The New Jersey Draft Energy Master Plan:
Opportunities to Integrate Health and Health Equity

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INTRODUCTION AND BACKGROUND

Economic, environmental and societal forces contribute substantially to our health – as much as, studies show, or more than genetics, individual behavior and access to healthcare.[1] Examples of these **Social Determinants of Health** include quality of housing and schools, access to healthy foods, living-wage jobs, transportation mobility, environmental exposures to pollution and other hazards, availability of social support networks and community safety.[2]

The New Jersey *Energy Master Plan* (EMP) "is intended to set forth a strategic vision for the production, distribution, consumption, and conservation of energy in the State of New Jersey."[3] Energy, too, is an important social determinant of health including its source, generation, transmission and delivery, mode of use, cost, and associated wastes and emissions. Whether used for home heating and cooling, cooking, transportation, industrial and commercial operations or other purposes, energy can be an important contributor, positively or negatively, to individual and community health. The contribution of energy systems to health can be direct, such as through environmental exposures to emissions from energy generation, or indirect, such as may be the case for certain populations that pay disproportionate amounts for energy bills which, in turn, may affect the availability of resources to support healthy living such as food, quality housing and healthcare (US DOE, 2018).

Rutgers scholars have been at the forefront of promoting **Health in All Policies (HiAP)** as a collaborative approach to reducing disparities and improving the health of all communities and people by incorporating health considerations into decision-making across sectors and policy areas.[4] Given the limited time available in the review period of the draft Energy Master Plan and its high level nature, the authors have not conducted a comprehensive assessment of all health and health equity implications of the EMP and its implementation. To do so would require many months of data gathering and detailed analysis.

Instead, as part of our continuing HiAP efforts in New Jersey, we prepared a set of insights on opportunities to integrate health considerations into the EMP, based in part on collective knowledge in the health impact and health equity fields, and in part on a literature review conducted on prioritized portions of the EMP. The report offers a "health lens" through which to view some of the potential impacts of implementing elements of the EMP. This analysis focuses on health equity, or the concept of equitable access to conditions and resources that allows one to live the healthiest life possible. It pays strong attention to impacts on populations and communities that may already suffer disproportionate health, social, environmental, and economic inequities, which may be exacerbated by a proposed decision. Thus, this evaluation is in effect a public health prevention model intended to help to prevent potentially unanticipated negative outcomes and costs, and to provide guidance on policy decisions that will improve health and reduce disparities.

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[1] http://www.countyhealthrankings.org/what-is-health
[2] https://www.cdc.gov/socialdeterminants/
[3] State of New Jersey. Energy Master Plan. Available at: https://nj.gov/emp/
[4] https://www.cdc.gov/policy/hiap/index.html

The report includes the following two main sections:

1. **LITERATURE REVIEW: PROJECTED HEALTH IMPACTS OF SELECTED EMP COMPONENTS** – Describes a rapid review of recent scientific and public health literature conducted on selected strategies within the EMP, including generalized findings supported by the literature. Some of these suggest areas where additional research is needed.
2. **INCORPORATING HEALTH AND HEALTH EQUITY INTO ENERGY PLANNING AND IMPLEMENTATION -** Presents a set of overall insights for consideration in preparation of the final EMP on subjects for which there is a clear connection to health or health equity. Insights derived from the literature on selected priority areas are also included.

This report was prepared with support from The Energy Foundation and benefitted from the guidance of a group of advisors from several public health organizations in New Jersey including the New Jersey Public Health Association, the New Jersey Association of County and City Health Officials, the New Jersey Society for Public Health Education, New Jersey Chapter, American Academy of Pediatrics and the New Jersey Environmental Health Association. The authors note that these organizations and others that participate in the New Jersey Public Health Associations Collaborative Effort (NJPHACE) have a strong interest in advancing greater integration of public health into energy and other sectoral planning in New Jersey.

Below we first include brief explanatory background and definitions related to cross-cutting themes that are found throughout the analysis presented and apply to many aspects of the EMP.

New Jersey Public Health Infrastructure: New Jersey is characterized by a decentralized public health system. Public health is overseen by the state's Department of Health (DOH); primary responsibility for services lies with local public health agencies. There are 94 local health departments covering the state's 565 municipalities, varying from county, regional, municipal and multi-municipal structures. Typical services provided by the local health departments include preventive care, immunizations, investigation of communicable diseases, environmental health and sanitary code inspections, public health education, and emergency planning and response.[5]

Fuel Poverty: This term refers to the tradeoffs that can occur in a household between paying for heating or cooling and paying for other household essentials like food, rent or clothing. As Hernandez (2016) writes: "The "heat or eat" dilemma demonstrates the trade-offs that low-income householders make in order to meet the basic necessities of life whereby at-risk groups are forced to decide between food and energy, often sacrificing one for the other.

Fuel poverty is connected to energy inefficient buildings and poor quality housing that is expensive to heat, and disproportionately affects low-income households (Hernandez et al., 2014, 2016). It can be particularly dangerous for the elderly in times of extreme heat or cold, and can create food insecurity or hunger, which can negatively affect the early growth and development of young children (NEADA, 2011;

[5] A Summary of Climate Change Impacts and Preparedness Opportunities for the Public Health Sector in New Jersey. New Jersey Climate Change Alliance. 2014. Available at: https://njadapt.rutgers.edu/docman-lister/working-briefs/109-public-health-2014-march/file

Frank et al., 2006; Cook et al., 2008; Nord and Kantor, 2006). Because of necessary budget trade-offs, a lower-income family might not address other housing hazards like pests, water leaks and mold, creating unhealthy living environments.

The implications of any program or policy implemented from the Energy Master Plan on fuel poverty will determine whether the health outcomes associated with fuel poverty are more or less likely. If costs for residential heating, cooling and other household energy needs increase as a result of a new initiative, for example, those costs will account for a higher percentage of household budgets, creating more fuel poverty and creating health impacts disproportionately greater on poorer households. An energy efficiency program for fuel poor households, on the other hand, for example, can potentially positively impact wellbeing, quality of life, financial stress and comfort (Curl and Keans, 2017; Grey et al, 2017; Liddell and Guiney, 2015; Maidment et al, 2015).

A related term, "**energy insecurity,"** is defined as "an inability to adequately meet basic household energy needs." Energy insecurity is an important contributor to chronic stress in low-income households (Hernandez, 2016; Curl and Kearns, 2017).

Energy Justice: An emerging concept related to energy planning is "energy justice," a framework that focuses on how costs and benefits of an energy system are distributed throughout society (distributive justice), and on representative decision-making (Sovacool 2016; Sovacool, 2019). Jenkins et al (2018) define it normatively as a "world where all individuals, across all areas, have safe, affordable and sustainable energy that is, essentially, socially just."

Other scholars have referred to the "three A's" of energy systems: availability, accessibility and affordability. Availability indicates the technical availability of a particular form of energy; accessibility is the opportunity to access it and its associated services; and affordability is the capacity of all populations to afford the energy services (Johansson and Goldemberg, 2002; Reddy, 1985).

Health Equity: Health equity is "the principle underlying a commitment to reduce—and, ultimately, eliminate—disparities in health and in its determinants, including social determinants. Pursuing health equity means striving for the highest possible standard of health for all people and giving special attention to the needs of those at greatest risk of poor health, based on social conditions." By focusing on both health disparities as well as the social, physical and economic determinants of health, efforts to advance health equity include policies, programs and strategies to address underlying factors like structural racism that unjustly and unfairly preclude people from access to the systems and conditions that support health and well-being. (Braveman, 2014).

LITERATURE REVIEW: PROJECTED HEALTH IMPACTS OF SELECTED EMP COMPONENTS

The study followed a modified version of a methodology developed for a new initiative piloted at Johns Hopkins University with support from the Health Impact Project[6] called "Health Notes."[7] The expedited review of research identifies recent available evidence of how a proposed plan could affect health. The review collects studies that seek to explain how the measures in the plan could affect the social determinants of health.

Selection of EMP Strategies:

The research team conducted a detailed but limited literature review to examine health impacts of four elements within the EMP: Electric Vehicles, Vehicle Miles Traveled, Energy Efficiency (particularly as it relates to retrofits of residential buildings) and Renewable Energy (including Workforce Development Opportunities in Clean Energy and other health impacts of a shift to renewables). These elements were selected because the research team assessed that they had strong connections to health and equity, and that adequate literature regarding social determinants of health and/or health equity would be available. These four elements are included or implied within five of the EMP strategies as outlined below:

Strategy 1: Reduce Energy Consumption and Emissions from the Transportation Sector

1.1 Electrify the Transportation Sector

1.2 Decrease Vehicle Miles Traveled

Strategy 2: Accelerate Deployment of Renewable Energy and Distributed Energy Resources (DER)

2.1 100% Clean Power by 2050

2.2 Develop 3500 MW of Offshore Wind Power by 2030

2.3 Maximize local (on-site or remotely-sited) solar development and DER by 2050

Strategy 3: Maximize Energy Efficiency and Conservation and Reduce Peak Demand

3.1 Increase New Jersey's overall energy efficiency

Strategy 6: Support Community Energy Planning and Action in Low- and Moderate-Income and Environmental Justice Communities

6.2 Support local, clean power generation in low-and moderate-income and environmental justice communities

6.3 Prioritize clean transportation options in low-and moderate-income and environmental justice communities

6.4 Eliminate barriers to participate in and benefit from the clean energy economy

Strategy 7: Expand the Clean Energy Economy

7.2 Establish workforce training programs to ensure New Jersey has the local expertise necessary to support a growing clean energy economy and provide support to those in stagnating industries to refine their skills in line with new needs

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[6] A collaboration of the Robert Wood Johnson and the Pew Charitable Trusts (www.healthimpactproject.org).

[7] Policy Tools to Address the Social Determinants of Health. Keshia M. Pollack Porter. June 5, 2018. Available at: https://www.jhsph.edu/research/centers-and-institutes/health-services-outcomes-research/_images/Materials/Policy%20Tools%20to%20Address%20the%20Social%20Determinants%20of%20Health.pdf

Research Questions and Conceptual Model: Identifying Health Impacts associated with EMP Strategies

Research Questions

The following three main research questions address the EMP components selected for evaluation. The sub-questions under each relate to the specific direct impacts examined.

1. How will ***reduced energy consumption and emissions in the transportation sector*** impact health outcomes? (Strategies 1 and 6)
    - Change in ***Electric vehicles and infrastructure***
    - Change in ***Vehicle miles traveled***

2. How will ***accelerated deployment of renewable energy and DER (including workforce opportunities)*** impact health outcomes? (Strategies 2, 6 and 7)
    - Change in ***Solar energy deployment***
    - Change in ***Wind energy deployment***

3. How will ***maximizing energy efficiency and conservation and reducing energy consumption from the building sector*** impact health outcomes? (Strategies 3 and 6)
    - Change in ***Building energy efficiency***

Conceptual Model: Health Pathways

The conceptual model is a depiction of the pathway from the implementation of an activity to its ultimate effects on human health. The model's first column uses the exact stated language of the EMP strategies as the "**Plan Components**." The next column lists "**Direct Impacts**" that can be expected as a result of implementation of the plan component. These match the sub-questions shown above, and are the changes in society, the economy or the environment that are reasonably expected to happen as a result of plan implementation. The next column "**Intermediate Impacts**" are the changes to social determinants of health that are hypothesized to occur – either positively or negatively (the direction of the changes are based on the finding of the literature review). Thus they are written as "changes" and not as "increases" or "decreases." The key objective of the literature review is to understand the linkages between the direct impacts of plan components and intermediate impacts. Finally, the "**Health Outcomes**" column displays the ways that those determinants listed in the prior column affect human health as ultimate physical or mental health outcomes. Many of these linkages are well-established in literature. For this reason and because the same intermediate impacts are hypothesized for several of the direct impacts, we briefly discuss these well-established connections between "Jobs and Health," "Air Pollution and Health" and "Physical Activity and Health" in their own sections in the Findings below.

Conceptual Model – New Jersey EMP and Health Impacts

Plan Components[8]	Direct Impacts/Changes	Primary Intermediate Impacts	Health Outcomes
REDUCE ENERGY CONSUMPTION AND EMISSIONS FROM THE TRANSPORTATION SECTOR	Increase in electric vehicles Reduction of vehicle miles traveled	Change in air pollution Change in active transportation behaviors, such as walking, bicycling, scooter Change in public transit use Change in noise pollution	Change in outcomes associated with air pollution, such as asthma, respiratory illness Change in outcomes associated with active lifestyle and exercise (walking, etc.) Change in outcomes associated with noise pollution (stress, mental health, educational attainment, etc.)
ACCELERATE DEPLOYMENT OF RENEWABLE ENERGY AND DISTRIBUTED ENERGY RESOURCES	Increase in offshore wind generation Increase in local solar development	Change in jobs/employment opportunities Change in air pollution	Change in jobs and income-related health outcomes, such as chronic disease and mental health. Change in outcomes associated with air pollution, such as asthma, respiratory illness
MAXIMIZE ENERGY EFFICIENCY AND CONSERVATION AND REDUCE PEAK DEMAND	Increase building energy efficiency	Change in housing quality and safety. Change in indoor air quality Change in housing affordability. Change in utility costs. Change in HH disposable income.	Change in income-related health outcomes, such as chronic disease and mental health. Change in health outcomes associated with healthy homes and indoor air pollution.
EXPAND THE CLEAN ENERGY INNOVATION ECONOMY	Increase in clean energy workforce opportunities and training programs.	Change in jobs.	Change in jobs and income-related health outcomes, such as chronic disease and mental health.

[8] Strategy 6 is not listed here, as it cuts across the other strategies in that it seeks to focus benefits from enactment of other strategies on low-income and environmental justice communities.

Methodology: Literature Review Process

Based on the model and research questions, a set of search terms was developed. We searched for studies that examined the connection between the direct impacts of the proposed plan components and the health determinants (e.g. Electric Vehicles and Air Pollution, Renewable Energy and Jobs, etc.). Searches were conducted using platforms available through the Rutgers Library system including EBSCO and PubMed. Individual sector-specific journals were also searched (*Energy Policy*, *Energy Journal*). The team attempted to find systematic reviews or meta-analyses, whenever possible. We only included studies conducted in the past five years, unless we determined it to be key research through reference review, and we also focused only on studies published in English, and those that closely related to the research questions

After reading the titles generated by the searches (n = 7428 articles in total), we selected only those that seemed to apply to the topics (n = 2956), and read those abstracts. From those, we then included only the most relevant to in the summary analysis (n = 174). For some of them, we downloaded and read the full text of the papers to confirm inclusion. Search results by database and by article were documented in an Excel spreadsheet that tracked the search terms used, article titles, author, source, year, study type and key findings.

As a supplementary search, we also consulted key pieces of grey literature (nonsystematic research, U.S. agency and nongovernmental organization reports and publications), and also some Health Impact Assessment (HIA) reports from the national database (available at www.healthimpactproject.org) that pertained to related topics. These HIAs were particularly useful for the sections of this report that discuss the pathways between the intermediate impacts and the health outcomes.

It is important to note that although we attempted to find key pieces of literature, we were limited in time and thus had to make choices that may have resulted in missing some important pieces of literature, such as using only two main search engines for generation of results. We also did not, for example, look comprehensively at the reference lists of included papers to find additional key literature. Full and complete reviews of literature on each of these topics was beyond the scope of this report, but would be a worthy investment.

Literature Review Summary Findings

The narrative summary of the literature review is found in the Appendix. Here we list some of the key findings related to the research questions and key components we studied:

1. How will ***reduced energy consumption and emissions in the transportation sector*** impact health outcomes?

ELECTRIC VEHICLES

- Electrification reduces tailpipe emissions and emissions from petroleum refining, transport, and storage, but increases electricity demand.
- The emissions and human exposure impacts of electric vehicle (EV) adoption depend on numerous factors including geography, electricity generation, and fuel mix.
- The health advantages depend strongly on the electricity power plant portfolio and potentially also on the charging strategy.

- The limited literature on health effects of EV's shows that pollution is shifted from urban areas (tailpipe emissions) to areas where power plants are located (considering that energy is generated from fossil sources).
- The largest reductions from electrification of vehicle fleets for ozone and PM occur in urban areas.
- Public recharging, which can occur at retail locations, rest stops and other public locations, might help curb what has been called 'range anxiety' among EV drivers and encourage greater EV driving.
- Electric mobility has distributive justice implications for being accessible primarily only to wealthier households. However, benefits of reduced tailpipe emissions are disproportionate in urban and high-traffic areas where some environmental justice communities are located.
- EVs can achieve noise reductions, but there are also negative impacts to pedestrian safety because they are difficult to hear.
- As electrification increases, jobs in gasoline-related industries could be lost, but there is evidence that more jobs are potentially created in electricity and related industries than in gas/petroleum.

VEHICLE MILES TRAVELED (VMT)

- Literature suggests strong negative relationships between gasoline-powered engine emissions and many human health outcomes, implying significant positive outcomes when tailpipe emissions are reduced.
- Achieving reduced VMT through adopting policies to reduce private car use has positive health benefits for carbon dioxide reduction, reduced collisions and reduced noise.
- Driving restriction policies alone cannot effectively motivate commuters to use public transportation without public transportation improvements, enhanced commuter awareness of costs and benefits of transit, and incentives to car owners to change driving behavior, like reducing parking availability and/or eliminating free parking.
- Efforts to achieve reduced VMT may not yield maximum health benefits without strong promotion of physical activity. Perceived neighborhood aesthetics, pedestrian-friendliness and safety can magnify the positive effects of mixed-use neighborhoods on residents' physical activity by interacting with the perceived ease of access to a variety of destinations.
- The positive health impacts of measures to reduce VMT (such as compact development, public transportation improvements, driving discouragement policies) can be maximized by integration of these measures into comprehensive programs.
- Good accessibility to public transportation, as well as a dense urban structure (versus sprawl), could contribute to reduced risk of depression and benefits socially vulnerable populations.
- There are both physical and mental health benefits of compact development that results in people spending less time sitting alone in a car and more time walking or bicycling and interacting with their fellow citizens in public spaces.

2. How will ***accelerated deployment of renewable energy and DER*** impact health outcomes (including ***clean energy workforce opportunities***)?

- Literature reveals significant uncertainties in quoted figures for job creation in the renewable energy sector.
- The health impacts of jobs in the renewable energy sector will only be realized if these jobs are safe and offer a good living wage with benefits.

- Repurposing solar photovoltaic panels at the end of their roughly 30-year lifetime can unlock raw materials and other valuable components that can further stimulate economies.
- Shifting to renewable energy generation reduces emissions compared to fossil fuel plants, but it is important to consider health and equity impacts of the entire life-cycle of the energy source, from production of components and siting of infrastructure, through operation and disposal.
- High shares of renewables can improve system resilience due to the variety and dispersion of generation sources and also capacity for on-site storage, but the adequacy of supply during peak demand will require more attention when planning future carbon-free energy systems.
- When considering renewable initiatives, there is a strong demand for fair decision-making processes and an equal distribution of environmental and economic gains and losses.
- There are lower levels of solar adoption in disadvantaged communities, suggesting clear distributive and equity impacts of existing photovoltaic (PV) support policies.

3. How will ***maximizing energy efficiency and conservation and reducing energy consumption from the building sector*** impact health outcomes?

- If properly implemented alongside ventilation, energy efficiency retrofits in housing can improve health by reducing exposure to cold/heat and outdoor air pollutants.
- Weatherizing without maintaining proper ventilation can negatively affect indoor air quality through trapping of toxic chemicals and lead to build up of moisture and mold. Groups at high risk of these adverse health effects include the elderly (especially those living on their own), individuals with pre-existing illnesses, people living in overcrowded accommodation, and the socioeconomically deprived.
- Energy efficiency programs in low-income communities can improve well-being and mental health, as the home is perceived as more of a safe haven, particularly for households who suffer disproportionately from housing-based hazards.
- Energy efficiency retrofits can accomplish a co-benefit of addressing other health and safety hazards in homes.
- Energy efficiency improvements should save money for lower-income households, but can also result in increased cost to homeowners if rents or other costs/rates increase, negating the savings that could have been created from reduced energy usage.

Social Determinants and Health Outcomes:

The main social determinants identified as impacted by components of the EMP that have clear connections to health outcomes are air pollution, physical activity and jobs. For these, we provide brief descriptions of their connections to health outcomes.

Physical activity and health:

The connections between increased physical activity and health are strong and well established. Even small changes in physical activity can result in marked reductions in diseases associated with obesity, diabetes incidence, cardiovascular morbidity (including heart attacks and stroke), cancer, and mortality (Blair et al, 1989; Greg et al, 2003; CDC, 2012). Regular, moderate physical activity (at least 30 minutes a day, 5 days a week), which could occur with increased use of public transportation and walkable communities, provides substantial health benefits, including lower risk of mortality, cardiovascular disease, stroke, cancer, depression, high blood pressure, diabetes, and obesity (US DHHS, 2018; Heath et al, 2006).

Air pollution and health:

Many studies support an association between higher rates of outdoor air pollution (such as nitrogen dioxide and small particulates) and higher rates of lung cancer, cardiopulmonary mortality, and all-cause mortality (Filleul et al, 2005; Pope et al, 2009). Outdoor carbon monoxide and nitrogen dioxide levels are also associated with higher rates of asthma in children (Guo et al, 19997). There is evidence of a causal relationship between exposure to emissions from motor vehicle traffic and a number of adverse health outcomes, including lung function impairment, asthma incidence, cardiovascular disease, and cardiovascular and overall mortality (Saelens et al, 2003).

Jobs and health:

Literature is clear that secure and quality employment provides income, benefits and stability that promotes health (RWJF, 2013). Likewise, unemployment creates stress and is connected to chronic disease and variety of poor health outcomes and behaviors. Unemployment has been linked to higher mortality rates (Martikainen, 1996), while a well-paying job that provides benefits can lead to longer lifespans (RWJF, 2013). The income associated with having a job is beneficially connected to many other aspects of a healthy lifestyle including education, access to healthcare, food access and mobility.

INCORPORATING HEALTH AND HEALTH EQUITY INTO ENERGY PLANNING AND IMPLEMENTATION

This section outlines potential opportunities for enhancing positive health impacts and mitigating negative health impacts during the finalization and implementation of the EMP. We first highlight a set of key opportunities where energy planning and policy can contribute to improved health in New Jersey that either cut across or apply widely throughout the programs and policies of the EMP. We then detail some specific opportunities evidenced by the literature review that apply to the particular components included in the study.

Key Overall Opportunities:

- **Use a Health Lens Throughout Implementation** – This report provides an initial set of insights as to the intersection of health and energy. Using the items listed in this report as a starting point, the Board of Public Utilities (BPU) has an opportunity to pursue improvement to the health of NJ residents by continuing to actively identify where opportunities exist to prioritize health as a driver of implementation.
- **Incorporate Health in Determining the State's Mix of Clean Energy –** The EMP is intended to lay the groundwork for New Jersey to meet Governor Murphy's goal of achieving 100% clean energy by 2050 as set in Executive Order 28. The mix of sources of energy that will contribute to that 100% may have varying degrees of impact on health and health equity. While the current EMP draft moves New Jersey away from its historic reliance on coal-fired power plants that release large quantities of hazardous air pollutants and greenhouse gas emissions, the long term mix of the state's energy portfolio will have important implications for health. The Rutgers team

did not have the resources nor the time during this comment period to review the scientific literature to consider the potential health impacts of a mix of different energy types (e.g., nuclear, natural gas, renewables). Consideration of health and health equity impacts of options for a mix of energy sources to achieve 100% clean energy, and involvement of the state's public health leaders, can serve to be a positive contributor to advancing Health in All Policies goals in New Jersey.

- **Implement Comprehensive Community Energy Planning** – The concept of community-based energy planning has clear implications for improving health and health equity, but only if it is upfront, authentic and truly participatory. Engaging members of the community in the energy planning process is an opportunity to highlight public health issues and strategies. Certain populations, particularly low income and people of color have historically been underrepresented in planning processes. This process could include implementation of tools to identify Environmental Justice issues such as equity analysis. In the rule adopting the Clean Power Plan, USEPA indicated that an equity analysis should include analysis of direct and indirect pollution, and health and socioeconomic impacts on communities, including those with residents of color, low-income residents, and indigenous populations (Herb and Kaplan, 2019).
- **Promote Energy Efficiency** – Given its limited scope, this study looked only at efficiency retrofits on existing housing. However, in general, improving energy efficiency generally in all sectors of society (business, industry, government) is expected to be a big win for health particularly for low-income residents. Health benefits come in the form of reduced emissions from power plants, improved condition and safety of residences, reduced expenditures on energy, as well positive impacts from contributions to local economies. While New Jersey was ranked 18th nationally in the American Council for an Energy Efficient-Economy's annual ranking of state energy efficiency programs for 2018, it was also identified as most improved for the same year. Continuing to expand on the state's improvements would appear to offer opportunities for health as well (Berg et al, 2018).
- **Monitor and Evaluate Health Impacts** – Implementation of the EMP presents an excellent opportunity to institute a process of evaluation of health impacts. This could involve identification of expected impacts through an HIA or checklist (see below), collection of relevant baseline data for affected populations, and tracking of changes through time. This would contribute to general knowledge about health impacts of energy programs, and also help energy agencies to better understand co-benefits and costs, and modify implementation to either enhance those co-benefits or reduce costs and negative impacts.
- **Support Public Health 3.0** – The concept of *Public Health 3.0* offers a new model for the future of public health practice in the United States. Energy planning can support and augment this concept, with the goal of transforming communities while emphasizing cross-sector collaboration and environmental, policy, and systems-level actions that directly affect the social determinants of health (Desalvo et al, 2016). In the vision of Public Health 3.0, a community public health officer serves as the 'chief health strategist' to foster healthy, sustainable and thriving communities. Applied to the concept of community energy planning as outlined in the draft EMP, Public Health 3.0 could envision a Public Health Officer, if adequately resourced as a key participant in community planning, helping to address issues of fuel poverty and energy justice. Doing so would present an opportunity to engage all organizations across the health

care continuum (to include the public health community, health care systems and health care) to contribute to these shared goals.

- **Coordinate with HEALTHY NJ 2030** - Every decade, the state Department of Health launches a new set of science-based, 10-year state objectives with the goal of improving the health of all New Jerseyans. The development of Healthy New Jersey 2030 (HNJ2030) includes establishing a framework for the initiative—the vision, mission, foundational principles, plan of action, and overarching goals—and identifying new objectives. This effort serves as the long-term strategic planning effort for health for the state and presents a tremendous opportunity for BPU to engage with NJDOH on collaboration with regard to integration of health into the EMP.[9]
- **Consider Health Impact Assessment (HIA**) - As implementation begins, lead agencies can look toward Health Impact Assessments as a way to bring health to the table as part of the decision-making process in several ways: engaging health professionals in the discussion, using available tools/literature/science to project the magnitude and distribution of direct and indirect health outcomes. HIA is a nationally recognized, evidence-based approach that is designed to consider potential health outcomes during the decision-making process so modifications can be made to promote positive health outcomes and mitigate negative ones. By design, HIA has a strong focus on engaging the populations most affected by a decision, including populations and communities that are under resourced and traditionally under represented.
- **Use Health Checklist** - If there is not sufficient time or resources to conduct a full or rapid HIA study prior to implementing elements of the EMP, phases of future energy planning, design and implementation could be reviewed for health impacts by use of a health and health equity checklist in consultation with the public health sector. Below for consideration are questions that could serve as a model template. Examples are available nationally that could serve as a foundation for efforts in New Jersey.

Health and Health Equity Checklist for Evaluation of Energy Projects

Checklists are practical tools to assist with evaluating the impacts of implementation of plans, policies, projects and programs. The following set of questions related to potential health impacts of energy projects is not an exhaustive list, rather it is provided by the authors as a starting point for consideration by the BPU. A more exhaustive checklist could be developed through a rigorous process including a cross-sector collaboration of health, economic, energy and environmental organizations with input from community-based organizations that represent environmental justice communities.

A model for implementation of such a checklist could include energy project planners, working in a team process with representatives from relevant fields like transportation, environment, socioeconomics and health, addressing applicable questions from the list below regarding specific plans under consideration, for example, the siting of a local distributed energy resource, or a plan to launch an electric transit bus fleet. Results could inform modifications in plans that result in enhancement of benefits, mitigation of negative impacts or shifting of impacts away from vulnerable communities.

[9] See: https://healthy.nj.gov/2030/

Health and Health Equity Checklist for Energy Projects: Model

1. Is there explicit language connecting the project to human health outcomes or health equity considerations?
2. How is the project including public health experts in the decision-making process?
3. How is the project engaging local stakeholders and how often? Does the public engagement reflect the diversity of the community and reduce barriers to participation (e.g. provide food, childcare, transit-access, translation)?
4. Where will this project be situated? How close is it to houses, schools, or other places where people congregate? In what ways is the land currently used (e.g., housing, agricultural, recreational, cultural uses)? Is there suitable alternative location for these activities?
5. What are the socioeconomic characteristics of the affected community? Will the project be located in a community that already suffers from a disproportionate environmental burden?
6. How will the project affect utility costs and other household expenses? How will this affect low-income populations?
7. What types of and how many jobs will be provided (e.g. temporary or permanent; high-skill or low-skill, benefits available)? Where will hires come from?
8. What are the sources, levels and types of project-related air pollution? How will air emissions be monitored? What populations will be most affected by the exposure?
9. How will the current background noise level change with the addition of this project?
10. Will there be risk of outages or fluctuation in power? Who will be most affected?
11. Does the project or program support walking, bicycling and transit? Are complete street, shared street, green infrastructure design, and traffic calming concepts being incorporated?
12. Does current or future land use development associated with the project incorporate neighborhood commercial and/or mixed-used development and density to encourage non-motorized transportation?

Next, we present specific insights and opportunities drawn from the findings of the detailed literature review of the four selected EMP components – Electric Vehicles, Vehicle Miles Traveled, Renewable Energy and Energy Efficiency.

Specific Opportunities for Selected EMP Components:

Electric Vehicles and Infrastructure:

- In recognition that lower-income households are unlikely to purchase EV’s in the near term, prioritizing electrification of public transportation will provide health benefits in terms of air pollution reductions to urban and lower-income neighborhoods. Instituting e-mobility options (e-bikes, e-scooters) are another opportunity to address inequities by locating them in low-income and minority communities, providing a zero emission option for general mobility and access to public transportation.
- To achieve maximum emissions reductions through adoption of EV’s and reduce pollution exposure shifts from power use areas to power generation locations, the electricity generation mix should become increasingly higher in renewable energy, with consideration of local power generation.
- To facilitate the ability of low-income individuals to purchase EV’s, rebates or availability of used EV’s could be considered, along with more equitably distributed public charging facilities and

dedicated parking areas to encourage EV use for all drivers. EV tax breaks and incentives can address inequities by focusing on cost subsidies for low-income individuals.

- Equity considerations can be incorporated by involving affected communities, through advisory groups or steering committees, in decision-making process regarding funding and location of charging infrastructure, and in issues concerning impacts on jobs (losses in the gasoline-based sector and gains in the EV sector).
- New policies could promote car sharing programs, in which multiple drivers/families can own/use "community EVs and charge stations."
- Promotion of workplace charging is an opportunity to encourage use of EV's, as it is a convenient charging option for and reduces charging during off-peak hours.
- More research is needed to assess the potential impact of the availability of home- and non-home-based charging options on health and equity.
- More studies of EV driving and recharging behavior, particularly in the U.S. context, will help to inform analyses of the most cost-effective and beneficial strategies for investing in recharging infrastructure.
- More research of the life-cycle costs and impacts of EV's and EV batteries is necessary to fully understand health impacts through their manufacture, use and disposal. Battery recycling could be considered as a new business opportunity for New Jersey, provided potential health, safety, and environmental issues are addressed.

Vehicle Miles Traveled:

- As the EMP is implemented, policy-makers can influence positive health impacts by focusing on "first mile/last mile" issues that make it easier for people to safely walk, bike, e-bike, e-scooter or ride-share to access public transit, and incentivize behavioral changes that will lead to active transportation, particularly in low-income neighborhoods.
- To the extent possible, measures to reduce VMT should be well-integrated into comprehensive programs. For example, increasing density and mixed use land development patterns will create mode shifts from driving and foster more physical activity if streets are also made safer and pleasant for walking and biking for users of all ages and abilities, and transit options are improved and accessible.
- Complete Street policies that focus on eliminating road deaths and prioritizing the need of underserved populations (seniors, children, persons with disabilities, low-income residents, car-free households, etc.) are an excellent way to reduce VMT while also addressing many health and safety hazards.
- Governments and industry can reduce driving to work and rush hour congestion by continuing to support car-pooling and telecommuting policy, including improving high-speed internet access in all areas.
- More research and systematic measurement and inventorying of the state's pedestrian and bicycling infrastructure, and of active transportation behavior will inform new development patterns to maximize physical and mental health benefits while reducing use of private vehicles.

Renewable Energy:

- To maximize health benefits from jobs created in the renewable energy sector, it will important for the energy sector to offer jobs that are safe with a living wage with health benefits.

- Health equity impacts can be addressed in the deployment of new renewable programs (e.g. siting of distributed energy resources) by carrying out robust consumer education and outreach to customers and affected communities to ensure their awareness of and obtain input and participation in programs.
- As the proportion of renewables increases in the electricity mix, disproportionate impacts to utility costs that could exacerbate fuel poverty could occur, presenting an opportunity to enact programs to assist low-income residents with utility bills.
- More research is needed to further analyze the vulnerability of wind energy to extreme weather events, and resultant impacts to resiliency.
- More research is needed on life-cycle costs and benefits of solar energy deployment, including the opportunity to repurpose solar PV panels to unlock materials and components that can create jobs.

Energy Efficiency:

- Housing energy efficiency interventions that promote warmth, adequate cooling and energy savings and that include adequate ventilation systems are a significant opportunity to positively influence health outcomes, and addresses health equity if prioritized for populations living in sub-standard quality housing.
- Literature suggests that it is important for energy efficiency programs implemented in buildings occupied by vulnerable households to include education of households about maintenance of ventilation systems, cooking habits and other factors affecting the health of the indoor living environment.
- To protect against the threat of utility disconnection and increasing fuel poverty, rebates or financial assistance can protect low-income households from rent increases resulting from efficiency upgrades.
- If possible, there is an opportunity to track health impacts and learn more about maximizing the benefits of energy efficiency upgrades by monitoring homes that are weatherized with regard to the health of the indoor environment, including indoor air temperature, indoor relative humidity and indoor CO_2 concentrations, and resident health outcomes.
- Energy efficiency programs provide an opportunity to also perform priority health/safety repairs at the same time as energy upgrades, addressing inequities by giving priority to repairs that improve both health/safety and energy efficiency in substandard housing.
- Agencies and organizations implementing weatherization or energy efficiency upgrades in homes and schools can assure attention to optimal installation and functioning of the system by following the US EPA's comprehensive IAQ guidelines. (See https://www.epa.gov/indoor-air-quality-iaq/energy-weatherization-and-indoor-air-quality).

Concluding Comments:

We hope this study and its related insights will assist BPU in considering how to maximize benefits to health and health equity as it moves forward with finalization of the EMP and begins to implement its strategies. Our team of Rutgers University researchers stands ready to help in continuing study and application of these opportunities. The state's public health leaders actively support the concept of Health in All Policies in New Jersey, including in the energy sector, opening up opportunities for building cross-sector partnerships to advance efforts to more systematically consider health and health equity outcomes of energy policy and planning in New Jersey.

Appendix

Literature Review Summary

1. How will ***reduced energy consumption and emissions in the transportation sector*** impact health outcomes?

Electric vehicles and infrastructure

Since combustion engine vehicle tailpipe emissions are a leading source of air pollution, especially for particulates (PM), ozone (O3), and carbon monoxide (CO), electric vehicles (EVs) can be a reliable way to reduce these greenhouse gas emissions. Human exposures to tailpipe emissions are high because they are at ground level and thus lead to many human health impacts, particularly for those who live close to highways and in congested inner cities. A study in California found a higher prevalence of high-emitting vehicles in low-socioeconomic-status communities (Park et al, 2016). Introducing EVs in cities addresses health inequities, as they will disproportionately benefit some urban communities that also disproportionately suffer the negative air quality impacts associated with living in traffic-dense areas (Nopmongcol et al, 2017; Wengwei et al, 2017; Woodcock, 2009; Ferrero et al, 2016).

Electrification may be more beneficial for buses and trucks in urban neighborhoods (pollution and noise reductions), as lower-income residents are least likely to purchase and use EV automobiles, but we found no current research on the health impacts of electric buses on urban populations. Environmental justice (EJ) communities also often suffer disproportionately from high levels of noise. EV's improve noise exposure (Walker et al, 2016), and environmental noise like traffic is linked to sleep disturbance, stress and decreased cognitive performance, increasing risks for cardiovascular disease, decreased immune function, mental health decline, among other effects (Stansfeld and Matheson, 2003). A potential downside of the quieter EVs, though, is pedestrian awareness for crash avoidance. We found at least one study showing that adding external sounds can improve EV detection (Fleury et al, 2016).

Although for local air pollutants and noise, there are advantages, there is little evidence to support that other external costs of internal combustion engines such as accidents and congestion are improved with the shift to EVs. EVs as private cars still endorse a paradigm of private vehicle ownership. Those that rely on private transportation have higher rates of diabetes, cardiovascular disease, and obesity than those who walk or take public transportation (Woodcock et al., 2007).

Many studies support the assertion that the emissions and human exposure impacts of EV adoption, especially in comparison to conventional gasoline- or diesel-powered engines, depend on numerous factors including geography, electricity generation mix, type of EV and charging patterns (Requia et al, 2018). Primarily, the overall benefits to emission reduction depend strongly on the electricity power plant portfolio and somewhat on charging strategies (Jochem et al, 2016; Chong et al, 2016). EVs replace tailpipe emissions but increase electricity demand. Therefore, maximum health benefits are not achieved until the charging power generation fuel mix generates fewer emissions than gas and diesel engines (Sabel et al, 2016; Requia et al, 2017; Gabbatis, 2018; McLaren et al, 2017; Shi et al, 2016; Frey 2018; Perez et al, 2015).

Even though most EV and hybrid fuel options do reduce GHG and urban air pollutant emissions compared with conventional gasoline vehicles, this benefit is reduced and can even be eliminated if coal without carbon capture is the sole electricity source for charging (Delucchi, 2013). When entirely or almost entirely powered by completely renewable fuels such as wind, solar and hydroelectricity, fuel-cycle GHG emissions from EVs can be almost 100% eliminated, but if power is coal-based, battery electric vehicles may reduce emissions by 20% or even slightly increase them (Requia et al, 2017).

Many studies use scenarios to model the impact of different electricity mixes on emissions. Results vary based on model assumptions, but some recent research concludes that EVs can achieve anywhere from a 40% to 99% GHG reduction between a moderate renewable electricity mix to a full wind/solar generation mix (Emery, 2017; Nichols et al, 2015; Sarigiannis et al, 2017). Jacobson et al. show that in the US, EVs charged by renewable energy could save 3700 to 6400 lives annually (Jacobson et al., 2005).

On the other hand, when electric vehicles are recharged from electricity produced from conventional technology power plants such as oil or coal-fired plants, they may produce equal or sometimes more greenhouse gas emissions than conventional gasoline vehicles (Poullikkas, 2015). A review of literature from the past year summarized that: "EV's can reduce tailpipe emissions and associated air pollution, but the scale of adaptation needs to be wide and energy sources need to be clean for benefits to occur" (Glazener and Khreis, 2019). Another study examined the air quality impacts of EVs and disputed that EVs reduce particulate matter as much as expected due to their high weight – 24% heavier than equivalent combustion engine vehicles. Non-exhaust particulates are emitted during operation (Victor et al, 2016).

Distributional injustices can occur with EV promotion, as pollution, and therefore health, impacts shift spatially from the location of the tailpipe emission to the power plant locations (assuming fossil fuel technology), which may or may not be more remote, and may or may not affect more socially and environmental vulnerable populations (Nichols et al., 2015).

Another health equity consideration is that access to vehicular mobility is not equal, as wealthier households drive more frequently, drive further distances, and have a greater ability to purchase new cars (Offer et al., 2011; Jenkins, 2018). Thus, consumers who cannot afford to buy a new EV may end up paying more to run an older, less efficient gasoline car. Lower-income people also are more likely to live in homes without offstreet parking and may face higher costs to install or find charging infrastructure. Furthermore, as EV use increases, petroleum fuel stations may begin to close, delivering the double negative impact of eliminating jobs and also making it more difficult to fuel gasoline-powered vehicles (Sovacool et al, 2019).

Concerning job impacts, there is some limited study suggesting that under current electrification trends, jobs could be lost in the automobile and related industries, and that some auto companies are taking measures such as attrition and re-training (Eichenberg, 2018), while new jobs will be created related to electric vehicles (Thiel et al, 2019). A Europe-focused study found that "(a) crucial multiplier result is that for every £1million of spending on electricity (or gas), eight full-time equivalent jobs are supported throughout the UK. This compares to less than 3 in the case of petrol/diesel supply. Moreover, the importance of service industries becomes apparent, with 67% of indirect and induced supply chain employment to support electricity generation being located in services industries" (Turner et al, 2018).

Scholars studying the uptake of EVs among consumers found that among key barriers are lack of charging infrastructure, cost concerns, operational restrictions, and lack of knowledge (Mehmet et al, 2018). Concerning charging, availability of workplace charging generally results in lower emissions, while restricting charging to off-peak hours results in higher total emissions, until coal is removed from power generation (McLaren et al, 2016; Kim and Rahimi, 2014). Public recharging, which can occur at retail locations, rest stops and other public locations, might help curb what has been called 'range anxiety' among PEV drivers (the fear of running out of battery charge) and encourage greater EV driving (Delucchi et al, 2014).

Vehicle miles traveled (VMT)

Fewer gas or diesel-powered vehicles on the road will decrease air pollution and have positive benefits for health. Vehicular traffic accounts for 20-76% of particulate matter of less than 2.5 mm (PM2.5), and 35-92% of particulate matter less than 10 mm (PM10) in the urban US. (Abu-Allaban et al, 2007). Reducing vehicular traffic of all types also results in reduced risk of injury to pedestrians (Wier et al, 2009). Policies to reduce VMT can be loosely organized into three categories: altering the built environment (improving pedestrian safety measures, creating mixed-use neighborhoods, increasing street connectivity), providing financial incentive or discouragement for individual driving (taxing vehicle miles traveled, implementing parking fees, increasing the fuel tax), and increasing access to and use of public transit (Perdue et al, 2012). As examples, some cities are trying to reduce VMT and urban air pollution by making active transportation more accessible and feasible for citizens, while others have altered the built environment to be amenable for pedestrians and cyclists through increased safety and accessibility measures. Yet others have enlisted bans or taxes on vehicles and fuels to improve air quality and encourage modal shifts to walking, cycling, or public transportation. The positive health impacts of these measures can be maximized by their integration (or bundling in policy packages) (Grazener and Khreis, 2019).

Ideally, adopting policies to reduce private car use may have benefits for carbon dioxide reduction and positive health impacts through reduced noise and increased physical activity (Sabel et al, 2016). But a driving disincentive alone is usually not sufficient for increasing physical activity levels. Comparing VMT reduction policies for their impact on increasing physical activity, Green et al (2013), Perdue (2012) and more recently, Grazerer and Khreis (2019) found that built environment investments supporting complete neighborhoods, street connectivity and active modes of travel (walking and biking), and adding greenspace are the best for promotion of physical activity.

Public transportation service levels and use also effectively promote physical activity (Purdue et al, 2012; Tiziana et al, 2014), and can reduce depression (Yang et al, 2019), especially for women and elderly, by increasing opportunities to move around and have an active social life. (Melis et al, 2015). It also enhances the mobility of vulnerable populations, such as older adults without access to personal vehicles (Paulozzi, 2006). Integrating public transit and ridesharing systems to provide easier multimodal transportation promotes the use of both modes, and enhances sustainable mobility, which benefits both the environment and public health (Zhang and Zhang, 2018). Densely populated neighborhoods with neighborhood aesthetics and safe access to transit and parks have the potential to significantly and equitably contribute to adults' physical activity (Ester et al, 2018).

In terms of financial incentives, there is some limited evidence that pricing policies, such as a direct tax on gasoline, may reduce VMT and shift trips to active modes of travel. However, these policies may simply reduce the number of driving trips without increasing active transportation, and therefore would not be associated with health benefits associated with physical activity (Green et al, 2013; Liu et al, 2016). Literature supports telecommuting as a policy with potential to reduce network congestion and vehicular emissions specifically during rush hours (Shabanpour et al, 2018).

Prioritizing investments and thoughtful implementation of active transportation policies and programs in vulnerable communities could improve inequitable health outcomes for vulnerable populations. For example, since African-Americans experience disproportionately higher rates of heart disease, diabetes, and stroke, active transportation investments in predominantly African-American communities may have greater health impacts (Green et al, 2013).

Another concern for densification is that gentrification might push people out, so while compact forms may have environmental benefits, if it is accomplished with new construction that leads to high rents, it might be negative for the housing security of low-income populations, a strong social determinant of health. Concerns about crime and other social ills could arise also, but it is generally well-supported that if compact development is coordinated with open spaces, good lighting, urban greening and walkable streets, the benefits to safety, physical activity and social capital outweigh potential threats posed by density (Crewe, 2001; McCormick, 2006).

One of the most frequently cited and touted options for reducing VMT is to build more compact urban centers with mixed residential, business and commercial uses, and encourage workers to live there, reducing the need for using automobiles to commute to work or to shopping and services. A recent study found that urban compaction reduces regional GHG (13%) and local air quality emissions (up to 9%), but that air quality deterioration can occur in the dense urban center, depending on the ratio of gas to electric vehicles (Namdeo et al, 2019).

Researchers have run scenarios comparing compact urban forms to more sprawled forms in terms of impacts on air pollution. Yu and Stewart (2017) found that compact scenarios were projected to result in lower regional emissions of all pollutants than sprawl, with differences of −18%, −3%, and −14% for NOx, butadiene, and benzene, respectively. However, complete vehicle fleet electrification resulted in higher exposures to NOx due to increased demand on power plants. These results suggest that urban designs should consider multiple pollutants and the diverse mix of pollutant sources. Green et al (2013) examined VMT reducing scenarios, and found that those with the most positive impacts on human health had the highest levels of active transportation (including transit) and lowest levels of single occupancy driving. The majority of the health benefits result from increased physical activity (60%), followed by reductions in road traffic crashes (approximately 33%) and lower exposure to particulate matter in the air (6%).

2. How will ***accelerated deployment of renewable energy and DER*** impact health outcomes (including workforce opportunities)?

Smith et al (2013) in evaluating health impacts of every major energy source globally, concluded that the biggest negative health impacts accrue to the harvesting and burning of solid fuels, coal and biomass, mainly in the form of occupational health risks and household and general ambient air pollution. Given this, moving away from the burning of solid and fossil fuels can have the greatest positive health impacts of any energy plan or program.

Analysis shows an increase in the percentage of renewable energy and a decrease in energy demand can lead to improved energy security, more jobs in the electricity generation sector, and a decrease in greenhouse gas emissions (Gielen et al, 2019). Jobs created depend on the type of technology and vary across the stages (construction, operation, etc.) (Hondo and Moriizumi, 2017). The health impacts will only be realized if these jobs offer a living wage with benefits and are safe (RWJF, 2013). A review of research on job creation found that there is significant uncertainty in figures for job creation estimates in stages of renewable energy (Cameron and van de Zwaan, 2015). However, another study found a persistent ‘renewable energy wage premium' of more than ten percent in construction/installation activities and architectural/engineering services over the same jobs in other energy sectors (Antoni et al, 2015).

Some studies have found that a high proportions of renewables can improve resilience against extreme weather (Abdin et al, 2019; Esteban and Portugal-Pereira, 2014). From an energy justice standpoint, it is important that energy systems are more resilient so that outages do not occur. Further research is needed to clarify this aspect, as some studies have found that power outage and adequacy of supply during peak demand will require more attention when planning future carbon-free energy systems (Heard et al, 2017).

Researchers have stressed that to adhere to energy justice principles, people of color and low-income need to be socially and economically included in transition to renewables, e.g. to assure consideration of distributional impacts and fair employment opportunities, etc. (Baker, 2019; Healy and Barry, 2017; McCauley and Heffron, 2018). We found little literature about the impact of renewables on utility costs, and this is important to study for its impact on fuel poverty.

Solar energy

A health concern relates to the disposal of solar panels after their 30-year lifespans. The International Renewable Energy Agency (IRENA) and International Energy Agency Photovoltaic Power Systems Program (IEA-PVPS) found that over 90 percent of materials in typical photovoltaic (PV) solar panels, silicon, aluminum and glass can be recycled and used again to produce new solar panels, injecting an estimated 15 billion into the US economy by 2050 (IRENA, 2016a). Encouraging efforts to examine ways to effectively recycle PV panels and stimulating economic activity and creating jobs is a way to minimize negative health impacts that could occur if these panels became waste and maximize health benefits associated with jobs.

Sovacool et al (2019) examined justice aspects of solar energy and concluded that those who do not currently own their own property or have access to a roof are functionally excluded from benefitting from solar PV. There are lower levels of PV adoption in disadvantaged communities, suggesting clear distributive and equity impacts of existing PV support policies, and indicating that the benefits bypass some of the most vulnerable populations (Lukanov and Kreiger, 2019; Barrett et al., 2018). But the risks to justice are not just about the income of consumers. As a substantial piece of technology in the home and from a relatively new retail sector, consumers need information and knowledge in order to make a choice to purchase and use solar PV equipment. This barrier could be most significant to those without access to the internet, with poor health, previous financial difficulties and lower education levels (Walker, 2008).

Again, though Sovacool points out that there is the potential for solar PV to increase reliability for consumers when the main electricity supply isn't available, such as during power cuts and maintenance. "This can be especially important for households where constant electricity supply is important, such as those who are reliant on electricity for medical equipment like a stair lift, nebulizer or refrigeration to preserve medicine."

Also, in the future, those with solar PV and storage could benefit by storing electricity when it is cheap and selling it later when prices rise, but those unable to afford the equipment, or unable to shift their consumption patterns, will be worse off. Globally, however, solar energy technologies have a great potential for overcoming energy poverty issues for growing population and raising the living standard (Shahsavari and Akbari, 2018).

Wind energy

We found little literature connecting wind energy, particularly offshore wind development, and social determinants of health. A recent study asserted that wind power generation would be beneficial despite its vulnerabilities to rising seas and storms, because, as a clean energy source, it curbs the use of fossil-based power generation and carbon emissions and thus ultimately reduces climatic changes and extreme weather events (Zhang et al, 2019). Other studies found that wind farms can contribute to visual deterioration that decreases social welfare (Mattmann et al, 2016), and pointed out that there is a strong demand for fair decision-making processes and an equal distribution of environmental and economic gains and losses in wind development (Scherhaufer et al, 2017).

3. How will ***maximizing energy efficiency and conservation and reducing energy consumption from the building sector*** impact health outcomes?

Energy-efficiency measures aimed at retrofits of existing housing include sealing the building envelope, increasing thermal insulation, and changing windows. A number of studies have found that investments in warmth and energy efficiency improve housing conditions, reduce fuel costs, and increase comfort and a sense of pride in one's home, which then lead to direct and indirect improvements in general health, respiratory health and mental health (Curl and Kearns, 2017; Hernandez, 2016; Grey et al, 2017; Chen and Chen, 2019; Free et al, 2010; Berry and Davidson, 2015).

Homes that are not energy efficient can be drafty and cold. The literature shows that these conditions and low indoor temperatures are commonly associated with a wide range of negative health consequences, including an increased risk of strokes, heart attacks and respiratory illnesses, as well as with common mental disorders (Grey et al, 2017; Hernandez, 2016). Groups at high risk of these adverse health effects include the elderly (especially those living on their own), individuals with pre-existing illnesses, people living in overcrowded accommodation, and the socioeconomically deprived (Vardoulakis et al, 2015). Renters are at a significant disadvantage when landlords have little incentive to improve older, less efficient building systems and appliances particularly when the onus of payment falls on the tenants (Hernandez, 2016

A review of studies on energy efficiency and their impact on health found that recipients on low incomes saw greater improvements in health following energy efficiency interventions, supporting the inclusion of energy efficiency measures in strategies to tackle social issues like fuel poverty and health inequity. People with low incomes or, particularly, poor health are starting from a lower baseline of health, and also tend to spend more time in their homes. For both of these reasons, it is likely that they will benefit more from any improvement to the indoor environment (Maidment et al, 2014). A possible concern related to fuel poverty, though, is that even if energy use is reduced, either utility rates or rent can go up, adding pressure to household budgets and negating potential gains from reduced energy usage (Copiello, 2015).

Another benefit of energy efficiency programs, studies have found, is an increase in general well-being, and self-reported improved respiratory health and fewer missed work days after energy retrofits, regardless of actual indoor environmental quality improvements, suggesting a subjective component (Grey et al, 2016; Haverinen-Shaughnessy, 2018).

Energy efficiency measures, however, can come with unintended consequences. Insulating a building and sealing its envelope, especially in combination with energy-efficiency measures to reduce the air flow rates, could lead to unhealthy indoor environments. In general, thicker thermal insulation might lead to built up moisture and increase the risk of mold growth (Wierzbicka et al, 2018; Mundt-Peterson, 2015).   Chronic exposure to damp in dwellings is associated with important health risks and mainly respiratory problems as asthma and allergies (Kolokotska, 2015). Air-tightening with inadequate ventilation in buildings allows accumulation of pollutants indoors (e.g. gas, smoke, radon, chemicals in building materials and consumer products such as formaldehyde and VOC's), highlighting the need to consider indoor pollution in assessments of exposure and possible health effects after energy efficiency retrofits (Hamilton et al, 2015; Morawska et al, 2017; US EPA; Vasiliyev et a., 2016; Milner et al, 2014; Vardoulakis et al, 2015).

To reduce indoor air quality problems and potentially improve health, careful selection of indoor building materials and ensuring sufficient ventilation are important for achieving the expected health benefits from retrofits and for green building designs. (Coombs et al, 2016; Hamiliton et al, 2015). However, refurbished or newly built sealed homes with optimized ventilation may still lead to lower ventilation rates than intended due to occupant interventions, for example, closing windows to reduce noise. Effective communication strategies focusing on awareness and perception of risk may help address indoor air quality issues. This must be supported by improved household energy efficiency with the provision of more effective heating and ventilation strategies, specifically to help alleviate those suffering from fuel poverty (Sharpe et al, 2015; Mari-Dell'Olmo et al, 2017). US EPA stresses that residents need to have fresh air ventilation systems, radon testing, and training on identifying and isolating other pollutants in homes that could build up to unsafe levels.

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