Exhibit 3

Sierra Club/Exhibit 3

Synapse
Energy Economics, Inc.

Co-Benefits of Energy Efficiency and Renewable Energy in Utah

AIR QUALITY, HEALTH, and WATER BENEFITS

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1. Executive Summary

Synapse Energy Economics, Inc. (Synapse) was contracted by Utah State agencies, including the State Energy Program, the Division of Public Utilities, the Division of Air Quality, the Office of Consumer Services, and the Governor's Energy Advisor (collectively, "Utah Agencies") to develop and apply methods of calculating water and health co-benefits of displacing electricity generation technologies in Utah with new energy efficiency (EE) or renewable energy (RE).

Co-benefits are defined herein as the monetary value of avoided externalities, or the indirect social costs, of energy production. The externalities of power production include both socialized benefits, such as employment opportunities and an increased tax base, as well as significant social and environmental costs, such as health problems, regional haze, and acid rain caused by emissions, as well as the consumption of limited natural resources, including water. Co-benefits are the social and environmental externalities that can be avoided through the implementation of new policies that either displace or replace existing generation. Regulatory mechanisms, such as compelling emissions and/or water controls on existing and new generators, are one method of mitigating external social costs.

According to this and other research, the monetary value of co-benefits and externalities is on the same order of magnitude as the direct costs of energy production (such as capital, fuel, and operational costs) and benefits (such as reliability and availability). These monetizations provide a more comprehensive economic evaluation of existing generation, and of technologies that avoid harmful externalities. Toward this end, Synapse' research establishes and applies a methodology to quantify and monetize two co-benefits of energy efficiency and renewable energy: avoided human health costs and depletion of water resources.

Currently, electricity generation in Utah is almost entirely fired by fossil combustion, and of that, about 82% is fired by coal. This resource mix is relatively inexpensive in direct costs to both Utah and out-of-state consumers, but results in significant emissions of air pollutants and consumes a large share of Utah's increasingly valuable water resources. The authors estimate that fossil generation in Utah today:

- consumes about 73,800 acre feet, or 24 billion gallons, of fresh water per year;
- results in 202 premature deaths per year;
- contributes to 154 hospital visits per year for respiratory injuries, and 175 asthma-related emergency room visits each year.

We estimate that the health and water impacts from Utah fossil generation have a monetary value of between $1.7 and $2.0 billion dollars per year (2008$), or between

$36 and $43 per megawatt-hour (MWh) of fossil generation in Utah, a value similar to the direct costs of conventional electricity generation.[1]

The purpose of this study is to put forth methodologies estimating the co-benefits that can be achieved from renewable energy and energy efficiency. The quantification of these co-benefits, and of the externalities from which they derive, is by no means straightforward, and there are significant assumptions and uncertainties that underlie this study. Some of these uncertainties are:

- The statistical dispatch model relies on limited, public historic generation data to estimate how fossil resources will respond to efficiency and renewable energy (Section 3);
- Emissions of fine primary particulate matter ($PM_{2.5}$) are estimated where reported data are not available, primarily for gas-fired generators (Section 4.2.1);
- Population exposure to $PM_{2.5}$ emissions are based on previous modeling exercises, which carry an intrinsic degree of uncertainty (Section 4.2.2);
- For most gas-fired power plants in Utah, no direct chemistry-transport modeling has been conducted, and therefore this study relies on extrapolations from previously modeled power plants (Section 4.3);
- Ozone exposure modeling is based on a single paper in which relationships were derived for a single summertime month in 1996, and therefore the uncertainties on ozone impacts (morbidity) are likely large and potentially highly biased (Section 4.3);
- Morbidity estimates are based largely on recent peer-reviewed meta-analyses, rather than Utah-specific studies (Section 4.2.3);
- The relationship between population emissions exposure and premature mortality (the concentration-response function) is approximated as linear (Section 4.2.3);
- While this study uses the federally recommended value of $8 million per statistical life. This, economic estimates of the value of a statistical life (VSL) is based on the previously EPA-designated value of $5.5 million (1999$) adjusted to $8 million (2008$). The range of economic estimates of the VSL in EPA's determination ranged widely between $1 and $10 million dollars (1999$) (Section 4.2.5);
- Water use at power plants is inconsistently reported and sparsely available, and therefore this study has estimated water consumption for some power plants based on values from the literature (Section 5.2);

[1] The ranges on the co-benefit and externality values reflect only uncertainties in the externality cost of water consumption, a previously undefined metric which was derived for the purposes of this study. The range indicates neither the uncertainty associated with the impacts of emissions on health, nor does it incorporate the range of published value of statistical life (VSL) measures.

- The externality cost of water is undefined and likely highly variable by region, even within Utah (Section 5.3)

To give a sense of the magnitude of the uncertainties for just some of these estimates, a paper co-authored by one of this study's authors quantified and propagated uncertainties in all aspects of uncertainty modeling.[2] For the coal-fired power plants in Utah, health damages per kWh ranged between 20% of the central estimate (at the 5th percentile) to 250% of the central estimate (at the 95th percentile) represented in this paper.

Most of the externality costs estimated in this study are sourced at coal-fired generators. Reducing the level of in-state coal-fired generation would result in significant benefits for residents of Utah and downwind states. This reduction could occur, in small part, from a reduction in load in Utah, or the integration of new renewable energy onto the grid in Utah and surrounding states. However, Utah is a net electricity exporter in an extensive and highly integrated Western electric grid that extends from the Rocky Mountain States to the Northwest, and from the Northwest down to California. Because of the dynamics of this system, it is unlikely that modest amounts of EE or RE in Utah alone would effectively displace coal-fired generation in Utah. Therefore, the co-benefits from the "passive" integration of EE and RE are modest relative to the externality costs of generation. We estimate that total co-benefits for EE and RE range from a high of $27 per MWh of fossil generation avoided, when wind or solar photovoltaics are employed, to a low of a *cost* of $4 per MWh, when high water-use concentrating solar thermal systems are employed.

By way of contrast, an active replacement of the least efficient power plants in Utah with energy efficiency and either gas generation or renewable energy results in very high co-benefits to the state. We find that for each MWh of coal generation avoided, Utah avoids $69 - $79 of externality cost, a benefit that exceeds the cost of most electrical generation.

This analysis examines the marginal health and water benefits from modest amounts of energy efficiency and renewable energy in Utah. It does not examine the benefits that could be realized from a market transformation in the West, with significant penetrations of new renewable energy, dramatic load reductions, or a price on greenhouse gas emissions.

1.1. Approach

In this study, calculating co-benefits entails four processes. First, we must determine which conventional resources are likely to be displaced, replaced, or avoided by EE and RE. Second, we must establish the health and water impacts that are avoided by displacing conventional generation. Third, a monetary value must be ascribed to these physical externalities. Finally, we present the co-benefit cost-effectiveness of EE and RE

[2] Levy, J.I.; Baxter, L.K.; Schwartz, J. Uncertainty and variability in health-related damages from coal-fired power plants in the United States. *Risk Analysis*. **2009**, 29(7) 1000-1014.

as the value saved for every unit of conventional energy avoided. Applied in this research, co-benefits are estimated as the difference in externality costs between a baseline (business-as-usual) future versus alternative scenarios with new investments in energy efficiency, renewable energy, or a proactive replacement of existing generators.

Synapse analyzed a range of feasible energy efficiency and renewable energy options to assess their potential in realizing health and water co-benefits. These scenarios are organized into four over-arching categories, including:

1. **Baseline**, in which load growth continues unabated and new in-state demand is met with gas generators; [3]
2. **Energy efficiency and demand response**, ranging from modest reductions of 1% per year relative to baseline load growth, to more aggressive targets of 3% per year by 2020;
3. **Renewable energy**, including wind at any of three locations (Porcupine Ridge, TAD North, and Medicine Bow, Wyoming), two photovoltaic options (flat plate and tracking), two concentrating solar thermal projects (parabolic trough and a solar tower), and geothermal operations; and
4. **Replacement** of selected inefficient and aging coal generators with either energy efficiency and new combined cycle gas, or energy efficiency and a combination of renewable energy projects

We compare the projected 2020-21 generation and emissions from each of the alternative scenarios to the projected baseline generation and emissions using a load-based probabilistic emissions model, described in Chapter 3. This model, which is based on statistical analysis of 2007-2008 generation and emissions data from the US EPA's continuous emissions monitoring (CEM) program, was developed by Synapse to determine the emissions benefits of replacing conventional generation with emissions-free resources. Once the generation and emissions for each scenario have been determined, we estimate water and health impacts for each scenario, including water use, mortality, and morbidity, relative to the baseline. We also estimate some aspects of lost productivity, including restricted activity days and lost school days. The externality costs are calculated based on the physical impacts (mortality, morbidity, and water use).

In addition to producing carbon dioxide (CO_2) that has been linked to climate change, the combustion of fossil fuels results in the emission of pollutants such as nitrous oxides (NO_X), sulfur dioxide (SO_2), and fine particulates, and in some cases mercury, all of which are harmful to human health. We use an independent modeling framework to estimate the downwind chemical and particulate impacts, as well as resulting premature deaths (mortality), hospitalizations for respiratory and cardiac illnesses and asthma (morbidity), and lost productivity.

[3] Load growth is estimated from data provided in 2008 by PacifiCorp, a western utility serving over 88% of Utah generation.

A value of statistical life (VSL) is used to assign monetary values to health outcomes, reflecting a societal willingness-to-pay to avoid adverse health effects. The VSL used in this study is not an explicit recommendation. Numerous studies have attempted to derive a VSL, with estimates ranging from under $1 million to over $10 million per statistical life, as noted above. Based on an EPA's recommended value of $5.5 million (in 1999$), this study used a time-adjusted VSL of approximately $8 million. The method used here has been widely applied, and is endorsed by the EPA Science Advisory Board, the US Office of Management and Budget, and the National Academy of Sciences, amongst others.

The water-related externality cost is derived from the consumption of water by thermal generators (both fossil and renewable), and the estimated marginal cost of water in Utah. Thermal generators use water for boilers, cooling, and emissions controls. In this study, we track consumptive (non-recycled) water use for cooling purposes, based on the historical rate of water consumption for individual fossil generators in the state. We estimate a range of social values for water in Utah based on recent water-rights transactions. We estimate that, in general, Utahns are willing to pay between $520 and $5,182 per acre-foot, or 0.16 to 1.59 cents per gallon for water rights (2008$). Fresh water consumed by power plants that could otherwise be used for other purposes costs the state $38-$383 million per year today.

1.2. Summary of Results

1.2.1. Externalities

In a business-as-usual baseline scenario, we project 279 premature deaths per year by 2020 associated with electric generation impacts, compared to 202 premature deaths in the the reference year, an increase primarily due to population growth.[4] We further project nearly a 25%-45% increase over the baseline year in hospital admissions and ER visits per per year associated with electric generation impacts. However, we estimate that water consumption for generation will grow only moderately, to 77,400 acre feet per year (a 5% 5% increase) due to increasing gas use and only moderate increases in existing coal-fired fired generation (see

Table 1-1).

The energy efficiency and renewable energy scenarios reduce externalities only moderately relative to the baseline. Clean energy programs in Utah would tend to primarily displace gas generation, and do not result in significant externality savings. According to our analysis, significant co-benefits would accrue only when older, inefficient coal units are retired and replaced with energy efficiency programs, renewable enegy and gas-fired generating units.

[4] Approximately 86% of these deaths occur in downwind states from particulates and pollution emitted from generators in Utah. Breakdowns between Utah and out-of state externalities are given in Table 7-2.

Table 1-1: Physical externalities from baseline and scenarios in 2020-2021

	Health Externalities				Water Use, Acre Feet per Year
2007-2008	Statistical Deaths per Year	Cardiovascular Hospital Admissions per Year	Respiratory Hospital Admissions per Year	Emergency Room Visits per Year	
Reference Case	202	21	154	175	73,800
2020-2021					
	Baseline Scenario				
Baseline Load Growth	279	32	194	225	77,400
	Energy Efficiency Scenarios				
EE (SWEEP)	277	31	193	224	75,900
EE (2% per yr)	274	31	192	223	75,800
EE (3% per year)	267	30	186	216	72,400
	Renewable Scenarios				
Wind (Porcupine)	273	31	189	220	74,400
Wind (TAD North)	271	31	187	218	74,000
Wind (Medicine Bow)	271	31	187	218	73,900
Solar (Flat Plate PV)	276	31	191	222	75,900
Solar (One-Axis Track)	275	31	190	221	75,500
Solar (CSP Trough, Wet Cooled)	277	31	192	224	82,700
Solar (CSP Trough, Dry Cooled)	277	31	192	224	76,500
Geothermal	269	31	186	217	89,600
	Replacement Scenarios				
Replace Coal w/ EE and Gas	182	20	137	157	57,300
Replace Coal w/ EE and RE	178	20	136	155	56,200

In this research, mortality, morbidity, and water consumption are monetized to obtain an externality cost for the reference case (2007-2008), a business-as-usual baseline scenario, and the EE and RE scenarios. We find that fossil-fired generators in Utah result in $1.6 billion (2008$) of health-based damages, and consume between $38-383 million of water. On a per unit energy basis, externalities cost between $36 and $43 per MWh today.

Synapse was not contracted to estimate damages or externalities associated with the emissions of greenhouse gasses, such as carbon dioxide (CO_2). However, other research has evaluated the extent of potential damages occurring from climate change and estimated a range of costs attributable to climate change associated with each ton of CO_2 emissions. If the externality cost of CO_2 were included at a cost of $80 per ton of CO_2, the externality cost of greenhouse gas emissions from power generation in Utah today would be approximately $3.4 billion (2008$), or $72 per MWh of conventional generation.

1.2.2. Co-Benefits

To monetize the estimated co-benefits of avoided fossil generation in Utah, we have calculated expected externality savings, relative to the baseline scenario, in dollars per unit energy of avoided generation. The most significant cost savings from a co-benefit perspective are in avoided mortality, followed by avoided water and morbidity (Table 1-2).

Table 1-2: Monetary co-benefits in dollars per avoided MWh of generation in 2020-2021.

2020-2021	Health Co-Benefits 2008$ / MWh All (in Utah) Mortality		Morbidity		Avoided Cost of Water 2008$ / MWh (Low - High)	Total Co-Benefit 2008$ / MWh (Low - High)
			Efficiency Scenarios			
EE (SWEEP)	**$5.6**	($1.5)	**$0.1**	$0.0	**$0.2 - $2.1**	**$5.9 - $7.8**
EE (2% per yr)	**$7.8**	($1.7)	**$0.1**	$0.0	**$0.1 - $1.4**	**$8.0 - $9.3**
EE (3% per year)	**$12.3**	($2.8)	**$0.2**	$0.1	**$0.3 - $3.1**	**$12.8 - $15.6**
			Renewable Scenarios			
Wind (Porcupine)	**$18.6**	($4.5)	**$0.4**	$0.2	**$0.5 - $5.5**	**$19.5 - $24.4**
Wind (TAD North)	**$20.4**	($4.5)	**$0.5**	$0.2	**$0.6 - $5.5**	**$21.4 - $26.3**
Wind (Medicine Bow)	**$18.9**	($4.4)	**$0.4**	$0.2	**$0.5 - $5.2**	**$19.8 - $24.5**
Solar (Flat Plate PV)	**$19.0**	($4.9)	**$0.4**	$0.2	**$0.6 - $5.5**	**$20.0 - $25.0**
Solar (One-Axis Track)	**$20.7**	($5.0)	**$0.4**	$0.2	**$0.5 - $5.5**	**$21.7 - $26.6**
Solar (CSP Trough, Wet Cooled)	**$7.7**	($2.6)	**$0.1**	$0.1	**-$12.0 - -$1.2**	**-$4.2 - $6.6**
Solar (CSP Trough, Dry Cooled)	**$7.7**	($2.6)	**$0.1**	$0.1	**$0.2 - $2.0**	**$8.0 - $9.8**
Geothermal	**$19.8**	($4.6)	**$0.4**	$0.2	**-$15.6 - -$1.6**	**$4.6 - $18.7**
			Replacement Scenarios*			
Replace Coal w/ EE and Gas	**$67.26**	($7.39)	**$1.00**	($0.48)	**$0.9 - $8.7**	**$69.1 - $76.9**
Replace Coal w/ EE and RE	**$68.94**	($7.79)	**$1.00**	($0.48)	**$0.9 - $9.0**	**$70.8 - $78.9**

*The replacement scenarios estimate co-benefits against is avoided *coal* generation. These values are not directly comparable to the other scenarios

We find that reducing energy consumption through energy efficiency measures results in savings of between $6 to $16 per MWh of conventional generation displaced. In the renewable energy scenarios, we find total co-benefits range from a *cost* of $4 per MWh to a savings of $27 per MWh.

To achieve even more dramatic co-benefits, if approximately one-third of Utah's most inefficient and polluting coal generators are replaced with a rigorous energy efficiency program and either gas or renewable energy, externalities amounting to $70 - $79 could be realized for each MWh of coal retired or displaced.[5]

1.3. Policy Implications

Externalities are costs that have an impact on society but that are not included (internalized) in the direct cost to the producer of a good or service. In the case of electric power generation, the externalities explored here are the costs of mortality, morbidity, and depletion of water resources as experienced in Utah and downwind – costs that are imposed upon society but are borne incompletely or not at all by the

[5] These last two scenarios cannot be considered on the same scale as the other EE and RE scenarios because the denominator (MWh of generation avoided) is different. Because externalities from coal-fired generation are far higher than those from gas-fired generation, simply replacing coal generation with gas reduces the externality cost significantly, but does not avoid fossil generation. Estimated as a co-benefit, this calculation would result in unreasonably high co-benefits per MWh avoided.

owners or operators of the generating plants. Avoiding these “indirect” costs represents a co-benefit to the state, as well as for neighboring states. This co-benefit is additional to the direct benefits of avoided fuel consumption, operating costs, and the need for new generation and transmission.

In this research, we find that the externality cost of fossil fuel combustion for electricity is expensive, comparable in magnitude to the total direct cost of conventional generation. However, we conclude that newn energy efficiency and renewable energy programs in Utah can achieve relatively modest externality savings. This is because efficiency and renewable energy in Utah primarily displaces natural gas-fired energy and imported hydroelectric capacity, rather than coal. As a theoretical bookend, we find that replacing older, inefficient generators with efficiency and low-emissions units results in a dramatic reduction in externality costs.

Another approach that is likely to achieve significant societal benefits in Utah, not quantified in this research, is to reduce energy consumption requirements throughout the Western United States. Utah is an electricity exporting state in a tightly interconnected regional grid; reducing regional power requirements or introducing a high penetration of renewables throughout the region could result in avoided generation in the region and significant water and health benefits in Utah. Coalitions such as the Western Regional Air Partnership (WRAP) or the Western Climate Initiative (WCI) provide opportunities to influence regional demand that affects Utah. Without integrated regional approaches, EE and RE are unlikely to produce significant co-benefits in Utah.

Modeling emissions avoidance, externalities, and co-benefits can be useful for planning and licensing purposes. The results of this study may be used in state processes for considering the full costs and benefits of new generators in utility integrated resource plans (IRPs), determining effective strategies to comply with federal or regional air quality plans and state implementation plans (SIPs), estimating pathways to meet emissions targets for regional and federal regulations, calculating benefits of state, regional, or federal renewable portfolio standards, and examining indirect costs and benefits of transmission expansion plans. This approach can help lead to resource planning and policy decisions that better reflect the interests of Utah and its residents.