHGs and air pollution, the increased availability of open space for foot and bicycle traffic greatly improves the living quality of city residents living and working in these areas.
61. Significant work is being performed to streamline the adoption of Vehicle-to-Grid (V2G) systems both nationally and in the State of California. (California Energy Commission 2016) However, the development of multiple platforms for vehicle identification, account maintenance and sales tracking as well as communication protocols and delivery methods makes an integrated single-service program managed and operated by City extremely problematic. It is recommended that the city of San Francisco engage with industry leaders to identify and select a standardized platform for adoption and use within the residential V2G program and that this system be incorporated into building codes.
62. For more information on the current regulatory and policy hurdles for the implementation of fully-autonomous vehicle (AV-5) fleets see: (Circella 2017)
63. The rapid development and near-term deployment of fully-electric shipping vehicles produced by Cummings and Tesla in early 2018 are expected to severely disrupt this market with rapid adoption rates due to overwhelming per-mile savings over conventional vehicles. (Lambert 2017)
64. In addition to reductions in GHG emissions, the implementation of a mature autonomous vehicle (AV-5) fleet within the city will provide a vibrant, low-cost transportation alternative to personal vehicle use with resulting reductions in parking space requirements and road congestion. Projections of reduced total parking space needs under a fully mature AV-5 fleet are surprisingly high. However, the stated potential benefits of this technology shift may not be realized if proper policy is not developed to guide a timely and beneficial transition. For policy recommendations regarding implementation and land-use within an AV-5 ride-sharing vehicle platform see: (Circella 2017). For an interesting discussion of the potential impacts of AV-5 fleets on the urban environment, including land-use changes, increased transportation accessibility, shifts in spending priorities by city governments, open space and community space opportunities and the utilization of this space for urban greening and storm water capture see: (Lovins, Castor and Tierney 2017)
65. This technology is already being used for electric busing fleets globally. (Sisson 2016) The recent adoption of international SAE standards for light-duty vehicle wireless charging (SAE 2016) was seen as a major hurdle for EV manufacturers and it is expected that this technology will become the industry standard in future years. (Pyper 2016)
66. (see 63 above)
67. (see 67 above) in addition to in-place inductive charging stations, developments in the design and production of inductive vehicle lanes afford electric vehicles the opportunity to charge their batteries while driving. (Goodwin 2017) This technology will eventually be developed into dedicated-lanes for autonomous vehicle fleets, allowing greatly increased safety, reductions in driving times and increased operating efficiencies of up to 20% using a process called “platooning”. (Chu 2016) Future

developments of this technology will allow rapid vehicle travel over long-distances with very high efficiencies and at reduced costs as freight transport companies begin to provide Platooning as a Service (PaaS) to privately owned and public-use autonomous vehicles.

68. These systems will be identified and codified through a process of consultation with a consortium of electric vehicle manufacturers, mass-produced locally and installed as an offered measure within the deep-energy efficiency retrofit program.
69. A recent study by the Rocky Mountain Institute projects that AV-5 ride-sharing fleets will generate \$11.7 billion dollars of revenue in the City region in the year 2025. (Johnson 2017)
70. Autonomous Mobility-on-Demand (aMOD) platforms in the form of reduced speed shuttles for local trips in an urban environment is a promising new market development. This technology offers greatly increased ease of transport at very favorable costs. The first dedicated manufacturing plant for these autonomous shuttle vehicles was commissioned in the United States in the summer of 2017. (Zart 2017) While currently limited to closed campus environments, these autonomous shuttle services will soon enter full city-street operational capacity.
71. It is assumed that some city residents will continue to operate internal combustion engine vehicles after 2025. Other vehicles may continue to operate in the city while traveling from outlying regions. Projections of eventual cost comparisons indicate that these outliers will fully adopt non-fossil fuel transport sometime after 2025.
72. (see 73 above)
73. Projected operation costs for AV-5 vehicle fleets range from 24 to 45 cents per mile. (Morgan Stanley 2016) These are single-passenger costs and cost under ride sharing

will be reduced according to the number of passengers per vehicle. This plan conservatively estimates an average of 1.7 ride-shares per trip to yield a final person-mile operational cost between 14 and 26 cents. Current national average costs of owning and operating a fossil-fuel vehicle are estimated to be between 60 and 80 cents per mile. (AAA 2017) Reductions in private vehicle ownership rates in urban environments with a mature fleet of AV-5 ride-sharing vehicles range from 45% to 85%. (Johnson 2017) As these disruptive technologies are implemented they will rapidly push traditional municipal transportation platforms into forced obsolescence. It is therefore recommended that the City of San Francisco perform an in-depth impact assessment of these technologies and provide recommendations for shifts in funding resource within current transportation development plans to ensure a rapid and low-impact transition.

74. (Lovins, Castor and Tierney 2017)
75. (Navigant Research 2016) The rapid transformation of city streets will be a necessary response to the greatly increased open space made available as parked vehicles begin to disappear from city curbs.
76. (see 72 above)
77. (see 50 above)

Industrial Sector

78. The electrification of heating sources for high-temperature industrial processes is a very difficult hurdle to overcome as recent reductions in natural gas prices have driven industry trends toward that fuel source. To achieve these emission reductions in the industrial sector a comprehensive portfolio of economic (incentive + financing) and flexible technology solutions must be offered to the industrial consumer. In some cases, these industrial customers will be unable to transform their processes economically and will relocate from the city

as the least-cost alternative. However, the increased manufacturing and economic activity that will occur in the city as a result of this plan is much greater than these expected losses and the exclusion of fossil-fuel sourced manufacturing within the city is vital to the development of the “Made Green in San Francisco” national label that will attract significant regional investments, providing increased economy and employment for city residents.

79. (see 80 above)

Food and Water Production

80. City ordinance requiring 4-bin waste collection (landfill, recycling, paper and green/food waste) at all collection points was passed by the Halifax Municipal Region (HRM) in 1999. This policy worked to provide valuable feedstocks for municipal recycling, increased container recycling rates and reduced landfill volume deliveries. The increased volume of paper products recycled within this platform will provide a low-cost feedstock for the production of blown-in cellulose insulation to be later used by the City’s deep-energy efficiency retrofit program.

81. The streamlining of Community Sourced Agriculture (CSA) delivery mechanisms is a potent market facilitation effort that will aid in the regional economic development of San Francisco. As latter stages of the mobilization plan are implemented, increased land-use opportunities resulting from reduced vehicle parking needs will allow the creation of more traditional neighborhood farmers’ markets that will increase local resiliency, Green Gardens program participation, increase community interconnection and interdependency as well as provide regional economic benefits. Educational and material assistance for the growing, processing and preserving of foods for consumption and sale should also be developed, following the activities performed during the U.S. “Victory Gardens” project during WWII. A platform

of city-sponsored community kitchen facilities, similar to the Grange network will provide a system of distributed certified commercial cooking spaces and support other local needs of the Green Gardens program.

82. Guidelines for this type of regional sourcing of agriculture must be developed by the City of San Francisco. These guidelines will be extremely valuable in developing effective platforms for the sale of food produced through the city’s Green Gardens program.

83. The California Energy Commission has provided significant funding through the Electric Program Investment Charge (EPIC) program to develop viable technologies that produce electricity from biomass waste streams and are suitable for inclusion in a municipal composting system. (California Energy Commission 2015) The inclusion of bio-digesters for food waste processing and peak electric power generation produces effluent that is then used within the municipal composting system. This integrated system has many significant benefits over standard composting operations including pathogen reduction, nitrate capture, increased capacity with minimal land-use increases and reductions in effluent treatment costs. For more information on the integration of anaerobic and aerobic decomposition of green wastes for municipal use see: (Kraemer 2014)

84. (see 31 above)

85. The State of California’s Electric Program Investment Charge (EPIC) program administered by the California Energy Commission is developing publicly-available state-wide surveys of biomass feedstocks to help facilitate the effective siting of regional biomass and biogas production facilities throughout the state. (California Energy Commission 2015) It also supports innovative leaders who are developing technologies that generate biochar as an end-use product. (California Energy Commission 2015), (California

Energy Commission 2015). These efforts will be easily duplicated and adapted nationwide in coming years.

86. This very rough estimate of potential food production from local farms is somewhat arbitrary and reflects the perceived full potential of a mature, publicly engaged and supported, intensive urban agriculture program. While U.S. national victory garden production represented only 40% of all consumed produce, (Colby 2017) the majority of this consumption occurred in the North East regions with limited growing potentials due to higher levels of urban density than found today and using less productive agricultural practices than currently available, therefore a 56% target is established in this plan.
87. (see 32 above) The combination of new atmospheric water vapor condenser systems combined with increased groundwater aquifer charging and operating within a comprehensive water conservation retrofit program for all residences and small commercial buildings will provide significant gains toward achieving a 20% city-wide reduction in draws from municipal water systems. These efforts are seen to work in parallel with current City of San Francisco water conservation and sustainability efforts that may support groundwater aquifer charging, storm-water capture and water conservation.
88. (see 10 above)
89. (Rhodes 2017)

City Services

90. (see 20 & 22 above) The development of high-pressure air as a municipal service should be seen as long-term strategy toward achieving the goals of GHG mitigation and city resiliency within a WWII-scale mobilization effort. This is especially true

as the growing impacts of heat-waves and population shifts occur in coming decades. The use of these systems to provide large volumes of cold air for community cooling centers will be a useful additional benefit of this technology. For cities that have access to deep offshore waters close to shore, the use of newly developed subsea bladders (Maloney 2017) for the storage of large volumes of high pressure air at very low cost. This will eventually remove the need for any stopgap fossil fuel power generation that may continue to be necessary due to the variable nature of renewable energy resources.

91. The replacement of municipal vehicle fleets with non-fossil fuel equipment is currently underway in many locations. This mobilization plan requires an expedition of this general timetable for full fleet replacement/retrofit by 2023.
92. Large construction equipment electrification is a lagging sector compared to the rapid development of electric light-duty and heavy-duty vehicles. However, advancements are being made to this end. (Eldredge 2017) The development of cost-effective retrofits of existing equipment and the utilization of Li-ion battery trailers for construction and maintenance operations will be developed as per-unit battery prices continue to decline.
93. (CARB 2000)
94. (CDC 2012)

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¹ Current UN International Panel on Climate Change carbon budget analyses show that we will overshoot 1.5°C and, when carbon cycle feedbacks from warming soils (Crowther 2016) and precipitation regime shifts (Page 2002) (Jiménez-Muñoz 2016) are included, have likely surpassed the current carbon budget available to prevent 2°C of globally averaged warming. The growing consensus among climate scientists is that some form of atmospheric CO₂ extraction and sequestration will be required. For more information see: (Peters and Geden 2017)

² (Höhne 2015) This assessment of national benefits from projected COP-21 voluntary reduction targets finds that the U.S. goals would produce 470,000 new jobs with significant benefits in reductions of pollution, health care costs and fossil fuel purchases. The emission reduction and sustainability activities within this localized plan are more comprehensive within a much shorter timeline and result in greater per-capita emissions reductions than the national targets offered by the Obama Administration under the Paris Climate Accords.

³ (Pearce 2017) “Policymakers are beginning to understand the scale of carbon dioxide removal that is required to keep global warming “well below 2°C”.

⁴ For a comprehensive analysis of U.S. efforts during the national mobilization to defeat global fascism see: (Wilson 2016)

⁵ For a detailed analysis of the implications of future climate impacts on disadvantaged communities as well as the economic and environmental justice advances obtained through focused urban mitigation and adaption activities see: (Jabareen 2011)

⁶ (Roosevelt, Annual Message to Congress on the State of the Union 1941)

⁷ (Roosevelt, Annual Message to Congress on the State of the Union 1944)

⁸ As the city of Los Angeles moves toward a sustainable zero-carbon emissions economy the growing impacts of climate change will require intense adaption and CO₂ drawdown efforts. These activities will require separate implementation plans. This mobilization plan sets the stage for these critical activities with the engagement of civil leaders, the development of energy and transportation democracy platforms as well as increases in city resiliency and sustainability through new infrastructure and city service developments.

⁹ Examples of other areas omitted are the development and implementation of pricing structures governing imported goods according to their embedded greenhouse gas emissions in production and transport, Hyperloop and electric high speed rail construction, and automated electric vehicle freight transport. These necessary activities are outside of the influence of any single-city and will likely be incorporated within larger regional or national climate mobilization projects.

¹⁰ The development of regenerative agriculture as a means to offset current greenhouse gas emissions is fundamental to restoring a safe climate. (Rodale Institute 2014) The adaption of biochar as a secondary feedstock has been demonstrated to increase soil fertility and to greatly extend the retention of carbon in soils. (Bolan 2012) The specific application of this strategy toward urban agriculture environments results in increased soil fertility, local resiliency, regional economic development and improvements in groundwater retention and aquifer recharge. (Rhodes 2017)

¹¹ (Marcott 2013) Shows that globally averaged temperatures are currently above 66% of the entire span of temperatures during the current interglacial period, called the Holocene. This work shows that as globally averaged temperatures exceed 1.5°C we will pass the maximum temperature experienced during the previous 11,300 years. Projections of future temperature increases indicate that it is very likely that we will exceed the previous interglacial maximum temperature (MIS-5e) of 2.5°C above pre-industrial that occurred 123,000 years ago.

¹² This timeline assumes an immediate engagement by the city of Los Angeles with necessary ramp-up to eventually achieve full mobilization from all sectors of the local economy. It includes the projected development schedules of emergent technologies and development of new resources with aggressive implementation schedules, similar to those that occurred during the re-tooling of the U.S. manufacturing sector to meet the resource demands of WWII.

¹³ (Wilson 2016, 59-91)

¹⁴ (Seel 2013)

¹⁵ (Econoleur 2016) also: (Henwood 2015)

¹⁶ (Google 2017) This satellite survey of potential rooftop generation includes full-sun and partially-shaded roofs and includes rooftop orientation in its analysis. Cumulative solar potential for the City of Los Angeles is projected to be 80% of all rooftop space. It is expected that some percentage of this total will be considered unfeasible and this mobilization plan projects that 70% of all rooftops will be developed for distributed energy generation. It should also be noted that this tool uses current solar panel efficiencies in their analysis. As solar panel research and development continues, panel efficiencies will continue to increase, therefore this total rooftop solar potential is conservative.

¹⁷ This location for large-scale wind farm development was selected through wind-resource analyses provided by the National Renewable Energy Laboratory. (National Renewable Energy Laboratory 2014)

¹⁸ Vehicle-to-Grid (V2G) operations allows private electric vehicle owners to provide excess stored battery potential to power their home or to sell to the grid during the evening peak power demand. It is assumed that 20% of vehicles with this capability will provide a small portion (15 kWh) of their daily battery storage potential each evening. These individuals are charge their vehicles during the solar-peak during mid-day, do not use their vehicles for daily commute, or have short commute. For more information on the use of V2G and impacts on battery performance see: (Dubarry 2017) While this operation will likely lead to somewhat reduced battery life, current industry demand for batteries allows for individuals to resell their used batteries on the second-life market for use by electric utilities where they will be configured into grid-scale storage platforms. For current industry projections of the use of second-life car batteries for grid-scale storage see: (Martin 2016)

¹⁹ This grid-scale battery storage platform is similar to the currently operating 80 MWh Mira Loma substation storage facility provided by Tesla to Southern California Edison and was completed in January, 2017.

²⁰ This energy storage system makes up the majority of total energy storage potential for this mobilization plan in an integrated system of distributed compression, storage and power generation facilities to be installed at large-commercial and industrial sites. These locations require significant electricity consumption for heating, heat-process, cooling, refrigeration and chill-water loads. The use of thermal energy storage (hot and cold), combined with high-efficiency turbine pneumatic drive motors to generate electricity is projected to provide a total energy storage and utilization system efficiency of 68%. In addition, the use of very cold exhaust air provided during the power-generation cycle will be extremely valuable in later phases of climate adaption where projected future heat-waves will become life-threatening, requiring the development of community cooling centers distributed throughout the city. As an added benefit, upon the development of a standardized design, this system can be locally mass-produced and installed by local trade unions. For a detailed explanation of this system and its operations see: (Kim 2012) Section 3.4 Trigenation Micro-CAES System.

²¹ These efficiency gains represent 30% of total residential electricity consumption through the implementation of traditional efficiency measures that are known to have a simple pay-back period of 10 years or less. Case studies demonstrating more extensive deep-energy efficiency retrofits, with resultant efficiency gains of 50-90% have been performed. See: (Green Building Advisor 2015)

²² For conservatism, this estimated savings potential only considers large-commercial HVAC cooling loads, additional energy savings from the capture of heat and cold in a trigeneration micro-CAES applied facility will produce savings that may be very significant, including a potential 7% increase in rooftop solar panel generation efficiency. (Moharram 2013) This study analyzes the benefits of water-cooling for increased solar panel efficiency

gains. This plan identifies single-pass air-cooling as a more appropriate retrofit.

²³ (Logue 2014) “The simulation model estimated that—in homes using natural gas cooking burners without coincident use of venting range hoods—62%, 9%, and 53% of occupants are routinely exposed to NO₂, CO, and HCHO levels that exceed acute health-based standards and guidelines.”

²⁴ Heat pump water heater systems are a standard measure for utility industry energy efficiency programs in warm climate regions with incentive offerings that range between \$200 (Southern California Edison) and \$800 (Pacific Power). For the Los Angeles area the increased efficiency of these systems yields a breakeven cost that is calculated by the National Renewable Energy Laboratory to be less than 50% of the current market price for many models. (Maguire 2014)

²⁵ This is a significant portion of the 26 million cumulative electric vehicle sales projected worldwide through 2025 by OPEC. (Shankleman 2017) Increased rates of EV adoption can be facilitated through city-sponsored programs that provide financing mechanisms, partnerships with electric vehicle manufacturers for bulk purchases, and low-cost day-use charging facilities for individuals registered as Vehicle-to-Grid (V2G) program participants. Similar market facilitation projects are currently being offered in Northern California by Sonoma Clean Power. See: (Kovner 2017)

²⁶ Driverless autonomous vehicles (AV-5) are currently operating in some parts of the United States though they are required to have a driver for emergency operations. The California Department of Motor Vehicles released their proposed rules for AV-5 vehicle operations on April 25, 2017. The state has licensed 27 companies to test vehicle operations and fully-operational AV-5 vehicles are expected to be on California roads by 2021. (Lienert 2017)

²⁷ In 1999 the Halifax Regional Municipality (HRM) implemented a 4-bin waste collection protocol for all points of refuse pick-up. In addition, they partnered with local food industry to streamline the pickup of food waste from all sources. With a population of 400,000, HRM currently generates 53,000 tonnes of compost per year with plans to expand to 70,000 in coming years. (Panacci 2017)

²⁸ (Gaunt 2008) Regionally sourced biochar facilities may process farm and forestry waste stream products very cost-effectively for use as agricultural amendments. In addition, waste-heat from this process may be used in a combined-heat and power (CHP) system to generate net-zero carbon electricity which is then sold at peak demand to the electric power grid.

²⁹ Included in this estimate of installed gardens are urban community and school gardens. Similar to the Victory Gardens program, significant resource will be provided to citizens to design, develop, deliver, implement and maintain these plots. A minimum size requirement to qualify for this additional assistance will incentivize increased food production and environmental benefits, though private citizens may have access to soil delivery for personal use if excess resource is available through comprehensive municipal green and food waste collection and composting.

³⁰ (Blackhurst 2010) In addition to producing food, green-roof projects also provide clean space for building occupants, reduce building cooling loads, slightly reduce urban heat-island effects and help to reduce storm water runoff.

³¹ The additional cost of grey-water retrofits for capture and use in the green-gardens program will likely reduce participation for this part of the program. Consideration must also be made to ensure sufficient water flow is provided for transport of solids to wastewater treatment facilities. The use of greywater and storm-water runoff, combined with the use of rooftop solar condensers will greatly increase water flows to the ground water table and help to reduce urban heat-island effects.

³² New developments in the chemistry of metal-organic frameworks (MOF) promise a cost-effective, solar powered source of potable water using atmospheric capture of water vapor. The use of these systems to produce both potable water for home use and within an extensive urban farming program allows a portion of the water vapor released through plant evapotranspiration to be recaptured, effectively recycling water continuously within regional areas. While this technology is not currently market available, the city of Los Angeles can provide research funding and

resource to assist in its development and eventually produce this equipment for mass distribution within the Green Gardens program. See: (Sanders 2017)

³³ In 2013 the Energy Information Administration determined that 4% of U.S. total pre-tax household income was spent annually on the purchase of gasoline. (Energy Information Administration 2013) Assuming that Los Angeles household gasoline consumption is slightly lower than the U.S. national average and using census bureau data, a reasonable estimate of \$2.7 billion dollars is spent by city residents annually on the purchase of gasoline. This estimate is conservative since Los Angeles gasoline prices are 17% higher than the national average. (Energy Information Administration 2017) Similar estimates of residential natural gas expenditures for city residents are \$491 million dollars per year.

³⁴ A 2016 report from the American Lung Association of California (Holmes-Gen 2016) found that \$13.5 billion was spent annually on hospitalized health and climate impacts resulting from internal combustion vehicle use in the State of California. Extracting the climate impacts value from the state total sum yields the annual health impacts for the state. If state per-capita average values are then applied to Los Angeles, city residents have an annual expenditure of \$305 million dollars of hospitalized health care impacts due to fossil fuel vehicle use. Since Los Angeles experiences much higher pollution levels than the state average this value is a significant underestimate of the actual.

³⁵ (Google 2017)

³⁶ (Green Tech Media 2017)

³⁷ (Solar Energy Industries Association 2017)

³⁸ (Cooper 2017)

³⁹ (Energy Information Administration 2015)

⁴⁰ This strategy of local government market intervention is consistent with the rapid deployment goals of a society that has determined that it is under direct threat and must mobilize all potential solutions to reduce the impact of this threat. This type of government market intervention was very successful in reduction per-unit installed costs in Germany. (Seel 2013)

⁴¹ This streamlining of siting and permitting activity was performed by the Sacramento Municipal Utility District to reduce administrative hurdles for rapid solar adoption. Upon initiation of its *Solar Pioneer* project, these and other innovative solutions helped to reduce per-unit installed solar costs to half of the national average. For an excellent summary of these and other innovative implementation assists currently being engaged by municipal utilities to streamline the rapid adoption of solar power in their service territories, see: (Farrell 2016)

⁴² LADWP has recently re-offered its feed-in-tariff under a competitive pricing structure that targets large commercial and industrial solar systems. Unlike other municipal utilities or California Community Choice Aggregators (CCAs), there is no residential feed-in tariff currently available where a home-owner may recoup some additional value from their investment in solar through the sale of excess electricity above their annual or monthly consumption. Under a variable time-of-supply feed-in tariff, the returned value to the customer is dependent on the wholesale market cost during that period. Implementing this type of incentive system will greatly facilitate the adoption of distributed energy storage, spur reductions in consumption during peak demand periods and engage the private sector to invest in battery storage, with additional increase participation in the V2G program. For more information and analysis on the use of variable feed-in tariff to increase community-scale energy storage see: (Parra 2017)

⁴³ The California Alternative Energy and Advanced Transportation Finance Authority (CAEATFA) filed its regulations for the Residential Energy Efficiency Loan (REEL) Assistance Program on September 5, 2017. While this program provides loan guarantees for residential customers to help secure low-interest financing for energy efficiency projects, it falls far short of what is required for a rapid transformation of the State's electricity consumption profile. Within the province of Nova Scotia, subsidized loans were provided at low or zero interest for

efficiency program activities and these loans were paid through an on-bill attachment, usually at monthly values lower than the cost of electricity that would have otherwise been purchased absent the installation of energy efficiency equipment. For more information on best practices for energy efficiency program delivery see: (Energy and Mines Ministers' Conference 2016)

⁴⁴ Already adopted by several U.S. municipalities, the creation of a Green Bank/Infrastructure Bank provides economic return through the funding of cost-effective energy efficiency and alternative energy projects. By securing this financing mechanism, stability of operations going forward can be ensured through uncertain future levels of state and national support. A viable funding system also helps to secure additional bond revenue and, in future years, may allow an opportunity for city residents to provide significant additional economic support via their own market choices. The Yale University Center for Business and the Environment has recently initiated a new project providing case study analyses of green bank design and operations both nationally and internationally. See: (Shub 2017)

⁴⁵ For a detailed description of private and public sector adaption strategies that will facilitate the development of a distributed energy electric power grid see: (Rocky Mountain Institute 2011) also: (SAIC 2012)

⁴⁶ “During all of World War II, the U.S. government would spend close to \$20 billion (\$301 billion 2017 dollars) on manufacturing facilities and machinery, more than double the amount invested by the private sector.” (Wilson 2016, 61-62). The Government Owned/Government Operated (GOGO) and Government Owned/Contractor Operated (GOCO) system of market transformation is consistent with efforts in the U.S. during WWII to provide high volumes of necessary goods and services at least cost during a wartime mobilization. Within the context of the existential threat of climate change, every effective means must be engaged to help secure ‘victory’. The contracting of necessary municipal services, managed within government owned facilities, is commonplace and these mobilization activities should be seen as an extension of these current practices. However, the implementation of manufacturing and service delivery through government owned and government operated systems will be necessary to meet the maximum potential demand, at least cost and in a timely manner.

⁴⁷ The administration of energy efficiency programs by vendors selected through an open-bid process and reimbursed on a cost-plus basis is the industry-standard for publicly-owned utility demand-side management programs. Within the standard delivery contract, a schedule of approved measures with their per-unit installed reimbursement rates ensures these measures are extensively deployed in a cost-effective manner.

⁴⁸ City operated solar-parking facilities are designed as concierge-operated park & charge facilities with solar canopies that provide shade to parked vehicles and generate electricity. They are made available to electric vehicles at reduced cost of parking and electricity rates if they are registered in a city-managed V2G program. These facilities are necessary to assist in shifting electric vehicle energy demands to the mid-day solar peak and will increase the supply of stored electricity during the evening peak-demand period. For examples of cities that have incorporated solar parking canopy facilities see: (Matasci 2017)

⁴⁹ In addition to wind turbine siting and construction, extensive transmission infrastructure must also be scoped and constructed. The expansion of transmission capacity from this area to facilitate the implementation of the state’s Renewable Portfolio Standard (RPS) has been studied and their results published, (Transmission Technical Input Group 2016) though their projections of transmission needs for this location are slightly lower (500MW) than of those required by this plan (700MW).

⁵⁰ These systems are extremely cost-effective for the Los Angeles area (Maguire 2014) and their manufacture and delivery through government owned mechanisms is consistent with a rational response to an existential threat. (Wilson 2016, 59-91)

⁵¹ This represents a rapid expedition of the installation of 1,645 MW of wind generation currently scheduled to be installed in the years 2020-2036 by LADWP per their 2016 IRP Recommended Case. (Los Angeles Department of Water & Power 2016)

⁵² This value represents savings associated with the use of trigeneration micro-CAES exhaust air for thermal capture and storage for use in HVAC operations of large-commercial buildings. Additional savings associated with other

thermal energy capture uses (i.e. refrigeration, chill-water, heating etc.) and from the industrial sector makes this a conservative estimate.

⁵³ More aggressive deep-energy retrofit programs have achieved residential energy efficiency gains of 50-90%. (Green Building Advisor 2015)

⁵⁴ LADWP IRP assumes 8,125 miles per year per electric vehicle, this work assumes 10,000 miles per year. Vehicle per-mile electricity demand uses field-test results of Tesla Model S performance over several years. It is very likely that future electric vehicle designs will be more efficient than these models and makes this a conservative (higher) estimate of future demand for electric vehicle transportation.

⁵⁵ (ASHRAE 1997)

⁵⁶ (Williams 2015) Energy savings from this aspect of thermal energy capture are not included in this assessment for conservatism.

⁵⁷ (Los Angeles Department of Water & Power 2016, 153)

⁵⁸ (OEHHA 2016)

⁵⁹ It is estimated that aggressive GHG mitigation strategies will employ 4.5 million people in the United States by 2030. (Bezdek 2014) This study analyzes the impact of renewable energy generation and energy efficiency program delivery for the electric power sector. It does not include workforce needs necessary for GHG mitigation strategies applied to the transportation sector and to develop urban sustainability (food, water, land-use). Therefore these workforce estimates are likely conservative (low).

⁶⁰ The implementation of vehicle-exclusion zones in cities is rapidly being adopted all over the globe. (Garfield 2017) In addition to providing significant reductions in GHG emissions and pollutants, the increased availability of open space and foot and bicycle traffic greatly improves the living quality of city residents living and working in these areas.

⁶¹ Significant work is being performed to streamline the adoption of Vehicle-to-Grid (V2G) systems both nationally and in the State of California. (California Energy Commission 2016) However, the development of multiple platforms for vehicle identification, account maintenance and sales tracking as well as communication protocols and delivery methods makes an integrated single-service program managed and operated by LADWP extremely problematic. It is therefore recommended that the city engage with industry leaders to identify and select a standardized platform for adoption by LADWP for their residential V2G program and that this system requirements are codified by residential building codes.

⁶² For more information on the current regulatory and policy hurdles for the implementation of fully-autonomous vehicle fleets see: (Circella 2017)

⁶³ The rapid development and near-term deployment of fully-electric shipping vehicles produce by Cummings Inc. and Tesla in early 2018 are expected to severely disrupt this market with rapid adoption due to overwhelming per-mile savings over conventional vehicles. (Lambert 2017)

⁶⁴ In addition to significant reductions in GHG emissions, the implementation of a mature autonomous vehicle fleet within the city will provide a vibrant, low-cost transportation alternative to personal vehicle use with resulting reductions in parking space requirements and road congestion. Projections of reduced total parking space needs under a fully mature AV-5 fleet are surprisingly high. However, the stated potential benefits of this technology shift may not be realized if proper policy is not developed to guide an effective and beneficial transition. For policy recommendations regarding implementation and land-use within an autonomous ride-sharing vehicle platform see: (Circella 2017). For an interesting discussion of the potential implications of autonomous vehicle fleets on the urban environment, including land-use changes, increased transportation accessibility, shifts in spending priorities by city governments and the related benefits of GHG emissions reductions, open space and community space opportunities and the utilization of this space for urban greening and storm water capture see: (Lovins, Castor and

Tierney 2017)

⁶⁵ This technology is already being used for electric busing fleets globally. (Sisson 2016) The recent adoption of international SAE standards for light-duty vehicle wireless charging (SAE 2016) was seen as a major hurdle for EV manufacturers and it is expected that this technology will become the industry standard in future years. (Pyper 2016)

⁶⁶ (see 63 above)

⁶⁷ (see 67 above) in addition to in-place inductive charging stations, developments in the design and production of inductive vehicle lanes afford autonomous electric vehicles the opportunity to charge their batteries while driving. (Goodwin 2017) This technology will be developed into dedicated-lanes for autonomous vehicle fleets, allowing greatly increased safety, reductions in driving times and increased operating efficiencies of up to 20% using a process called “platooning”. (Chu 2016) Future developments of this technology will allow rapid vehicle travel over long-distances with very high efficiencies and significantly reduced costs as freight transport begins to provide “platooning as a service” to private vehicles and autonomous vehicle fleets.

⁶⁸ These systems will be identified and codified through a process of consultation with a consortium of electric vehicle manufacturers, mass-produced locally and installed as an offered measure within the deep-energy efficiency retrofit program.

⁶⁹ A recent study by the Rocky Mountain Institute projects that autonomous ride-sharing fleets will generate \$11.7 billion dollars of revenue in the Los Angeles region in the year 2025. (Johnson 2017)

⁷⁰ Autonomous Mobility-on-Demand (aMOD) platforms in the form of reduced speed shuttles for local trips in an urban environment is a promising new market development. This technology offers greatly increased ease of transport at very favorable costs. The first dedicated manufacturing plant for these autonomous shuttle vehicles was commissioned in the United States in the summer of 2017. (Zart 2017) While currently limited to closed campus environments, these autonomous shuttle services will soon enter full city-street operational capacity.

⁷¹ It is assumed that some city residents will continue to operate internal combustion engine vehicles after 2025. Other vehicles may continue to operate in the city while traveling from outlying regions. Projections of eventual cost comparisons indicate that these outliers will adopt non-fossil fuel transport in future years after 2025.

⁷² (see 72 above)

⁷³ Among several studies per-mile operational costs of autonomous vehicle fleets range from 24 to 45 cents per mile. (Morgan Stanley 2016) These are single-passenger costs and individual ride share costs will be reduced according to the number of passengers per vehicle. This plan assumes 1.7 passengers per average trip for a final person-mile operation cost between 14 and 26 cents. Current private gasoline vehicle operation costs are between 60 and 80 cents per mile on a national average. (AAA 2017) Higher fuel and insurance costs in Los Angeles makes these estimates low for this region. Reductions in private vehicle ownership rates in urban environments with a mature fleet of autonomous ride-sharing vehicles range from 45% to 85%. (Johnson 2017) As these disruptive technologies are implemented they will rapidly push traditional municipal transportation platforms into forced obsolescence. It is therefore recommended that the County of Los Angeles Metropolitan Transit Authority perform an in-depth impact assessment of these technologies and provide recommendations for shifts in funding resource within the current Short Range Transportation Plan (Placeholder1) to ensure a low-impact transition.

⁷⁴ (Lovins, Castor and Tierney 2017)

⁷⁵ (Navigant Research 2016) The rapid transformation of city streets will be a necessary response to the greatly increased open space as parked vehicles begin to disappear from the city’s roads. The expedition of this activity should be performed within the guidelines of the current Los Angeles County Model for Living Streets Design Manual. (Los Angeles Department of Public Health 2011)

⁷⁶ (see 72 above)

⁷⁷ (see 50 above)

⁷⁸ The substitution of electricity supplied heating sources for high-temperature industrial processes is a very difficult hurdle to overcome as recent reductions in natural gas prices have driven industry toward that fuel source. To achieve these emission reductions in the industrial sector a comprehensive portfolio of economic, financing and technology solutions must be offered at greatly reduced economic burden to the industrial consumer. In some cases, these producers will be unable to transform their processes or will find that relocating out of the area is the least-cost alternative. However, the increased manufacturing and economic activity that will occur within the city as a result of this plan is much greater than these losses and the exclusion of fossil-fuel sourced production in city limits is vital to the development of the “Made Green in L.A.” national label that will attract significant new local investment, providing increased economy and employment for city residents.

⁷⁹ (see 80 above)

⁸⁰ City ordinance requiring 4-bin waste collection (landfill, recycling, paper and green/food waste) at all collection points was passed by the Halifax Municipal Region in 1999. This policy worked to provide valuable feedstocks for municipal recycling, increased container recycling rates and reduced landfill volume deliveries. The increased volume of paper products recycled within this platform will provide low-cost resource that can be used in traditional recycling and also as a feedstock for the production of blown-in cellulose insulation.

⁸¹ The streamlining of Community sourced agriculture delivery mechanisms is a potent market facilitation effort that will aid in the regional economic development of Los Angeles. As latter stages of the mobilization plan are implemented, increased land-use opportunities resulting from reduced vehicle parking needs will allow the creation of more traditional neighborhood farmer’s markets that will increase local resiliency, Green Gardens program participation, increase community interconnection and interdependency as well as provide regional economic benefit. Educational and material assistance for the growing, processing and preserving of foods for consumption should also be developed, following the activities performed during the U.S. “Victory Gardens” project during WWII. A platform of city-sponsored ‘community kitchen’ facilities, similar to the California State Grange network will provide certified commercial cooking space and support other needs of the Green Gardens program.

⁸² Guidelines for this type of regional sourcing of agriculture has already been developed through the Los Angeles Food Policy Council and adopted by the City of Los Angeles in 2012. (Los Angeles Food Policy Council 2012) These guidelines will be extremely valuable in developing effective platforms for the sale of food produced through the city’s Green Gardens program.

⁸³ The California Energy Commission has provided significant funding through the Electric Program Investment Charge (EPIC) program for the development of viable technologies that produce electricity from biomass waste streams that are suitable for inclusion into a municipal composting system. (California Energy Commission 2015) The inclusion of bio-digesters for food waste processing and peak electric power generation produces waste streams that are then incorporated into municipal composting systems. This integrated system provides significant benefits over standard composting operations including pathogen reduction, nitrate capture, increased capacity with minimal land-use increases and reductions in effluent treatment costs. For more information on the integration of anaerobic and aerobic decomposition of green wastes for municipal use see: (Kraemer 2014)

⁸⁴ (see 31 above)

⁸⁵ The State of California’s Electric Program Investment Charge (EPIC) program administered by the California Energy Commission is developing publicly-available state-wide surveys of biomass feedstocks to help facilitate the effective siting of regional biomass and biogas production throughout the state. (California Energy Commission 2015) As well as innovative leaders in the development of facilities that produce biochar as an end-use product. (California Energy Commission 2015), (California Energy Commission 2015)

⁸⁶ This very rough estimate of potential food production from local farms is somewhat arbitrary and reflects the perceived full potential of a mature, publicly engaged and supported, intensive urban agriculture program. While U.S. national victory garden production represented only 40% of all consumed produce, (Colby 2017) the majority of this consumption occurred in the North East regions with limited growing potential, as opposed to the Los

Angeles region that can produce fruits and vegetables throughout the year.

⁸⁷ (see 32 above) The combination of new water vapor condenser systems, coupled with increased groundwater aquifer charging and coupled with a comprehensive water conservation retrofit program for all residences will provide significant advances toward achieving a 70% total water import reduction. These efforts are seen to work in parallel with the current City of Los Angeles One Water Plan activities of groundwater aquifer charging, storm-water capture, and the water conservation and urban greening activities of land-use reclamation and drought tolerant landscaping programs that are already showing results in reduced water consumption.

⁸⁸ (see 10 above)

⁸⁹ (Rhodes 2017)

⁹⁰ (see 20 & 22 above) The development of high-pressure air as a municipal service should be seen as long-term strategy toward achieving the goals of GHG mitigation and city resiliency within a WWII-scale mobilization effort. This is especially true as the growing impacts of heat-waves and population shifts occur in coming decades. The use of these systems to provide large volumes cold air for community cooling centers will be a useful additional benefit of this technology. For cities like Los Angeles that have access to deep offshore waters close to shore, the use of newly developed subsea bladders (Maloney 2017) for the storage of large volumes of high pressure air at very low cost will eventually remove the need for stop-gap fossil fuel sourced power generation that may result due to the variable nature of renewable energy resources after the first phase of the climate mobilization plan is completed.

⁹¹ The replacement of municipal vehicle fleets with non-fossil fuel equipment is currently underway in the city. This mobilization plan requires an expedition of the timetable for full fleet replacement/retrofit.

⁹² Large construction equipment electrification is a lagging sector compared to the rapid development of electric light-duty and heavy-duty vehicles. However, advancements are being made to this end. (Eldredge 2017) The development of cost-effective retrofits of existing equipment and the utilization of Li-ion battery trailers for operations will continue to be developed as per-unit battery prices continue to decline in the near future.

⁹³ (CARB 2000)

⁹⁴ (CDC 2012)