An Evaluation of Utah's Greenhouse Gas Reduction Options

An analysis performed by the
Nicholas Institute for Environmental Policy Solutions
for the State of Utah

Etan Gumerman
Brigham Daniels

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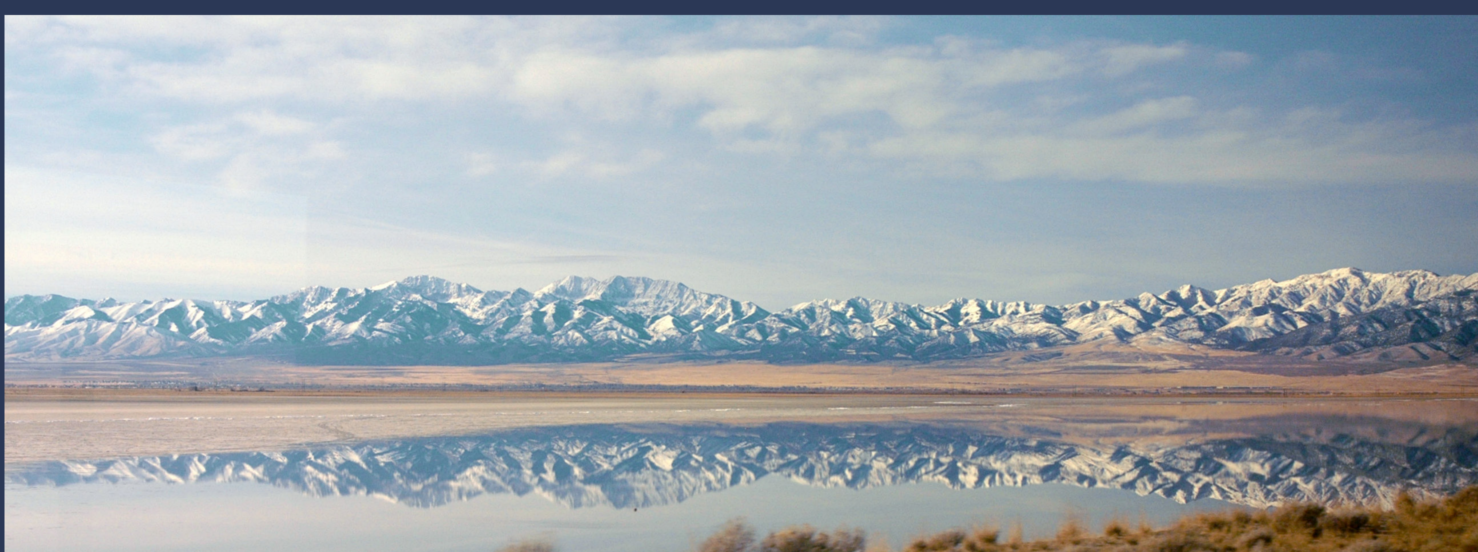
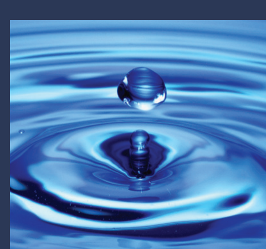
August 2009





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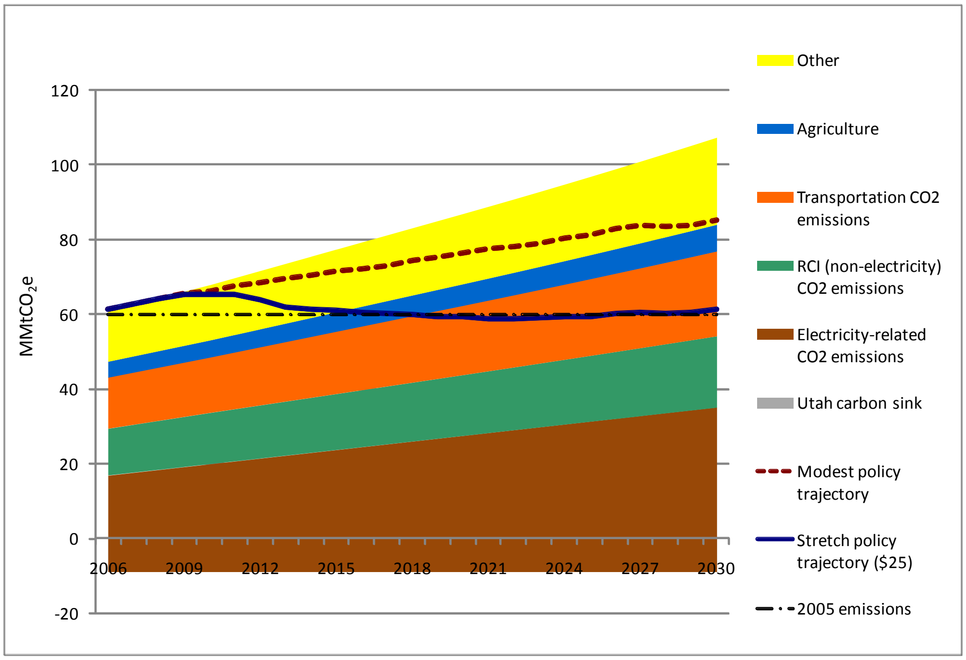
Abbreviations and Acronyms

ACEEE	American Council for an Energy-Efficient Economy
AEO	Annual Energy Outlook
BRAC	Blue Ribbon Advisory Council
BTU	British thermal unit
CARB	California Air Resources Board
CCS	carbon capture and sequestration
CHP	combined heat and power
DAQ	Utah Division of Air Quality
DEQ	Utah Department of Environmental Quality
DOE	U.S. Department of Energy
DSM	demand-side management
EIA	Energy Information Administration
EISA	Energy Independence and Security Act
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
IECC	International Energy Conservation Code
LEED	Leadership in Energy and Environmental Design
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
NO_x	nitrogen oxide
PSC	Public Service Commission
REC	Renewable Energy Credit
RCI	residential, commercial, and industrial sectors
RMP	Rocky Mountain Power
RPS	renewable portfolio standard
SO_x	sulfur oxide
UEES	Utah Energy Efficiency Strategy
UGS	Utah Geological Survey
USGBC	U.S. Green Building Council
UTA	Utah Transit Authority
WCI	Western Climate Initiative
WECC	Western Electricity Coordinating Council

EXECUTIVE SUMMARY

This report quantifies the avoided emissions potential from 16 of the strategies that the Blue Ribbon Advisory Council (BRAC) on Climate Change sent to Governor Huntsman for his consideration. This process was meant to be a quantitative companion analysis to the BRAC report[1] to provide further groundwork for Utah's climate plan. In addition, it was to be used to help inform Utah's decision-making regarding its Western Climate Initiative goal-setting. In order to accommodate these decision-making processes, the Nicholas Institute (The Institute) provided much of this analysis to the State prior to the completion of this report.

Figure 1. Utah's greenhouse gas emissions forecast, overlain with avoided potential.



The gray area ("Utah carbon sink") is not visible as it is behind the brown area ("Electricity-related CO_2 emissions") in the portion of the chart that is below zero. This is done in order to illustrate how sinks and sources offset each other.

For the strategies as defined in this report, the likely avoided emissions fall into the range shown in Figure 1 (between the bold lines, which represent projected greenhouse gas emissions of various sectors of Utah's economy). Our work attempts to deal with the inherent uncertainty in such calculations by evaluating a range for the depth and success of implementation of the strategies. Modest interpretations of these strategies are combined to form the combined modest policy emissions trajectory. Likewise, "stretch" interpretations of each of the 16 strategies are combined to form the combined stretch policy emissions trajectory. The solution space between the lines is the emissions range that we believe the State can reach

[1] The full BRAC report is available at http://www.deq.utah.gov/BRAC_Climate/final_report.htm.

before considering additional measures. Cumulative avoided emissions by 2020 range from 64 $MMtCO_2e$[2] in the modest scenario to 172 $MMtCO_2e$ in stretch scenario.

The avoided emissions attributed to each sector are summarized below in Table 1. The breakdown for each sector is shown following Table 1 in Figures 2 through 5.

Table 1. Summary avoided emissions from combined measures.

In $MMtCO_2e$			2030	
	Modest	Stretch	Modest	Stretch
RCI (natural gas)	1.0	1.7	1.3	3.3
Electricity (RCI, ES)	5.7	20.4	12.7	31.1
AF	1.2	1.2	1.8	1.8
TL	3.1	4.6	7.3	10.4
Other (jet fuel)	–	0.5	–	0.6
Total	11	28	23	47
% less than reference	13%	32%	21%	43%

For the stretch scenario, avoided electricity-related emissions account for about 50% of projected 2020 emissions. The AURORAxmp Electric Market Model analysis covers seven of the 16 strategies examined, specifically all six strategies in the Energy Supply (ES) and Residential, Commercial, and Industrial (RCI) sectors, plus the carbon cap strategy (CC-6: Regional/State Cap-and-Trade Programs, Carbon Tax, or Hybrid), which cuts across various sectors of the economy. With the exception of the Clean Car Program (TL-9), electricity measures encompass the strategies with the largest potential for avoided emissions: Carbon Cap (CC-6), Renewable Portfolio Standards (ES-1), Energy Efficiency Measures (RCI 1, RCI-8, RCI-20, and RCI-21) and Carbon Capture and Sequestration policies (ES-8, ES-9, ES-10, and ES-19).

Non-electricity-related RCI emissions result from the direct consumption of fuels in buildings and industry. Most BRAC strategies relate to natural gas demand for buildings, which is why the avoided emissions potential is small, reaching 10% of 2020 forecast in the stretch scenario. More than 50% of these emissions are industrial—and are not addressed by this analysis. Utah could obtain further non-electricity emissions reductions in this sector if it employed other strategies that reduced emissions related to burning wood, coal, or petroleum.

The agricultural strategies quantified in this report are manure management and the promotion of biomass fuels. These two strategies alone have the potential to offset 20% of emissions in 2020.

The transportation strategy with the highest potential is adopting California clean car standards. This, of course, will require EPA approval before any state may act. Three other transportation strategies are evaluated in this report: Mass Transit, Trip Reduction, and Idle Reduction.

[2] $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Figure 2. Electricity inventory with potential avoided emissions.

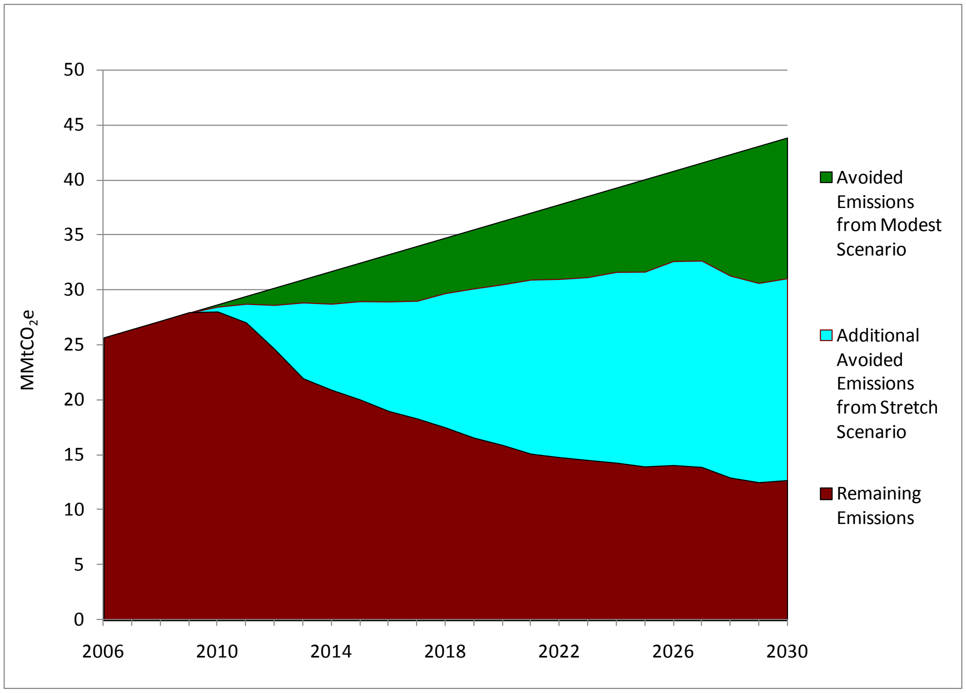
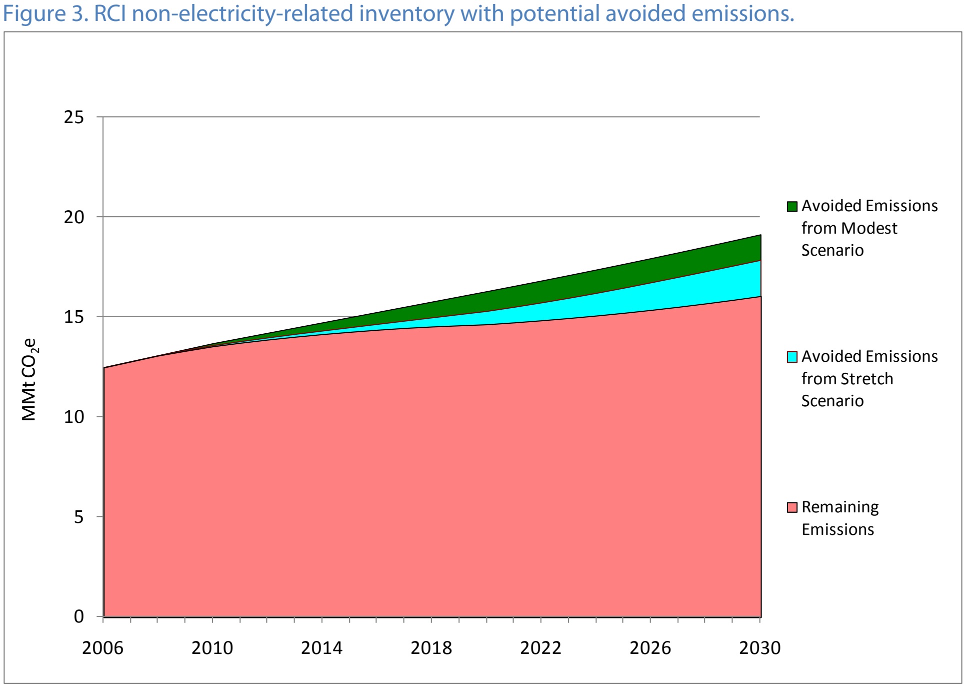


Figure 3. RCI non-electricity-related inventory with potential avoided emissions.



The body of this report explores in detail the reference inventory and forecasts by sector and offers our interpretation of the strategies. Each chapter also includes an explanation of the calculation of avoided emissions potential. We should note that this is not a prediction of what Utah will achieve; rather it is a prediction of what Utah could achieve in a concerted effort to implement these strategies in ways consistent with the assumptions of this report.

Figure 4. Agriculture inventory with potential avoided emissions.

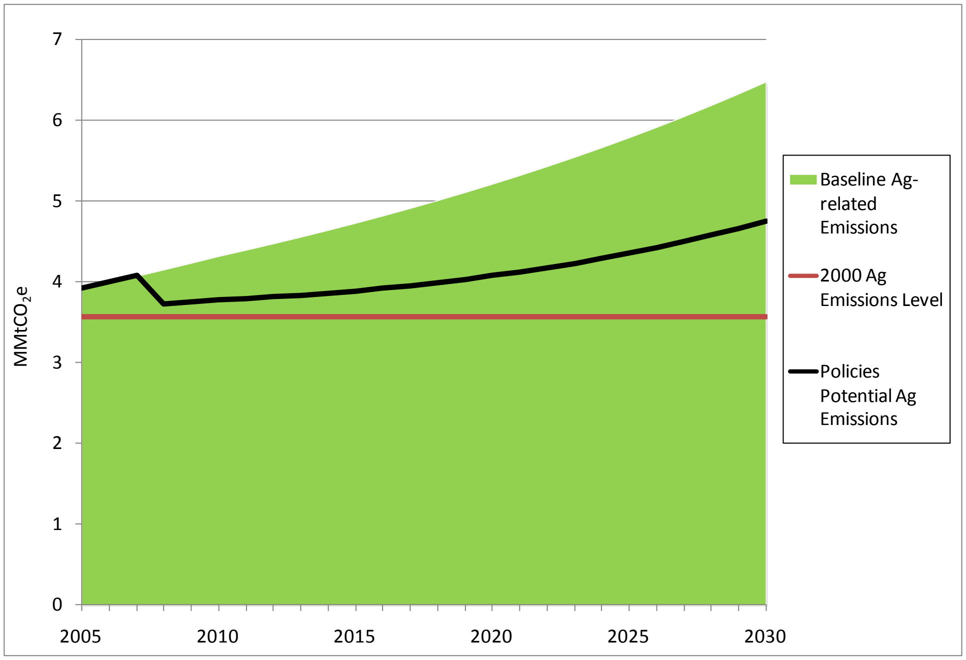
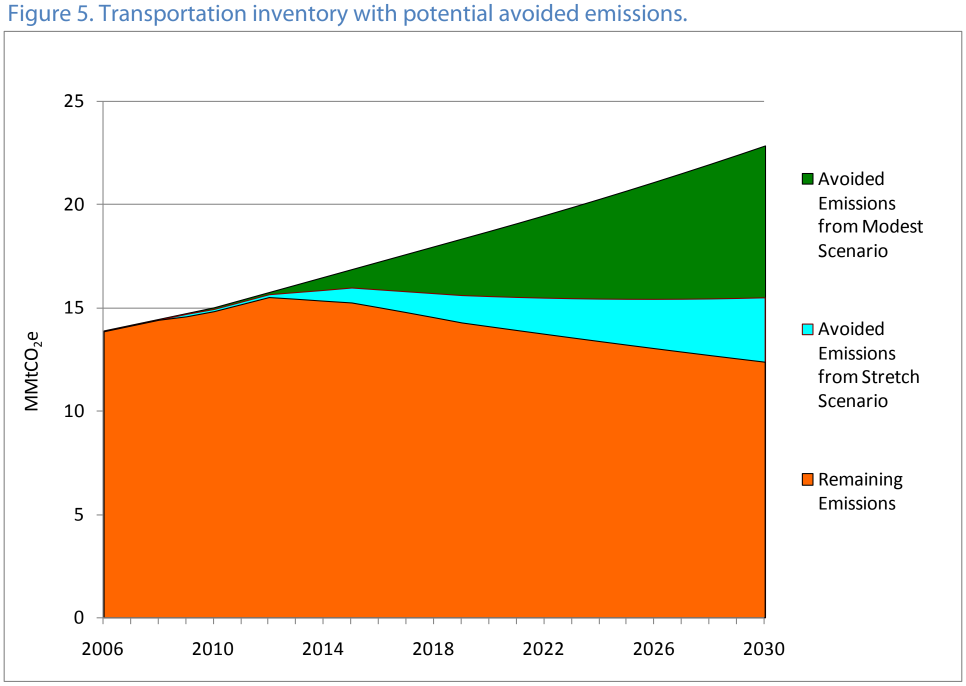


Figure 5. Transportation inventory with potential avoided emissions.



We are compelled to add a list of accumulated wisdom for any practitioners charged with building on this work or with implementing the State's plan:

- **Reference projections should be re-evaluated.** If they turn out to have been high, it will be easier to reach targets; if they turn out to have been low, it will be more difficult.
- **Some strategies are easier to implement than others.** Some strategies can be quickly implemented while others require careful research, planning, and coordination.

- **When and how these strategies are implemented will obviously affect their success at achieving reductions.** As a general rule, the earlier the action, the greater the potential for the strategy to achieve meaningful reductions.
- **Electricity reductions in particular must be quantified in a consistent manner when evaluating progress.** This is essential because of the impacts of electricity imports/exports and because of the regional nature of the electricity grid (electricity flows freely across state lines).
- **"Other emissions" and unexamined strategies should be evaluated independently.** These may reduce the need to achieve the amount of avoided emissions from the 16 strategies we analyzed, or they can be used to attain greater emissions reductions.
- **Emissions are temporally important.** Going forward, emissions are likely to continue to increase. As such, further emissions measures will be necessary to keep emissions from rising in synch with energy demand.
- **This report examines 16 BRAC strategies in detail.** That said, this should not be interpreted to mean that the other 56 strategies are not important. In fact, the enabling strategies in particular should be considered early in the process by the State as they may facilitate the adoption of the 16 strategies we analyzed as well as those we did not.

INTRODUCTION

Over the past two years, the State of Utah has seriously weighed the merits of taking action to address climate change. In large part, Utah's attention to this issue has grown out of two interrelated efforts. First, Governor Jon M. Huntsman, Jr., convened a Blue Ribbon Advisory Council (BRAC) on Climate Change. Second, Utah joined the Western Climate Initiative (WCI), a regional initiative among state governments aimed at addressing climate change. It is important to understand that this report is tied closely to each of these efforts. We explain each of these ties below.

This report could be considered an extension of the analysis performed by the BRAC.[3] As a reminder, we note that the BRAC relied on extensive stakeholder involvement which included some of the State's most notable voices. Those serving on the BRAC represented leaders and opinion-makers across important cross sections of the State. These members came from State and local government, vital Utah industries, and a number of community and nonprofit groups. Members of the BRAC considered a wide range of potential actions the State could take to reduce its GHG footprint. Because the task at hand was so large, the BRAC accomplished much of its work by breaking up into committees, each focused on a particular sector of the State economy. The committee approach allowed stakeholders to critically examine potential options and to focus on those options within their purview of expertise. The five sector groups included two focused on energy demand (one on transportation and the other on residential, commercial, and industrial demand); a third group focused on energy supply, primarily electricity; a fourth group focused on agriculture and forestry; and a fifth group, referred to as the "cross-cutting group," focused on strategies bridging different sectors.

To complete its work, the BRAC met and voted to determine which strategies they would ask the Governor to consider closely. Based on a convention created by the BRAC, if any one strategy received more than five votes of BRAC members (roughly 20%–25% of the members that ultimately voted), the strategy would be forwarded to the Governor for his consideration. Using this method, the members ultimately settled on 72 discrete strategies.

After completing this initial process, a number of the participants voiced concerns that—having only conducted the minimum level of analysis necessary to inform their decision-making—they lacked quantitative data to support their conclusions. The Utah Department of Environmental Quality (DEQ) provided a summary of estimated costs and GHG reduction potential of several policy options based upon evaluations conducted in other Western states. Nonetheless, Utah-specific analysis needed to be done for these strategies. These BRAC members suggested that the Governor and other decision makers be provided with a quantitative analysis to supplement the BRAC's recommendations. The DEQ commissioned this study by the Nicholas Institute in large part as a response to that suggestion.

[3] The BRAC's full report is available at http://www.deq.utah.gov/BRAC_Climate/final_report.htm.

As mentioned above, this report also has a tie to the WCI process. When Utah joined the WCI, it made a number of commitments. One such commitment was to establish a Utah-specific GHG reduction goal by May 2008. Other western states have set these goals in a number of ways. Utah has decided to take a "bottom-up" approach to setting its goal by evaluating discrete strategies and then determining the appropriate goal based on the strategies selected. While it is anticipated that this report will assist a wide range of policymakers in Utah assessing climate change, this report is most immediately intended to provide an independent and impartial analysis to assist in setting a reasonable statewide GHG reduction goal.

Scope of the Report

Both the State of Utah and the Nicholas Institute (The Institute) recognized that the timeline to complete the work contemplated by the State was an aggressive one. Originally it was hoped that the Institute would provide some analysis of all 72 of the strategies put forward by the BRAC. As the work progressed, however, it became clear that there was not sufficient time to conduct a full evaluation of all strategies.

With input and direction from the State, the Institute ultimately narrowed the range of options that would receive consideration. In doing so, the Institute prioritized the options based on the following criteria: reduction potential, BRAC interest (as determined by votes and, to a lesser extent, the priority rankings of the options), expected costs, and the time required to evaluate the strategy. These strategies, like the set of BRAC strategies overall, reflect a variety of implementation options ranging from incentives and education to standards and regulations. The State and the Institute agreed to focus on a subset of options and then to revisit whether to evaluate the remaining strategies. Using this prioritization scheme, the Institute analyzed the following strategies:

Renewable Portfolio Standard	ES-1
Encourage Carbon Capture and Sequestration Technologies	ES-8, ES-9, ES-10
Retrofit Plants with CO_2 Capture	ES-19
Utility Demand Side Management	RCI-1
State Appliance Efficiency Standards	RCI-8
Incentives for Improved Design and Construction	RCI-20
Improved Building Codes	RCI-21
Regional/State Cap-and-Trade Programs, Carbon Tax, or Hybrid	CC-6
Develop and Implement Aggressive Mass Transit Strategy	TL-1
Trip Reduction, Rideshare, Vanpool, and Telecommuting	TL-4
Clean Car Program	TL-9
Idle Reduction Program	TL-10
Promote Production of Biomass Fuels	AF-1
Improve Manure Management	AF-2

This report will lay out the parameters of these 16 strategies individually, and then explain how we combined them to calculate the avoided emissions potential. The Institute evaluated each of the strategies independently. The strategies at times were general enough that several different policies could accomplish the strategies. Still, where the State had begun to take steps to fulfill a particular strategy, The Institute tried to focus on the pathway Utah had identified rather than illustrate a range of options. So, for example, for ES-1 (Renewable Portfolio Standard), the Institute examined one implementation scenario as contained in the Energy Resource and Carbon Emission Reduction Initiative (S.B. 202, 2008 General Session). For other strategies, the Institute looked at a range of options. For example, for TL-1 (Develop and Implement Aggressive Mass Transit Strategy), we assessed three versions of the strategy, which we defined as either "modest," "medium," or "stretch." For each of these strategies, we worked closely with the State to determine the correct parameters to guide our analysis.

Unfortunately, a number of strategies the BRAC deemed important were either too general to allow for additional quantitative analysis in a timely manner or were too difficult to quantify in combination with other strategies. This does not mean that these strategies are not important. Rather, it is our judgment that without further refinement of these strategies, it would be difficult to provide the State with a useful and meaningful analysis. A couple of examples of such strategies are Green Power Purchasing (RCI-4) and Voluntary Efficiency Targets (RCI-2).

Finally, a number of strategies, while seemingly important, do not lead directly to GHG reductions. Rather, they serve to facilitate other strategies which may lead to carbon emission reductions; that is, they are enabling strategies. For example, establishing a GHG Registry (CC-1) will not by itself lead to reductions, although it is a fundamental piece of an overall GHG-mitigation puzzle which includes other strategies such as Climate Adaptation Strategies and Policies (CC-5). As such, these enabling strategies, while perhaps vitally important, do not fit within the parameters of this report.

When the time arrived to combine multiple strategies into a package, we chose to limit the suites under consideration as much as possible, while still being able to examine a wide range of results. We picked combinations that would represent the results boundaries based on how we defined the modest and aggressive scenarios for each strategy independently. Thus, we settled on the following scenarios: 1) "all modest" implementation/success; and 2) "all aggressive," including the strategy of Regional/State Carbon Cap-and-Trade Programs, Tax, or Hybrid (CC-6, henceforth referred to as "carbon cap/tax"). We have not evaluated carbon cap/tax independently; it made more sense to analyze how it complements other strategies. How it does so will be discussed throughout the report.

Calculating Utah's Carbon Footprint

Greenhouse gas emissions quickly diffuse throughout the global atmosphere. In terms of climate change, the impact of CO_2 emissions generated in South Jordan, Utah are no different from those generated in Amman, Jordan—or anywhere else in the world.

While the purpose of this report was not to create a baseline of emissions, the Institute nonetheless needed a baseline from which to work. We have tried as much as possible, except with the agriculture-forestry sector, to recreate the baseline created for the State in its July 2007 GHG inventory.[4] While we take it on face value that the inventory is an accurate inventory, we do note that the Institute nonetheless was forced to extrapolate from 2020 (the last date in the most recent inventory) to 2030 (the last year in our analysis).

It is necessary to briefly review the content of the inventory baseline and discuss how we extended the baselines of each sector.

We begin with the electricity sector (bottom wedge). The analytical work in this sector largely relies upon results from an electricity dispatch model called AURORAxmp Electric Market Model.[5] We modify the parameters of the model to take into account the annual growth rate 3.3% assumed in the inventory through 2020. After 2020, we assume a more conservative annual growth rate in this sector of 2.0%. Given these parameters, we produce the baseline shown in Figure I-1. Emissions from electricity production currently make up 37% of gross emissions and are projected to rise to 38% by 2030.

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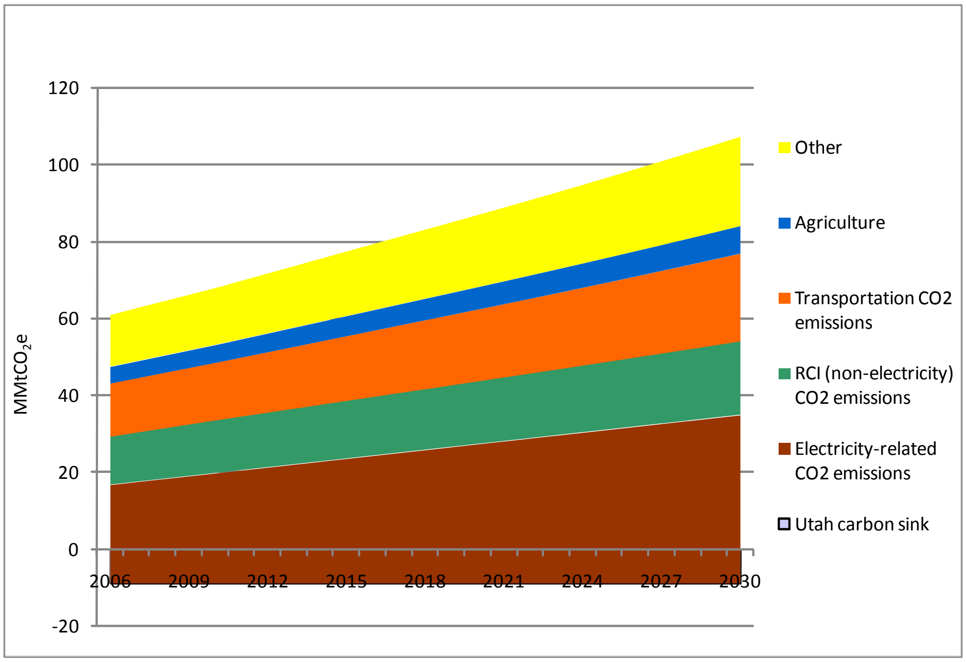
[4] Center for Climate Strategies, *Final Utah Greenhouse Gas Inventory and Reference Case Projections, 1990–2020* (hereafter cited as *Utah GHG Inventory*), July 2007. http://www.deq.utah.gov/BRAC_Climate/docs/Final_Utah_GHG_I&F_Report_080907.pdf.
[5] For more information on AURORA, see http://www.epis.com.

Figure I-1. Baselines for each sector.



The gray area ("Utah carbon sink") is not visible as it is behind the brown area ("Electricity-related CO_2 emissions") in the portion of the chart that is below zero. This is done in order to illustrate how sinks and sources offset each other.

The 2007 inventory separates the residential, commercial, and industrial sector emissions into two parts. First, we have emissions associated with the consumption of electricity. We attribute, as the 2007 inventory does, these to the electricity sector (emissions count at the time of electricity production rather than consumption). The second part is the non-electricity-related emissions—those emissions from the direct consumption of oil, natural gas, wood, and coal. Emissions from RCI direct fuel consumption currently make up 18% of gross emissions and, while rising on an absolute level, are projected to make up 16% in 2030.

In the transportation sector, we rely on a transportation model called MOBILE6 that the Utah DEQ ran for the Institute as part of the evaluation of a particular strategy. This model is typically used to calculate criteria pollutants regulated by the Environmental Protection Agency (EPA) under the Clean Air Act, as well as in the State's transportation planning processes. This transportation reference projection includes diesel and gasoline; other transportation emissions such as those from jet fuel have been included as Other Emissions. (MOBILE6 was calibrated to the 2007 inventory through 2020, and is shown in Figure I-1). Vehicle emissions account for 20% of Utah's gross emissions currently and are projected to account for the same share in 2030.

In the agricultural and forestry sectors, the 2007 inventory included two components. The first deals with emissions stemming from this sector. We take those on face value and extend them out into 2030 in a linear fashion. These emissions make up 6% of gross emissions currently and are projected to stay at that level in the future. The second deals with the carbon sink (i.e., natural carbon capture) associated with the agricultural and forestry sectors. The 2007 inventory estimated this component of these sectors twice in 2007. The first came in a February draft of the inventory. The estimate at that point was 38.5 $MMtCO_2e$, staying flat over time.[6] The final draft of the inventory adjusted the carbon sink downward to 13 $MMtCO_2e$ flat.[7] Appended to this report is a peer review of the 2007 carbon sink inventory performed by Professor Dan Richter of the Nicholas School of the Environment at Duke University. His revised estimate uses forestry inventory and analysis data to directly estimate a sink of 8.75 $MMtCO_2e$ flat over time.

All other emissions are also shown in Figure I-1. "Other Emissions" include jet fuel, natural gas vehicles, waste management, fossil fuel industry, and industrial processes. We extrapolate a linear increase of these emissions from 2020 to 2030. The most important thing to note about these emissions is that they are increasing at a higher rate than those from other sectors, and that the BRAC strategies do not address some subsets of "other emissions" at all. Therefore a component of the State's emission reduction plan may be to identify avoided emissions opportunities within this category. These emissions currently make up 19% of Utah's gross emissions, and are projected to account for 20% by 2030.

[6] CCS 2007a.
[7] CCS 2007b.

Contents of This Report

This report is designed to provide an independent analysis of the GHG reduction potential and the economic costs accrued to Utah and its citizenry of pursuing various policy alternatives. While keeping in mind the time constraints associated with this report, we have tried to identify other co-benefits and co-costs of each particular strategy.

The Institute notes up front some of the limitations associated with the analysis we provide. While we have estimated the GHG reduction potential of each of the strategies, it should be noted that the expected GHG benefits of a single strategy will differ when considered in tandem with other strategies. For example, some strategies may work to complement others. As shown by the work of Envision Utah, we might expect that the BRAC strategies that call for aggressive mass transit (TL-1) and quality growth (TL-2) may complement each other. Likewise, there are instances in which pursuing one strategy could reduce the effectiveness of another strategy. In such instances, pursuing both strategies may still be effective and desirable, but the net emissions reduction effect may be less than the sum of the emissions reductions associated with pursuing each strategy independently.

Keeping this limitation in mind, the Report proceeds as follows. Chapter 1 examines the strategies to reduce GHGs in the residential, commercial, and industrial (RCI) sectors. We analyze four strategies individually (RCI-1, RCI-8, RCI-20, and RCI-21). Then we perform a pair of analyses of these four strategies combined, which we call "Energy Efficiency Measures: Combined Analysis." One analysis is for a "stretch" scenario of avoided demand; the other is of a more "modest" scenario.

Chapter 2 analyzes BRAC strategies in the Energy Supply (ES) sector. We analyze one policy individually (ES-1), then we analyze four strategies related to carbon capture and storage together (ES-8, ES-9, ES-10, ES-19)—we call this suite "Encourage Carbon Capture and Sequestration Technologies."[8] We then attempt to define the avoided emissions potential for a suite of electricity-related strategies that span both the RCI and ES sectors. We do this by analyzing in AURORAxmp two scenarios of avoided demand—one "modest," one "stretch"—for the following strategy combinations: ES-1 + combined CCS suite + Energy Efficiency suite. The modest version uses the modest versions of the CCS and Energy Efficiency suites; the stretch version uses the stretch versions of those suites as well as the one suite we include from Cross Cutting group, Regional/State Cap-and-Trade Programs, Carbon Tax, or Hybrid (CC-6).

[8] Note that three of these strategies—ES-8, ES-9, and ES-10—are categorized by the BRAC under the heading "Encourage Carbon Capture and Sequestration Technologies (ES-B)," while ES-19 is categorized under "Improve Efficiency and Reduce CO_2 at Existing Electricity Generation Plants (ES-D)." For the purposes of our analysis, we include ES-19 under the umbrella of ES-B.

RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL POLICY OPTIONS

The BRAC identified 19 strategies to reduce GHG emissions from the residential, commercial, and industrial (RCI) sectors. The following strategies represent the BRAC's attention to two broad approaches to achieving this. Some strategies are directed at reducing the demand for energy (e.g., policies that make buildings or appliances more energy-efficient), while others call for the production of energy with lower associated GHG emissions (e.g., the strategy of distributed generation as well as certain enabling strategies that encourage the installation of alternative energy systems).

The strategies we analyzed are listed below in black, with those we did not analyze fully and therefore did not include in this report indicated in gray:

Utility Demand Side Management	**RCI-1**
Voluntary Efficiency Targets	RCI-2
Green Power Purchasing	RCI-4
Rate Design	RCI-5
Distributed Generation with Combined Heat and Power Systems	RCI-6
Distributed Generation with Renewable Energy Applications	RCI-7
State Appliance Efficiency Standards	**RCI-8**
Solar Hot Water and Photovoltaic Codes for New Buildings	RCI-9
Energy Management Training/Training for Building Operators	RCI-10
Government Lead by Example with Mandatory Efficiency Targets	RCI-11
State Promotion and Tax or Other Incentives for Efficient Products	RCI-12
Fuel Switching to Less Carbon-Intensive Fuels	RCI-14
Reinvestment Fund	RCI-15
Focus on Small and Medium Enterprises (SMEs)	RCI-16
Participation in Voluntary Industry-Government Partnership	RCI-17
Water Pumping, Treatment, and Use Efficiency	RCI-19
Incentives for Improved Design and Construction	**RCI-20**
Improved Building Codes	**RCI-21**
Waste/Recycling	RCI-23

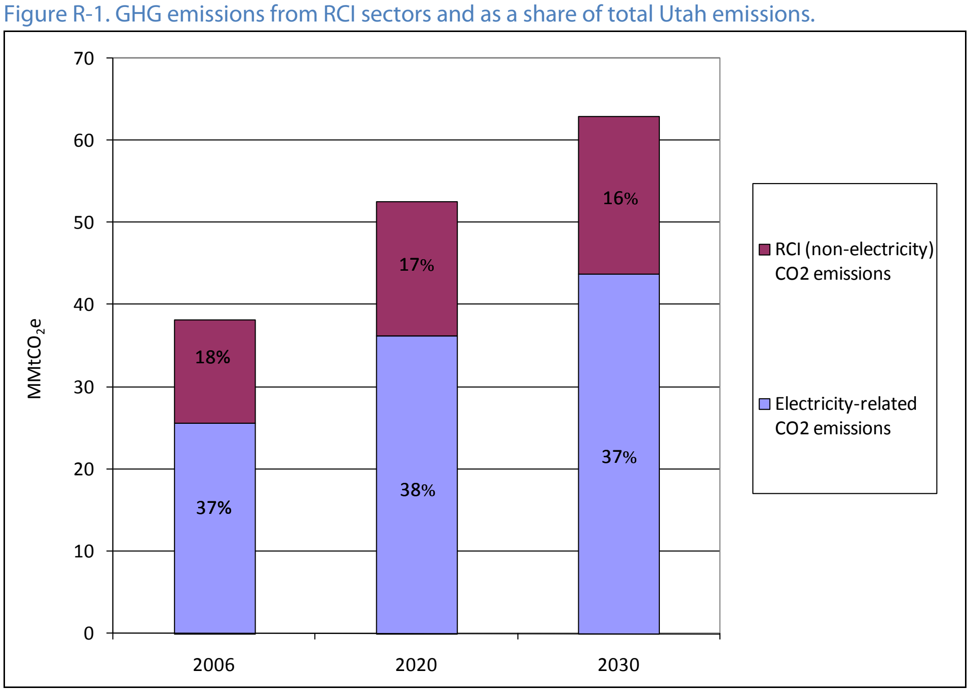
In this chapter, we used the AURORAxmp Electric Market Model in conjunction with a spreadsheet analysis to quantify some of the policy options. Many options aim to improve energy efficiency of both natural gas and electricity, and since we capture electricity effects in AURORAxmp, policies such as Demand Side Management and Improved Building Codes will have two components. While the methodologies for natural gas and electricity are presented together, the emissions effect of electricity policies will be considered in combination with Energy Supply policies (see Energy Supply chapter) as part of a suite of electricity policies.[9]

[9] In order to capture the effects of these energy efficiency measures on greenhouse gas emissions, we did not delve into time-of-day or time-of-year differences in this analysis. In particular, as far as AURORAxmp is concerned, it does not matter which strategy is the source of which avoided demand.

We began our analysis of these strategies by constructing a baseline of energy demand and emissions. The baseline uses data from the Utah Geological Survey (UGS), the U.S. Department of Energy's Energy Information Administration (EIA), and the EPA. This data was used to create a reference projection similar to that created by Climate Change Strategies in the latest statewide greenhouse gas inventory, noted below. For direct natural gas use, the strategies were assessed as deviations from this reference projection. Further information for the individual strategies produced was obtained from various state and federal agencies and other sources.

Greenhouse gas emissions from Utah's residential, commercial, and industrial (RCI) sectors are largely electricity-related. In 2006, electricity generation accounted for approximately two-thirds of the GHG emissions from these sectors, while direct natural gas use accounted for most of the rest. Thus, electricity-related GHGs from the RCI sectors account for about 37% of Utah's gross GHG emissions. Non-electricity RCI emissions accounted for about 18% of Utah's gross GHG emissions in 2006; the reference case projects this figure to be 16% in 2030. These shares are shown in Figure R-1 and are taken from the Center for Climate Strategies' "Final Utah Greenhouse Gas Inventory and Reference Case Projections 1990–2020."[10] We have extended their projection beyond 2020.

Figure R-1. GHG emissions from RCI sectors and as a share of total Utah emissions.

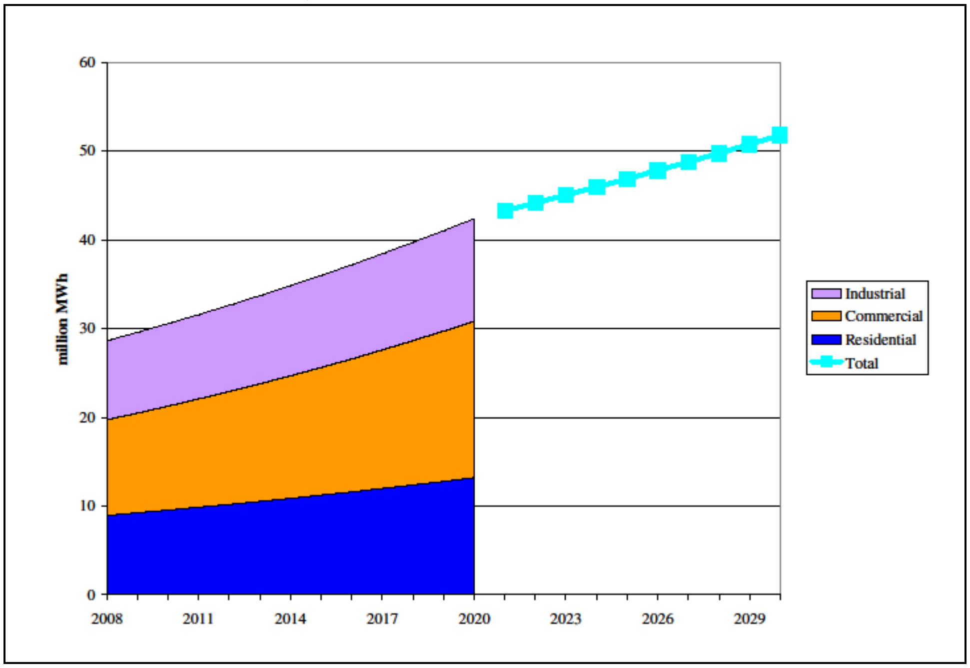


In 2007, Utah's RCI sectors used approximately 28 million MWh of electricity. The commercial sector was responsible for about 37% of the total electricity use, and the residential and industrial sectors each

[10] Utah GHG Inventory.

accounted for about 31%.[11] The Utah inventory projects a combined 3.3% annual electricity sales growth rate through 2020, and we alter annual growth rate to 2.0% beyond that. This leads to approximately 42 million MWh and 52 million MWh of demand in 2020 and 2030, respectively. Utah's electricity demand forecast (based on UGS historical data, the Utah inventory, and AURORAxmp projection) is shown in Figure R-2.

Figure R-2. Reference electricity demand projection.



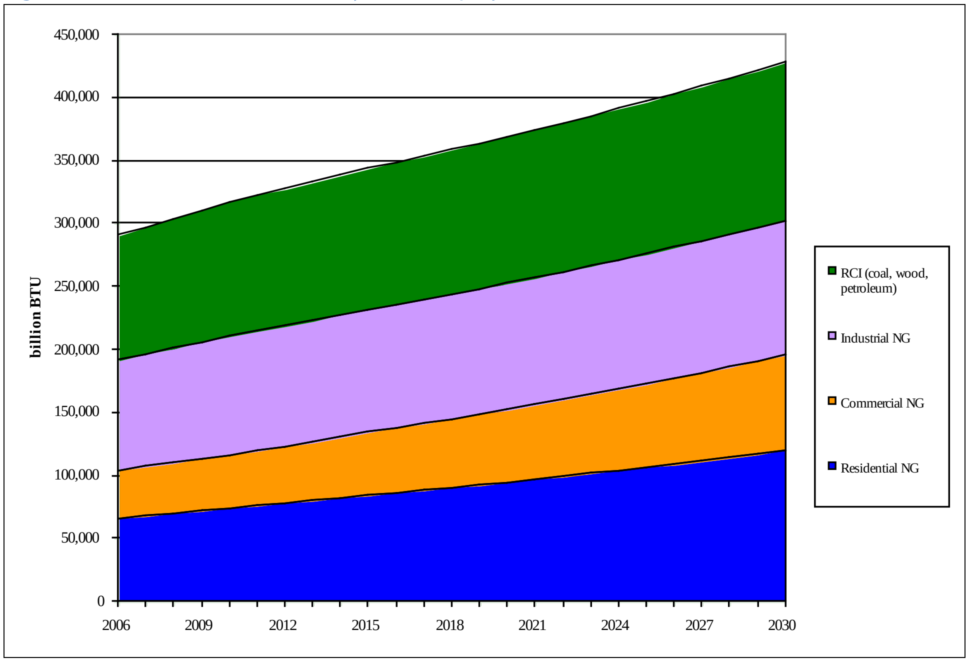
We derive our reference projection (shown in Figure R-3 below) for non-electric demand growth from Utah's inventory. The inventory has different demand growth rates for direct consumption of each fuel (wood, natural gas, coal, and petroleum) by sector. The inventory accounts for changing growth rates every five years,[12] as per EIA's forecast for the Mountain region in their 2006 Annual Energy Outlook (AEO). As these values were based on evolving analysis and models, we did not attempt to extend the direct fuel use projection with the same level of granularity. For the reference case, we extend emissions projections from 2020 to 2030 by simply continuing the growth rate trend.

Figure R-3 focuses on natural gas because it is the predominant non-electric fuel, accounting for over 65% of RCI use. In addition, the BRAC strategies generally do not focus on non-electric industrial strategies, and of residential and commercial non-electric demand, natural gas accounts for over 90%. The strategies that are evaluated for non-electric demand efficiency look at a subset of the residential and commercial natural gas demand. Of course, the figure also highlights that there are many industrial uses of natural gas

[11] Utah Geological Survey, Utah Energy and Mineral Statistics, Chapter 5.19a. http://geology.utah.gov/emp/energydata/electricitydata.htm (accessed Sept. 2008).
[12] Utah GHG Inventory.

as well as coal, petroleum, and wood demand to which the State could potentially apply efficiency programs.

Figure R-3. Reference non-electricity demand projection.



This chapter represents the synthesis of multiple strategies from the RCI sector highlighted above. It includes the strategy of Utility Demand Side Management (DSM) as well as strategies such as State Appliance Efficiency Standards (Standards), Incentives for Improved Design and Construction (Building Design), and Improved Building Codes (Building Codes). Each chapter will feature an introduction to the strategy, followed by an estimate of the energy efficiency each strategy could achieve in isolation, as well as avoided emissions for natural gas efficiency measures. Finally, we will discuss how we combine all of the strategies, while accounting for potential overlapping efficiencies, to arrive at the total avoided demand or avoided emissions projection.

There were a number of other BRAC strategies that could also be put under the energy efficiency umbrella but that we chose not to quantify for various reasons. Among the factors we considered when making these decisions include 1) the extent to which the strategy overlaps with other strategies and 2) the level of uncertainty inherent in the strategy. For example, we considered whether Government Lead by Example with Mandatory Efficiency Targets would achieve reductions significantly beyond those achieved by Standards, Building Design, and Building Codes. We concluded that there was enough overlap to make quantifying the reduction potential of Lead by Example difficult.

Utility Demand Side Management (RCI-1)

BRAC priority: High
BRAC bin: A
BRAC final vote: 18
Analysis method: spreadsheet analysis
Avoided electricity demand (2009–2030): 3–13 million MWh
Avoided natural gas demand (2009–2030): 336,000 billion BTU
Avoided natural gas emissions (2009–2030): 17.5 $MMtCO_2e$

Strategy Background

Utility-operated demand side management (DSM) programs have grown in popularity in recent years. These programs create incentives for various energy efficiency measures, including lighting retrofits, weatherization, heating and cooling system improvements, and efficient building design. Flexibility in the administration of the DSM programs can work to minimize costs and maximize program effectiveness.[13]

Utah's largest utilities offer DSM programs. PacifiCorp's Rocky Mountain Power (RMP)—which represents the majority of Utah's generation—has had DSM programs in place for more than 20 years. RMP's investment in DSM programs grew from $5 million in 2001 to $25 million in 2006, and the company estimates that it spent about $33 million (about 2.5% of revenues) on DSM programs in 2007. Much of this increase in DSM spending resulted from 2002 legislation and a 2003 Utah Public Service Commission (PSC) agreement permitting tariff riders on customers' bills to aid in cost recovery. In 2006, the programs provided about 29 MW of peak reduction and 120 GWh per year of electricity savings. Additionally, both the Utah Associated Municipal Power Systems and Utah Municipal Power Agency, which represent most of the rest of Utah's electricity generators, are working on developing energy efficiency or DSM programs.[14] Questar Gas Company has had natural gas efficiency programs approved by PSC since 2007.[15]

Methodology

For our modest scenario, we obtain a quantitative estimate of total DSM savings using a spreadsheet analysis. We calculate the exact avoided electricity demand by ramping up collective energy efficiency activities to reach 1% of total demand per year by 2014. These measures on average are assumed to persist for 7 years. By 2020, cumulative savings from projected energy sales are anticipated to grow to 6%.

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[13] U.S. EPA Clean Energy-Environment Guide to Action. http://www.epa.gov/cleanenergy/documents/gta/guide_action_full.pdf; Southwest Energy Efficiency Project, "Natural Gas Demand-Side Management Programs: A National Survey," January 2006. http://www.swenergy.org/pubs/Natural_Gas_DSM_Programs_A_National_Survey.pdf.
[14] Personal communication with Leon Pexton and Ted Rampton, October 2008.
[15] UEES 2007.

For the stretch scenario, electricity demand savings are 19% of projected demand. This value comes from our adjustments to the Quantec study.[16] For natural gas, we do not distinguish the modest and stretch scenarios until we combine multiple strategies. Natural gas measures are assumed to persist for 12 years on average. By 2020, cumulative savings from projected natural gas sales reach almost 9%.

We perform the following steps:

1. We take the 2009–2030 electricity consumption (MWh) projections from the AURORAxmp reference scenario and multiply annual values by the demand savings target. Similarly, for natural gas, we multiply the demand forecast by the same savings target.
2. We subtract the annual consumption forgone as a result of a DSM policy from the total annual consumption, and then add up the cumulative savings across the entire time period.
3. We estimate CO_2 savings for electricity by running an intermediate version of AURORAxmp with adjusted demand growth just for DSM. For natural gas, we calculate avoided emissions by multiplying the avoided natural gas demand by sector, by a UGS natural gas emissions rate.

Table R-1. Natural gas energy efficiency.

	2020	2030
Energy efficiency (billion BTU)	18,900	24,400
Avoided emissions ($MMtCO_2e$)	0.98	1.27

Table R-2. Demand forecast for Utah and demand reduction increments.

In GWh	2020	2030
Utah reference forecast	42,440	51,780
Modest scenario demand	40,900	48,760
Modest avoided demand	2,540	3,020
% less than reference	6.0%	5.8%
Stretch scenario demand	33,500	41,000
Stretch avoided demand	8,000	9,800
% less than reference	21%	21%

Implementation Ideas

There are a number of ways in which Utah could facilitate energy savings through utility DSM programs. Following are some of the more obvious examples:

[16] Quantec, Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources, Final Report Volume 1. Prepared for PacifiCorp, July 11, 2007. http://www.pacificorp.com/File/File75533.pdf. Quantec identified Class 2 DSM achievable potential of 7% but technical potential of 17%, and for CHP 1% achievable potential and 45% technical potential in 2027. We chose the technical potential for Class 2 DSM plus twice the CHP achievable potential.

- Energy efficiency standards, with or without standards for renewable energy, could be adopted via State legislation. An energy savings standard for utilities in Utah could include RMP and at least the largest municipal utilities and rural co-ops. The seven largest municipal utilities and rural co-ops along with RMP , supply over 92% of the electricity used in Utah.[17]
- The State may provide rebates for consumers that purchase ENERGY STAR or other energy-efficient products.[18]
- The State could provide technological assistance, especially to smaller or municipal utilities. (As municipal utilities are currently not regulated by the PSC, implementation by such utilities may depend on voluntary compliance.)
- The State could adopt shareholder incentives to grant utilities a bonus if they meet energy savings targets.[19]
- The State could evaluate decoupling protocols and the relationship between recovery cost and sales.

[17] Howard Geller et al., *Utah Energy Efficiency Strategy: Policy Options* (hereafter cited as UEES Report), October 2007. http://www.swenergy.org/pubs/UT_Energy_Efficiency_Strategy.pdf.
[18] Ibid.
[19] Ibid., 16.

State Appliance Efficiency Standards (RCI-8)

BRAC priority: High
BRAC bin: A
BRAC final vote: 17
Analysis method: spreadsheet analysis
Avoided electricity demand (2012–2030): 38.5 million MWh

Strategy Background

The most promising appliance standard identified by the BRAC—in regards to its potential effects on carbon abatement—was the standard for general-service light bulbs. The 2007 Energy Independence and Security Act (EISA), however, established new efficiency standards for most general-service light bulbs, thereby implementing much of this strategy by regulation.[20]

Today's standard 'A'-style incandescent bulbs that comprise the bulk of residential lighting offer about 10–17 lumens/watt. A standard 60-watt bulb provides about 860 lumens, or 14.3 lumens/watt. The new federal standards mandated by EISA which take effect beginning in 2012 will raise performance by at least 20% initially. This will effectively take many current incandescent models off the market. EISA will require a minimum of 45 lumens/watt from all general-service bulbs by 2020.[21] Relative to the next four top appliances that the State could target with policy instruments or other legislation, lighting standards will yield approximately ten times the amount of energy savings as the savings from those four appliances combined.[22]

Methodology

Because the benefits are so significant relative to other potential appliance standards, our analysis of appliance efficiency standards focuses exclusively on the energy savings from the new federal lighting efficiency standards. Other appliance standards, not preempted by federal standards, are also likely to be cost-effective, but they are far less likely to lead to great reductions in energy generation and greenhouse gases. The State may wish to consider implementing other efficiency standards not assessed in this report.

We assume the following with regard to the reach of federal lighting standards within Utah:

- All residential and commercial lighting will be affected by the federal standards
- Federal lighting efficiency standards will reduce projected lighting demand by an average of 20% in 2012, 25% in 2013, 30% in 2014, and 60% in 2020 and beyond.

[20] http://www.aboutlightingcontrols.org/education/papers/2008_energy_law.shtml.
[21] Ibid.
[22] UEES Report, 36–40.

- Based on this amount of lighting in Utah a simple spreadsheet analysis leads to the avoided emissions shown in Table R-3 below.

Strategy Benefits

Table R-3. Utah energy savings by sector from lighting standard.

In GWh	In 2030	Cumulative 2012–2030
Residential avoided electricity use	1,275	15,075
Commercial avoided electricity use	1,859	20,778

Implementation Ideas

Because this policy will be regulated by the federal government, the State will not need to manage the implementation of the lighting standard. If Utah chooses to increase appliance standards not covered by the federal legislation, Utah may want to look to those states that have adopted appliance efficiency standards. These include, among others, Arizona, Maryland, California, Washington, and New York. We note that while most of the energy savings for this strategy are achieved in the area of lighting, a comprehensive approach to a wide range of commercial products could still yield significant additional gains. Additionally, because energy efficiency products are constantly evolving on the market, it may make sense for the State to revisit this strategy from time to time.

Incentives for Improved Design and Construction (e.g., ENERGY STAR, LEED, green buildings, expedited permitting) (RCI-20)

BRAC priority: High
BRAC bin: A
BRAC final vote: 21
Analysis method: spreadsheet analysis
Avoided electricity demand (2009–2030): 7,800 GWh
Avoided natural gas demand (2009–2030): 104,000 billion BTU
Avoided natural gas emissions (2009–2030): 5.5 $MMtCO_2e$

Strategy Background

At present, Utah has a wide range of building incentives in place for improved design and construction. Utah has a fund that provides loans to State facilities seeking energy efficiency upgrades.[23] There is also a loan fund that provides K-12 schools with zero-interest loans of up to $250,000 for energy efficiency improvements that meet the fund's requirements.[24] With respect to schools, the State offers technical assistance for energy efficiency feasibility and implementation studies.

The State is in the process of examining and developing future incentives and standards. Utah is taking steps to form an advisory group which will assist in the creation of three programs: Energy Efficiency Products, Energy Design Standards, and High Performance Building Rating System. Additionally, the State has agreed to cooperate with the American Institute of Architects (AIA) in achieving its goal of reducing usage of fossil fuels in construction and operation of new buildings by 50% by 2010.[25]

Utilities provide incentives for energy efficiency. Among them:

- RMP has programs for business and consumer energy efficiency upgrades.
- RMP gives a rebate to residents who purchase eligible evaporative cooling systems.[26]
- RMP's Home Energy Savings Program provides the residential sector with rebates for a wide range of qualifying products and home efficiency improvements such as duct seals and energy-efficient dishwashers.[27]
- RMP also offers contractors cash back for qualifying new residential homes that meet ENERGY STAR standards and are constructed with low-e windows.[28]

[23] Database of State Incentives for Renewables and Efficiency. http://www.dsireusa.org.
[24] Ibid.
[25] http://www.utah.gov/energy/governors_priorities/utah_policy_to_advance_energy_efficiency_in_the_state.html.
[26] Database of State Incentives for Renewables and Efficiency. http://www.dsireusa.org.
[27] Ibid.

- Commercial and industrial facilities are eligible to receive incentives as well as technical assistance for energy efficiency projects through RMP's FinAnswer Express Program.[29]

In 2006, 16% of new homes in Utah were ENERGY STAR–certified.

Methodology

For this strategy we use a spreadsheet to estimate the potential of a hypothetical incentive program in Utah. This building incentive applies to energy use for space heating and cooling in homes and commercial space. The assumptions that we use are as follows: the policy will begin in 2009; 50% of all new residential or commercial electricity and natural gas consumption will be affected by the policy; new buildings will meet ENERGY STAR standards (meaning a 20% efficiency improvements over reference scenario); 2% of all existing residential and commercial entities will retrofit their facilities each year as a result of the policy; those 2% will realize 10% efficiency improvements. The fraction of Utah's electricity and natural gas consumption devoted to heating and cooling is estimated from EIA survey data for Climate Zones 1 and 2.[30, 31] The energy use statistics for these zones lead to the estimates that 26% of commercial and 17% of residential electricity consumption is heating- or cooling-related.

First, we calculate a residential and commercial electricity and natural gas consumption forecast from historical data which is extended by growth rates found in EIA's Annual Energy Outlook 2008.[32]

Then we calculate the avoided electricity and natural gas emissions from the Utah projections and multiply them by the heating and cooling shares and the appropriate share of building and efficiency improvements as explained above.

Strategy Benefits

Table R-4. Energy saving in 2030.

	Residential	Commercial
Avoided electricity use (GWh)	219	470
Avoided natural gas use (billion BTU)	7,000	2,700

Strategy Costs

Because the costs of Leadership in Energy and Environmental Design (LEED) and ENERGY STAR certification vary greatly depending on project type and the intensity of efficiency efforts, we did not directly estimate policy costs. A California report estimated that a cost range for LEED standard facilities is an increase of 0.66% of total cost of new construction for basic certification, about 2% for silver or gold

[28] Ibid.
[29] Ibid.
[30] EIA's Residential Energy Consumption Survey (RECS) and Commercial Building and Energy Consumption Survey (CBECS) define Utah as part of Climate Zones 1 and 2.
[31] http://www.eia.doe.gov/emeu/cbecs/climate_zones.html.
[32] EIA, 2008. Annual Energy Outlook 2008: With Projections to 2030. DOE/EIA-0383(2008). http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2008).pdf.

and 6.5% for platinum certification. If one assumes construction costs to be $150–$250/sq. ft., the green building premium would be $3–$5/sq. ft.[33] Retrofitted facilities tend to cost 25%–28% more per square foot than new construction projects.[34] Of course, the retrofitting costs depend upon the original design of the building and the energy saving measures available. The retrofitting costs of several ENERGY STAR success stories range from $0.22/sq. ft. to $14.28/sq. ft.[35]

In 2004, the ENERGY STAR program saved $10 billion and 135 billion kWh, an average savings of $0.07/kWh.[36] Also, several businesses featured as success stories by the EPA ENERGY STAR program had savings that ranged from $0.07/kWh to $3.36/kWh, with most of the benefits being below $0.15/kWh.[37] With a 30% reduction in consumption, the financial benefits are approximately $0.44/sq. ft. per year (with an electricity price of $0.11/kWh).[38]

Implementation Ideas

According to the DOE, commercial and residential buildings are projected to account for 40% of all energy consumed in the USA in 2010.[39] With this figure in mind, Utah may wish to expand upon its current program incentives to further encourage efficient design and construction.

Utah could consider offering incentives for the construction of buildings that exceed code requirements for energy efficiency. Incentives might include tax credits or cost-sharing with local governments or builders for training, planning, or green initiatives in construction. These incentives would in turn lead to an increase in ENERGY STAR- or LEED-certified homes and commercial buildings.

Utah might consider other states' and cities' programs as a template on which to base their own projects. Chicago offers one of the most thorough green permitting programs in the nation. Green permits may be issued in half the time of a typical permit and up to $25,000 in fees may be waived. Expedited green permitting allows green projects to begin construction sooner, and decreased waiting time translates into potentially less interest owed for a construction loan. The program has produced tangible results; green permit requests have increased over 400% from 2005 to 2007, and now Chicago has the largest number of LEED-registered projects in the country. [40]

The U.S. Green Building Council (USGBC) may be a potential partner for Utah as the State evaluates building incentives. USGBC created LEED initiatives and offers government implementation tools for

[33]Kats, G., L. Alevantis, A. Berman, E. Mills, and J. Perlman, 2003. "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force," 15. http://www.usgbc.org/Docs/News/News477.pdf.
[34] Tretiak, R. 2007. "Submission to the Nevada State Office of Energy." International Energy Conservation. http://energy.state.nv.us/IEC%20Submssion--SOE%20AB621%20Workshop%20Comments%208-21-071.doc.
[35] Energy Star Success Stories and Awards. http://www.energystar.gov/index.cfm?c=sb_success.sb_successstories.
[36] EPA Energy Star. Energy Star 2004 Achievements in Brief.
[37] Energy Star Success Stories and Awards.
[38] Kats et al., Costs and Financial Benefits.
[39] AEO 2008.
[40] http://www.iccsafe.org/news/green/0807BSJ24.pdf.

creating and maintaining green programs as well as a plethora of resources associated with LEED.[41] For instance, USGBC research for California has demonstrated that costs associated with green investments are easily offset. Up to 3% of project construction costs usually go to green improvements, but these improvements may save 20% of total cost. [42]

[41] http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1779.
[42] http://www.usgbc.org/ShowFile.aspx?DocumentID=1992.

Improved Building Codes (RCI-21)

BRAC priority: High
BRAC bin: A
BRAC final vote: 20
Analysis method: spreadsheet analysis
Avoided demand (2009- 2030): 8,000 GWh
Avoided natural gas demand (2009–2030): 108,000 billion BTU
Avoided natural gas emissions (2009–2030): 5.7 $MMtCO_2e$

Strategy Background

In 2007, Utah adopted the 2006 International Energy Conservation Code (IECC), which provides design and construction requirements for builders. By adopting the IECC, states are able to work within a uniform building code that promotes conservation and efficiency.[43] These codes are expected to avoid 5% of electricity and 10% of natural gas demand in new homes and 10% of both electricity and natural gas in new commercial space.

In order to realize energy savings from building codes, achieving a high level of compliance is important. Inspectors alone are not currently able to conduct sufficient monitoring to ensure a high degree of compliance.[44] The State has undertaken an education based approach to encourage higher levels of code compliance rather than trying to increase monitoring. The State Energy Program along with a number of partners, runs a free energy codes training program for building professionals. There are seven different programs which are offered throughout the State, covering topics such as HVAC, lighting, and general IECC codes for residential and commercial buildings.[45]

Methodology

In evaluating this strategy, we make the following assumptions:

- In order to realize the energy savings from updated codes, Utah improves compliance rates to approximately 95% through increased training and enforcement.
- Utah adopts the IECC code as it is updated every three years; with each update, we estimate a 5% efficiency gains in both natural gas and electricity use.
- Updates take effect in Utah in 2010, 2013, 2016, and 2019, following IECC changes in each year prior. Following 2019, savings are held constant through 2030 as per Utah Energy Efficiency Strategies.[46]

[43] http://www.iccsafe.org/news/about/#purpose.
[44] Personal communication with Curtis Clark, January 2008, Utah State Buildings Energy Efficiency Program.
[45] Building Energy Codes Program, Utah Geological Survey. http://geology.utah.gov/SEP/energy_efficiency/energycodes.htm.
[46] UEES Report.

- This analysis illustrates the impact of a hypothetical incentive program in Utah that would increase the percentage of new homes that meet ENERGY STAR standards to 50%. ENERGY STAR homes use 20% less energy for heating and cooling than the baseline home.
- Improvements from subsequent code updates are applied as percentage savings to the previous year, not a fixed 2006 baseline.

This analysis applies the savings from updated building codes only to those portions of energy use attributable to space heating and cooling in new homes and commercial space. It assumes the following shares of electricity and natural gas in the residential and commercial sectors are used for space heating and cooling (and therefore subject to reduction through improved building codes):

- In the residential sector, natural gas powers 77% of space heating and cooling, and electricity powers 17%
- In the commercial sector, natural gas is used for 45% of space heating and cooling, and electricity is used for 26%

These assumptions are based upon energy use statistics in DOE's Climate Zones 1 and 2, in which Utah lies, as pointed out in the previous strategy.

Our analysis also assumes that energy use from new homes and commercial space is built into the Utah baseline and is simply estimated as the growth in the baseline energy use for those sectors. This assumes that energy consumption in the existing stock does not change from the initial amount in 2006.

We perform the following steps:

1. We calculate the annual amount of electricity and natural gas that would be used for heating and cooling in both residential and commercial buildings.
2. We multiply the efficiency gains factors by the appropriate annual energy consumption to find the strategy savings potential.

Strategy Benefits

Table R-5. Energy savings in 2030.

	Residential	Commercial
Avoided electricity use (GWh)	203	574
Avoided natural gas use (billion Btu)	8,300	3,500

Implementation Ideas

The State has a mechanism for updating building codes. Continuing to adopt IECC or other updated codes on a regular basis and evaluating ways to improve compliance are the most important steps that can be taken related to building codes. State and local governments also have the infrastructure to enforce the codes. Achieving more complete compliance, however, will likely require additional resources.

Energy Efficiency Measures: Combined Analysis (RCI-1, RCI-8, RCI-20, and RCI-21)

Modest combined scenario
Analysis method: AURORAxmp Electric Market Model (electricity); spreadsheet analysis (natural gas)
Avoided emissions (by 2030): 30.8 $MMtCO_2e$ (electricity); 17.5 $MMtCO_2e$ (natural gas)

Stretch combined scenario
Analysis method: AURORAxmp Electric Market Model (electricity); spreadsheet analysis (natural gas)
Avoided emissions (by 2030): 172 $MMtCO_2e$ (electricity); 33.4 $MMtCO_2e$ (natural gas)

Our Approach

A number of BRAC strategies relate to future energy efficiencies. As these strategies essentially produce the same end result, we have quantified them together in order to account for interactive effects. We decided to model two policy scenarios that would represent a range for the success of all Utah electricity policies combined. One is considered a "stretch" scenario, while the other is considered a modest scenario. Both of the scenarios include the following components: traditional DSM, lighting standards, building codes, and incentives. In order to define that range, there were three key questions to consider:

1. *Of the many ways to improve energy efficiency, which ones are worth pursuing?* We leave this question for the State and note that this question should be reevaluated as conditions change. Some of the policy and cost considerations for the State include the following:

    - Is there support for conservation?
    - What are incremental costs of various approaches?
    - Are there inexpensive alternatives that meet the same goals?
    - How should incentives or investments to avoid demand be structured to be most effective?
    - Have changing electricity prices changed the value of reducing demand?

2. *How can the State avoid double-counting energy efficiency measures?* A good example to illustrate this concern is the obvious overlap between increasing DSM and appliance standards.

3. *How much energy efficiency should be pursued?* The natural gas energy efficiency policy scenarios are more straightforward than the electricity scenarios. For natural gas, the individual strategies are not differentiated by stretch and modest, while for electricity DSM, there are high and low estimates.

We chose to evaluate a range for electricity energy efficiency in AURORAxmp by picking reasonable high and low estimates for total demand reduction. We think that illustrating a range, or a solution area, rather than a point is critical to account for many types of uncertainty, not the least of which is how much public and State support there is for various strategies. By using a range, we acknowledge the difficulty in forecasting the answer to the key questions above, the unknowns of how much energy efficiency and how much overlap. The solution area represents our approximation of the most likely to be achieved results, not the absolute minimum or maximum. In addition to consulting with experts, there were two studies in particular that helped guide us to a modest and stretch version of this combined strategy, Pacificorp's Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources, performed by Quantec[47] and the Utah Energy Efficiency Strategy report. Below we briefly review those studies.

Context of Other Studies

The Quantec study estimates that with expanded Class 2 DSM services in PacifiCorp's service territories, Utah can achieve savings of 7% of their projected sales in 2027. "Achievable potential" is defined more narrowly than "technical potential," which could avoid about 17% of projected sales. Class 2 DSM savings will come from residential, commercial, industrial, and irrigation energy efficiency measures. The DSM measures relate to the end-uses outlined in Table R-6 below.

Table R-6. Pacificorp's residential, commercial, and industrial Class 2 DSM end-use categories.

air compressors	fans	plug load
central heating and cooling	freezers	process
cooking	heat	pumps
cooling	heat pumps	refrigeration
cooling chillers	HVAC	room AC and heat
cooling DX	HVAC auxiliary	space heat
dryer	lighting	water heating
electro-chemical	motors – other	other processes

Quantec also estimates the savings potential from Class 1 DSM initiatives, Class 3 DSM initiatives, and "supplemental" generation sources, such as dispersed generation. Class 1 and Class 3 DSM initiatives are capacity-based, while supplemental generation consists of combined heat and power (CHP), on-site solar, and capacity-based dispatchable standby generation. For our purposes it is important to note that capacity-shifting initiatives do not reduce demand, and in fact may increase emissions.

Supplemental generation sources are broken down differently than Class 2 DSM. There is huge CHP and solar technical potential (over 40% of demand), but the achievable potential is but a fraction of that, about 1% of 2027 demand.

The *Utah Energy Efficiency Strategy: Policy Options* (UEES) report evaluates 23 potential strategies that might be employed to achieve Governor Huntsman's goal of achieving a 20% increase in energy efficiency by 2015.[48] The UEES projection for avoiding demand through energy efficiencies is shown in Table R-7. The projected electricity savings from lighting standards was made before the Energy Independence and Security Act of 2007. UEES's appliance standards overlap with the aforementioned DSM expansion policy, because both assume increased use of fluorescent light bulbs. In order to account for overlap, the UEES

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[47] Quantec, Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources, Final Report Volume 1. Prepared for PacifiCorp, July 11, 2007. http://www.pacificorp.com/File/File75533.pdf.

[48] Of particular use to this report are the following efficiency policies examined in USSE report: electricity DSM expansion, building code upgrades, appliance standards, public sector initiative, and public education.

assumes that DSM expansion results in households purchasing three or four fluorescent lights by the time the general-service lamps standard becomes operative.[49]

Table R-7. Energy efficiency measures and avoided demand as identified by UEES.

In GWh/year	2010	2015	2020
Electricity DSM expansion	894	2,375	4,108
Building code upgrades	214	674	1,391
Lamp and appliance standards	137	1,334	2,137
Industrial challenge	130	615	1,183
Public sector initiatives	169	421	604
Public education	226	393	420
Other	202	377	476
TOTAL	1,972	6,189	10,319

After using the two aforementioned studies for guidance, conferring with experts,[50] and reviewing the literature, we determined a reasonable range of electricity demand reductions to model. In the modest scenario, demand grows to a level 6% less than the reference demand projection in 2020, and in the stretch case it reaches 25% less. Table R-8 below shows the reference demand forecast and avoided demand for the two scenarios.[51]

Table R-8. Demand forecast for Utah and demand reduction increments.

In GWh	2010	2020	2030
Utah reference forecast	30,580	42,440	51,780
Modest scenario demand	30,250	40,900	48,760
Modest avoided demand	330	2,540	3,020
% less than reference	1.1%	6.0%	5.8%
Stretch scenario demand	29,100	31,800	38,900
Stretch avoided demand	1,460	10,600	12,900
% less than reference	4.8%	25%	25%

Methodology

We choose two suites of energy efficiency policies to evaluate the potential range of avoided emissions for combined policies of this sector. There are two major differences between the modest and stretch suites of policies for RCI. The modest suite uses the modest DSM assumptions, while the stretch suite uses the stretch DSM assumptions. In addition, the modest suite uses a conservative assumption that building

[49] UEES Report.

[50] Personal communication with Dan York and Marty Kushler, ACEEE, April 2008.

[51] While it is difficult to directly compare these figures to the Quantec study, as those values were only for 2027, we wanted to keep the modest scenario close to a conservative interpretation of that study, i.e., only achievable potential Class 2 DSM. In addition to being in line with the Governor's energy efficiency goal, the stretch scenario seems reasonable in light of Quantec's technical potential for Class 2 DSM, supplemental resources, and all of the aforementioned strategies that the State might consider that would not be part of a utility analysis.

incentives, building codes, and standards as standalone programs all target the same low-hanging fruit as a utility DSM program. Meanwhile, the stretch suite of policies presumes that a coordinated program affects different segments of the population or targets energy end-uses.

Table R-9. Electricity measures: residential, commercial, and industrial energy efficiency.

In GWh	2020		2030	
	Modest	Stretch	Modest	Stretch
Electricity DSM	2,560	8,000	3,200	9,800
Lighting standards	2,170	2,170	2,650	2,650
Building incentives	386	386	689	689
Building codes	396	396	777	777
Sum total*	5,502	10,952	7,316	13,916
Degree of assumed policy overlap	full	partial	full	partial
Governor's 2015 goal		8,490		10,360
TOTAL avoided demand modeled	2,560	10,700	3,200	13,000

* Sum total is shown for the sake of comparison; we do not add these policies up as such.

Therefore for the combined modest scenario, as shown in Table R-9 above, avoided demand is completely overlapping and the total energy efficiency effect is the same as that for modest DSM alone. For electricity, we do not choose entirely non-overlapping policies to represent the stretch suite; rather, we choose the target of 25% energy efficiency starting in 2020. This level was deemed appropriate for our stretch number based on three related targets and assessments:

- The Governor's goal of achieving a 20% increase in energy efficiency by 2015. We presume that this goal would not only be met, but that the State will actively continue to pursue improved efficiency beyond 2015.
- Quantec identifies 17% energy efficiency as the Class 2 DSM technical potential in 2027. This does not even consider CHP potential, non-utility programs, and the lighting standard in EISA (2007).
- The UEES report identifies this level as achievable.

One reason we present the data as a range (with the stretch policy as an upper bound) is that we anticipate that the achievable level is a matter of public controversy. In the end, policy decisions and economics will ultimately determine the extent to which the State pursues this strategy. Additionally, we recognize that the State can and should consider adding or substituting other efficiency measures that we do not have time to fully evaluate. Indeed, Utah has already begun to implement other measures that are not captured in this analysis, such as State Lead by Example (i.e., four-day work week).

Both scenarios account for federal lighting standards. For the modest scenario almost half the avoided demand is attributable to the lighting standards. We determined that about 11% of commercial and residential electricity is used for lighting. Federal lighting standards mandate 20% reduction in lighting-based energy use by 2012, 25% by 2013, 30% by 2014, and 60% by 2020. We use these same assumptions for both the modest and stretch scenarios.

For natural gas, the key distinction between the modest and stretch policies is the assumption that in the modest scenario, the strategies are completely overlapping, while in the stretch scenario, the strategies are completely non-overlapping, i.e., they target different savings. Additionally, to account for the carbon cap/tax strategy, we have added an elasticity to avoided emissions in the stretch scenario. The carbon cap/tax, when combined with natural gas Energy Supply strategies in 2020 and 2030, leads to an additional 5% and 10% avoided emissions beyond the scenario without a carbon cap/tax. As explained in the Energy Supply chapter, the carbon cap leads to a premium of $25/ton in 2012. Natural gas avoided emissions are shown in Table R-10 below.

Strategy Benefits

Table R-10. Natural gas: Residential and commercial energy efficiency.

In $MMtCO_2e$	2020		2030	
	Modest	Stretch	Modest	Stretch
DSM	0.98	1.17	1.27	1.85
Building incentives	0.25	0.25	0.52	0.52
Building codes	0.24	0.24	0.63	0.63
Carbon cap–related increase	–	5% (0.08)	–	10% (0.3)
Sum Total*	1.47	1.74	2.42	3.30
Degree of assumed policy overlap	full	none	full	none
TOTAL avoided emissions	0.98	1.74	1.27	3.30

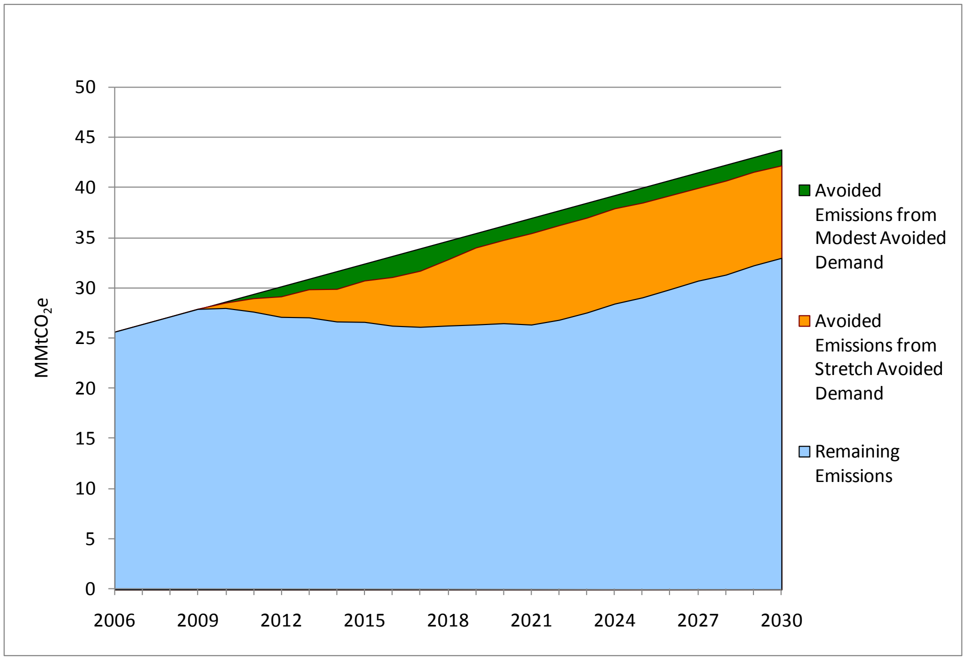
Note: Sum total is shown for the sake of comparison; we do not add these policies up as such.

Using AURORAxmp, we calculate the total avoided electricity emissions resulting from both modest and stretch sets of energy efficiency policies. These scenarios use the assumptions stated above. (Note: The carbon cap/tax is not applied to stretch policies here; it is only applied to scenarios in which RCI and ES strategies are combined.) According to our calculations, the modest policy would save 30.8 $MMtCO_2e$ by 2030 and the stretch scenario would save 172 $MMtCO_2e$ by 2030. Figure R-4 below shows avoided emissions over time from these policies.

Table R-11. Summary of combined energy efficiency measures.

In $MMtCO_2e$	2020		2030	
	Modest	Stretch	Modest	Stretch
Natural gas	0.98	1.74	1.27	3.30
Electricity avoided emissions (standalone energy efficiency effect)	1.46	9.75	1.61	10.8

Figure R-4. Effect of avoided demand on electricity emissions, just EE in AURORAxmp.



In addition to its GHG reduction potential, this strategy offers the following co-benefits:

- *Peak demand reduction*. Not only is overall electricity consumption reduced by these programs, but also peak load is reduced, thus sparing investment in additional power-generating facilities and transmission to meet peak demand.
- *New jobs*. The necessary expenditures would represent a significant investment in energy efficiency measures, which could potentially provide many in-state jobs in the energy and energy efficiency technology sectors.[52]
- *Reduced air pollution*. Reduced electrical demand would lead to significant reductions in air pollution.
- *Reduced water consumption*. Reduced electrical demand would also lead to avoided water use at power plants. Various power plants use differing amounts of water, however, one Western study estimates 0.33–0.67 gallons per kWh of avoided power generation at new plants.[53]
- *Lower electricity expenses for consumers*. Over time, the cost of efficiency measures should be exceeded by long term benefit of reducing the rate of expansion of new electricity generation and transmission.

[52] *The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest*. Boulder, CO: Southwest Energy Efficiency Project, Nov. 2002. http://www.swenergy.org/nml/New_Mother_Lode.pdf.
[53] Ibid

Strategy Costs

There are many factors to consider when calculating the costs of avoided demand. A utility pays to run a program, advertising, labor, and upfront costs, for which they may receive compensation, in which case the consumer ultimately pays while receiving the benefit. A State-based plan may not translate costs/ benefits quite as closely on a person-by-person basis.

A rough estimate of costs can be performed, based on first year electricity savings estimate of 8 kWh per dollar of program spending, taken from a North Carolina analysis based on averages from Western utilities.[54] At that rate, for the modest scenario, costs start at around $30 million in 2009 and would increase to about $90 million (nominal) by 2030. We assume that on average measures persist for seven years. For certain types of energy efficiency net benefits exceed costs.[55]

There are many uncertainties related to costs. The costs of efficient lighting, a huge component of avoided demand, are sunk regardless of Utah's actions. In addition, a less ambitious program would expect to have lower unit costs as the low-hanging fruit is exhausted. Since efficiency and avoided demand have cost curves, it can be misleading to talk about average costs or cost per MWh or cost per avoided ton of emissions. In addition, the savings lifetimes and electricity savings per program dollar are rather uncertain. As particular programs have not been modeled in AURORAxmp, average costs have not been estimated. The Institute tried to calculate a reasonable range of avoided demand to show a solution space for potential avoided emissions rather than model a particular policy implementation. The State may wish to consider under what circumstances determining benefits and costs would be appropriate and useful for its decision-making.

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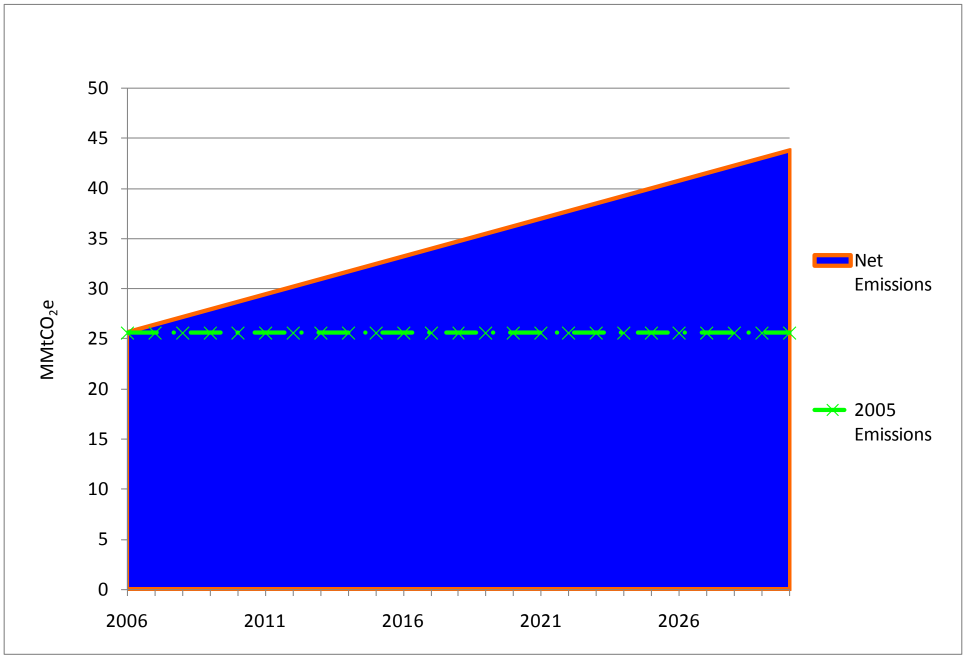
[54] RCI Mitigation Option Descriptions – Annex A & B, EESI/CCS, done for North Carolina. http://www.ncclimatechange.us/ewebeditpro/items/O120F12452.pdf.

[55] Gillenham, K., R. Newell, and K. Palmer, 2004. The Effectiveness and Cost of Energy Efficiency Programs. http://www.rff.org/Publications/Resources/Documents/155/RFF-Resources-155-energyefficiency.pdf.

ENERGY SUPPLY POLICY OPTIONS

Because the lion's share of Utah's electricity is coal-generated—and because coal is a carbon-intensive fuel—Utah's electricity sector is a major emitter of greenhouse gases. Figure E-1 shows the electric sector emissions projection, while Figure R-1 (p. 20) shows the relative share of emissions from Utah's electricity sector. The electricity sector currently accounts for approximately 37% of Utah's gross GHG emissions; in 2030, it is projected to still account for 38%.

Figure E-1. Utah's GHG emissions projection, electricity supply.



The BRAC recommended 15 energy supply strategies (listed below) to the Governor. While many of these strategies are important, some are more enabling and hence are not candidates for quantitative evaluation. The strategies we chose to analyze are listed below in black; those we did not analyze are shaded in gray:

Renewable Portfolio Standard	**ES-1**
Green Power Purchasing/Green Power Purchases and Marketing	ES-3/RCI-4
Tax Credits and Incentives for Renewable Energy	ES-5
Research and Development Renewable Energy Resources	ES-7
Develop CO_2 Capture and Sequestration Policy	**ES-8**
Issues for CO_2 Transmission	**ES-9**
Research and Development (Carbon Capture and Sequestration)	**ES-10**
Incentives for Advanced Fossil Fuel Technologies that Yield Carbon Reduction Benefits	ES-11
Efficiency Improvements (at Existing Electricity Generation Plants)	ES-17
Retrofit Plants with CO_2 Capture	**ES-19**
Incentives and Barrier Reductions for CHP (Combined Heat and Power) and DG (Distributed Generation)	ES-21
Tax Credits and Initiatives	ES-28
Remove Transmission/Distribution Limitations and Other Infrastructure Barriers for Renewables and Other Clean Distributed Generation	ES-22

As we discussed in the introduction, the methodology we used to calculate emissions for the energy sector strategies relied on the AURORAxmp Electric Market Model and used a Western Electricity Coordinating Council (WECC) data set in order to account for regional interactions. We used the energy sector baseline employed in the Center for Climate Strategies' "Final Utah Greenhouse Gas Inventory and Reference Case Projections, 1990–2020"[56] as a reference point in grounding the dispatch model and in truth-checking some assumptions plugged into the model. Due to the fact that the inventory was completed before the Renewable Portfolio Standard was passed, the reference case projection (Figure E-1) does not include an RPS for the electricity sector.

The use of such a model to evaluate something as complex as the electricity sector presents several advantages. We believe the model allowed us to take a more nuanced and realistic approach than otherwise would have been possible. For example, the model takes into account actual projected energy needs, not only on an average basis, but also at the peak of usage. Understanding the peak is important because electricity systems are not built to meet annual energy averages but rather the electricity demand in real time. AURORAxmp not only takes into account different times of the day but also different times of the year. It also tracks complex transmission relationships between states. This means the energy projections we have used for this report account for constantly changing imports/exports.

Additionally, this model not only provided us a robust baseline but also helped us hone our analysis of the strategies used within this report. For example, the model responds to changes in Utah's energy supply by importing/exporting more and altering decisions about when to build or retire electricity production resources, and prompting changes in the prices—and thus the desirability—of certain energy inputs.

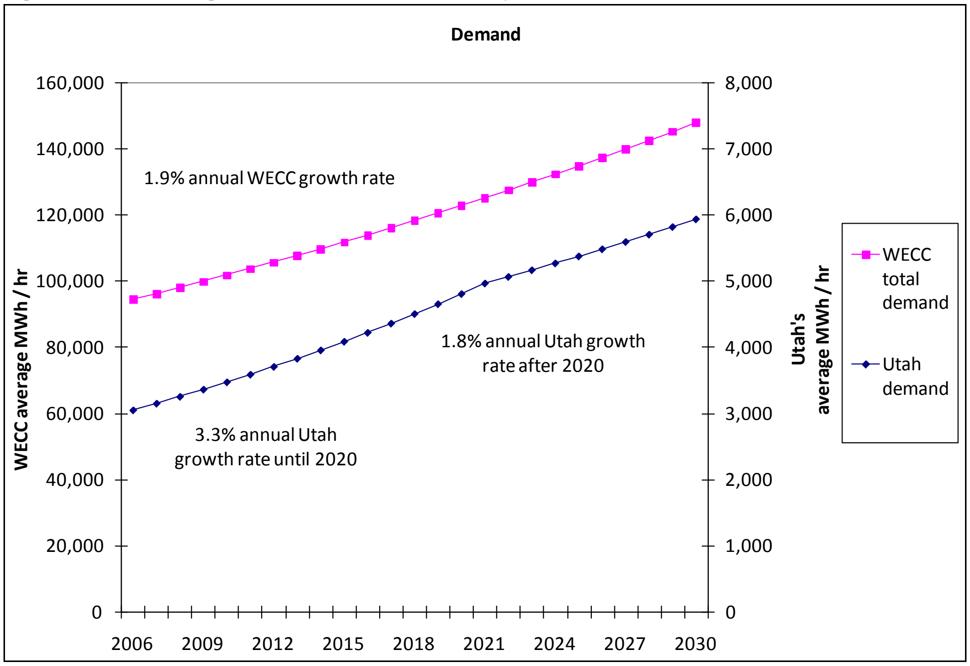
The first modeling step was to calibrate AURORAxmp to Utah's inventory. Utah's inventory calculated emissions in the electricity sector based on Utah's electricity consumption. A consumption-based emissions approach accounts for electricity consumed within the state but does not count emissions from electricity generated in Utah but exported to other states. This approach enabled us to simplify our assumptions about the emissions associated with imports and exports. Going forward, it is important for Utah to standardize a methodology for calculating electricity emissions that captures the appropriate emissions from Utah or the WCI's perspective. Figure E-1 shows the AURORAxmp emissions as calibrated to the inventory.

In addition to calibrating emissions, we tried to verify other major assumptions such as existing resources (power plants) and the rate of demand growth. In order to align our reference case with the inventory's projections, we adjusted AURORAxmp's demand rate growth for Utah from 1.8% per year to 3.3% per

[56] Utah GHG Inventory.

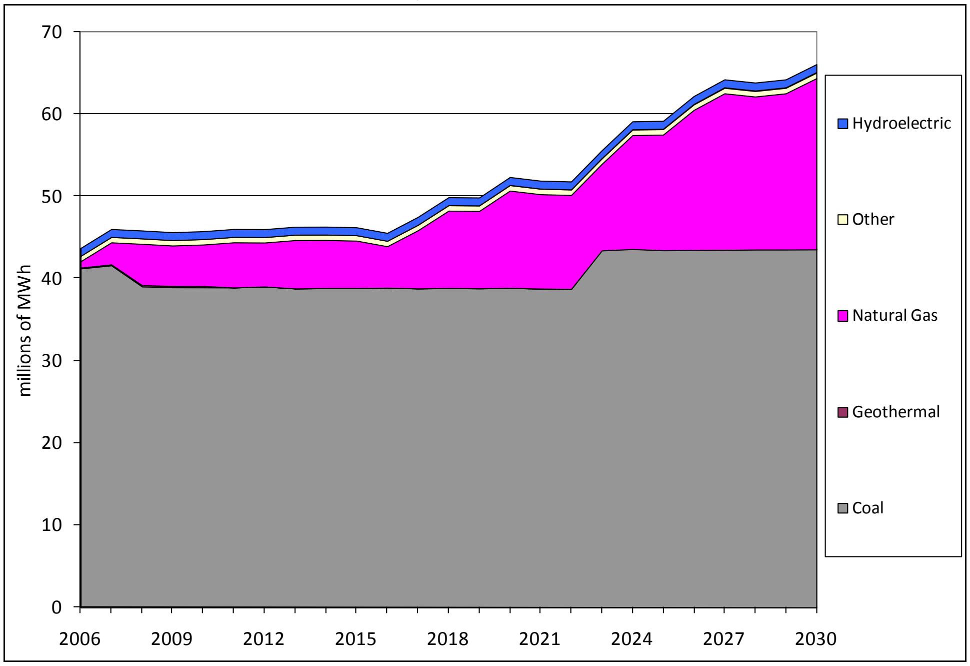
year through 2020. After 2020, we readjust demand growth to 2.0% per year. Figure E-2 plots the rate of annual average demand growth for both Utah and the WECC used in our modeling.

Figure E-2. Demand growth over time AURORAxmp reference case.



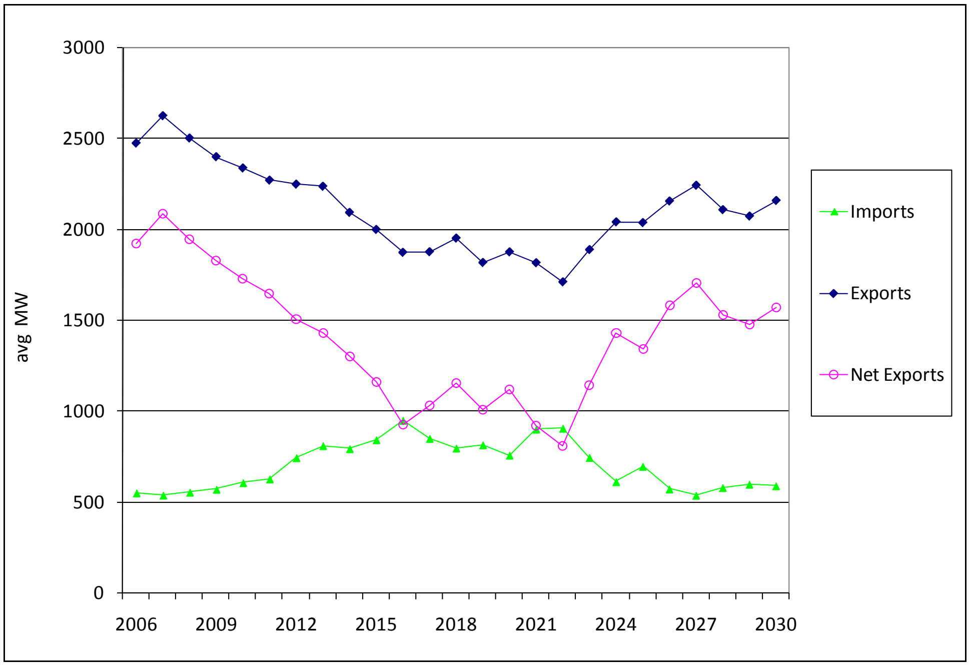
The reference case forecast for Utah generation is shown below in Figure E-3. The model suggests that the amount of electricity coming from coal-fired power plants will remain essentially constant. Currently coal accounts for about 85% of electricity generation. By 2025, the same absolute amount of coal generation represents about 70% of generation. The vast majority of new electricity generation is expected to come from natural gas, both in Utah and across the country. In 2008, renewable generation comprised about 4% of Utah's electricity generation; that proportion is expected to decrease over time as natural gas meets the growing demand. By 2025, approximately 2.5% of Utah's electricity generation is projected to come from renewable resources.

Figure E-3. Expected fuel mix for electricity generation in Utah (AURORAxmp).



We also see under the reference case projections that Utah will be exporting a little less of its energy production. This is illustrated best by Figure E-4. In the reference case, the amount of electricity imported and exported changes over time. For this sort of analysis, it is important to note that alternative scenarios will lead to changes in future transmission. One reason we chose to use a model to forecast emissions was to capture the dynamics of these transmission changes in the future. These changing transmission trends are critical as they help determine how future demand should be met and what type of new capacity Utah will likely build. All of these components affect future dispatch, which ultimately determines GHG emissions. The electricity model used in our analysis is explained next.

Figure E-4. Utah's export/import projections.



Methodology for Measuring Avoided Emissions with AURORAxmp

There are multiple components to tracking Utah's emissions—the starting point, the reference projection, and alternative projections. Measuring something that does *not* happen is challenging when it takes place a decade or two in the future; getting it right requires an accurate estimate of these components.

The first obstacle is that AURORAxmp, unlike Utah's inventory, counts emissions on a consumption basis. Rather than try to map Utah's projected generation-based emissions (from Aurora) onto the State's projected consumption based emissions (from Utah inventory), the Institute in consultation with the State, decided the best way to proceed was to use the emissions forecast from the Inventory as the starting point. Meanwhile, Aurora's emissions would be used to capture the change in emissions between the reference projection and the alternative projection.

The second obstacle was that we had to determine how to measure Utah's avoided emissions. While this sounds simple, there are two concerns that complicate this process: 1) how to account for imports and exports, and 2) how to account for leakage. Leakage occurs when, for example, the implementation of a program within Utah leads to avoided emissions both within and outside of Utah. Can and should Utah get credit for achieving emissions reductions that occur outside of Utah or reduce the credit it takes if emissions increase elsewhere due to Utah's actions?

In order to identify avoided emissions that Utah should take credit for, we determined that leakage and imports/exports could be accounted for by treating the entire WECC like Utah and then determining Utah's share of WECC's emissions benefit.[57] Therefore the methodology we devised for using AURORAxmp to evaluate the emissions effects of Utah's strategies was to apply the Utah strategy in proportion throughout the West (henceforth we will call this "scaling up"). The avoided emissions of the West as a whole are then counted and scaled down to Utah's share in order to project Utah's avoided emissions. While this method may seem imperfect in that it presumes that all states "act like Utah," it would be equally inaccurate, if not more so, to either assume that no other states take action or to evaluate what happens in Utah as if in a vacuum without recognizing how it is interconnected by the electricity grid. This underscores that the actions of other states will have a profound effect on electricity prices and on what strategies work for Utah. An illustration of this methodology will follow a brief introduction to electricity generation and emissions in the West as a whole.

[57] From this point forward, this report will use the term "West" to refer to the WECC.

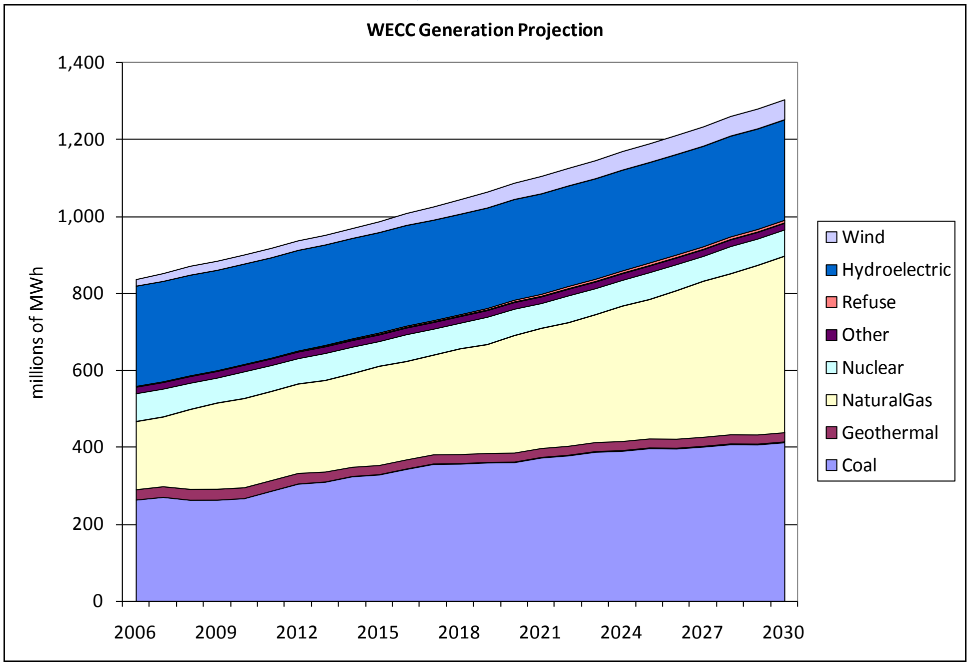
Regional Context for Utah's Electricity-Related Emissions

Evaluating Utah's electricity emissions in a regional context is logical since the electricity market is regional. Understanding what is going on in the regional picture is particularly important for in our analysis of Utah's electricity sector for two reasons. First, approximately 80% of Utah's electricity is supplied by PacifiCorp, a multi-state utility which provides power throughout the West. Obviously, the actions of PaciCorp will have major implications for Utah's future electricity outlook, which is inherently a regional one. In fact, PacifiCorp attributes ownership (including costs and assumedly emissions) to states within their service territory proportionally on the basis of each state's share of PacifiCorp's total demand, regardless of the physical location of any of the resources. Utah's Public Service Commission recognizes this approach in the way it manages PacifiCorp's resources. This perspective was rather difficult to integrate into our analysis, but regionalizing the analysis helps approach this perspective.

Second, because of the nature of the electricity grid, it is very difficult to separate what happens in Utah from what happens in West at large. As prices increase in one state, electricity providers within that state may look to import from outside the state's borders. Additionally, electricity providers outside the state may look elsewhere to source their electricity imports. As noted in the introduction, GHG emissions quickly assimilate into the global atmosphere and have the same climate impacts regardless of their origin. Understanding this connection is essential in determining whether Utah's actions lead to actual reductions in greenhouse gases or merely to the accounting of "hot air."

Because what happens in the West has and will continue to have major implications for Utah's electricity outlook, we have derived a reference case for the West. AURORAxmp projects general trends in the West. These trends are illustrated in Figure E-5 below. Note that there are important similarities and differences between Utah's outlook and that of the West more generally. The most significant similarity is that most new demand in both Utah and the rest of the West will be met by the growth of electricity generated by natural gas. In the rest of the West, however, the fuel mix for electricity generation will be much more diverse that in Utah: hydroelectric, natural gas, and coal generation each account for 25% of generation. In 2025, approximately 30% of generation in the West as a whole will come from renewable sources, whereas the figure for Utah for that year is projected to be 2.5%.

Figure E-5. Expected fuel mix for electricity generation in the West (AURORAxmp).



To better understand why we put great weight on the regional picture, it may be worth illustrating the merits of this approach by explaining the shortcomings of a simpler analysis that we briefly considered. To do this, we will focus a bit on Renewable Portfolio Standards (RPS). A simple approach would focus on emissions from Utah's generation and the effects of applying an RPS in Utah alone. Figure E-6 illustrates Utah's emissions based on Utah generation. This figure shows Utah's emissions for three scenarios: a reference case scenario, a scenario in which Utah implements an RPS (simple approach), and a scenario in which Utah's RPS is applied to the West as a whole. One problem with the simple approach lies in the fact that Utah's emissions as captured by AURORAxmp are much higher and rather flat compared with the consumption-based estimates found in Utah's inventory (Figure I-1, p15). Nonetheless, at first glance, it would seem that measuring avoided emissions works similarly for the two RPS scenarios.

Figure E-6. AURORAxmp's "Utah" emissions for three scenarios.

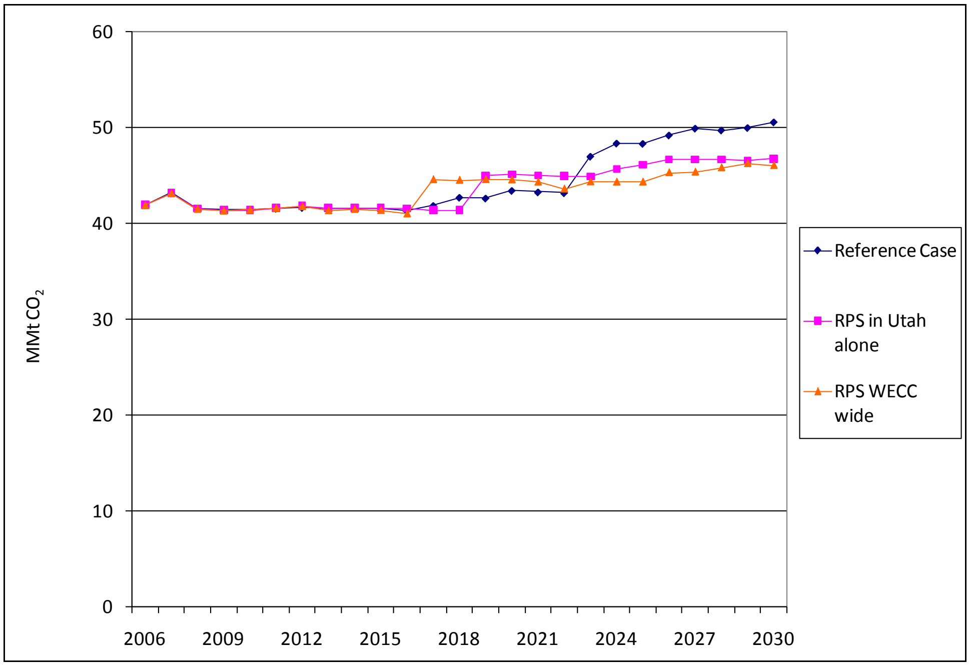


Figure E-7 shows the systemic effect of these scenarios. The top two lines practically overlap: AURORAxmp attributes no net emissions benefit to instituting an RPS in Utah in isolation. This is because as Utah adds resources, other electricity providers in the West alter their own investment decisions and begin to import electricity made from Utah coal. As a result, how effectively an RPS reduces emissions depends in substantial part on what else is going on in the West. This analytic exercise also helps highlight some of the uncertainty associated with this exercise, as well as the importance of considering how regional actors will respond to Utah's policies.

Figure E-7. WECC system emissions for three scenarios (AURORAxmp).

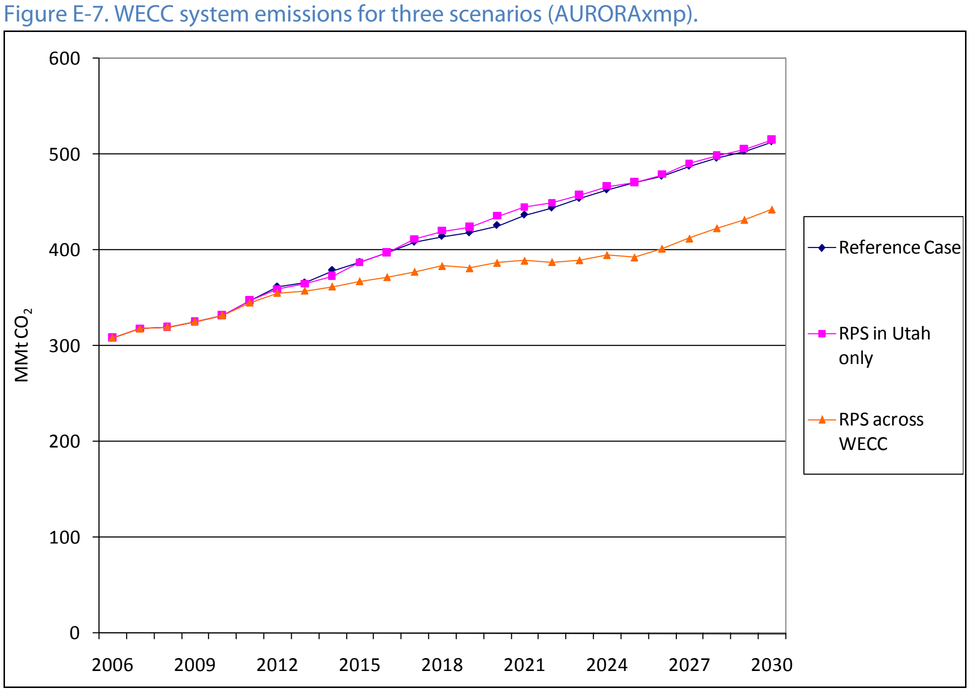
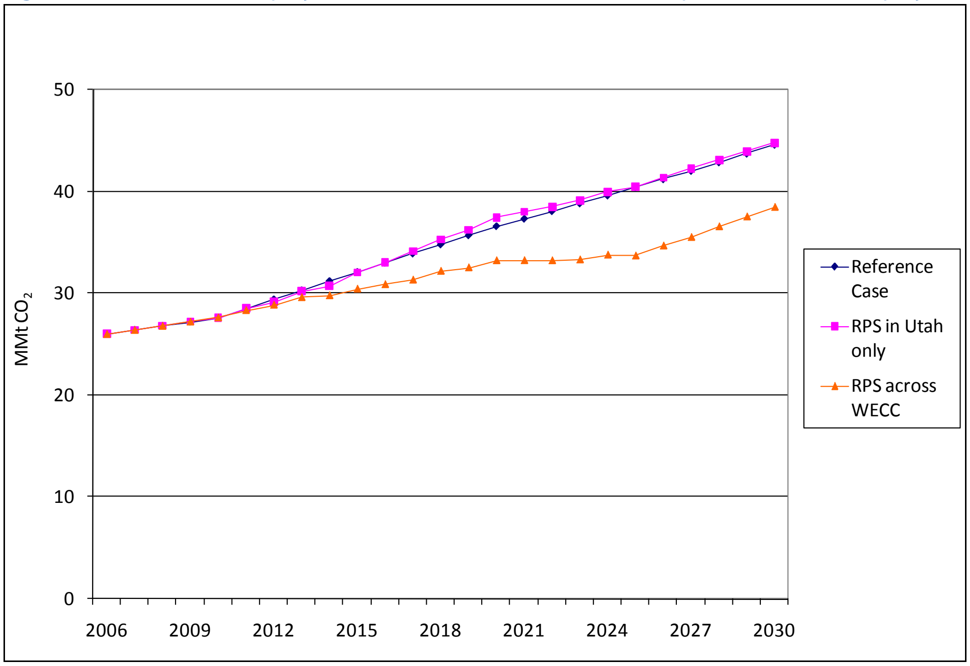


Figure E-8 presents Utah's emissions using our methodology in order to capture leakage and transmission effects as explained earlier. The values in Figure E-8 are based on the same data as Figure E-7, but reflect the emissions after the scaling down step takes place. The area between the two lines represents Utah's avoided emissions due to an RPS.

Figure E-8. Utah emissions projection scaled down from AURORAxmp's WECC emissions projections.



Summary

Our methodology for using AURORAxmp to count avoided emissions in Utah tries to address the following obstacles:

- the issue of leakage,
- the challenge of working within the consumption-based analysis of Utah's emissions found in Utah's GHG inventory, and
- the challenge of accounting for changing electricity imports and exports.

We did this by using a regional version of the model and by scaling the strategy for Utah to the West at large. Afterwards, we scaled avoided emissions back down to Utah's share.

This methodology cannot overcome the uncertainty of not knowing the details of the RPS strategies various Western states will adopt. However, this approach helps us answer the questions posed by Utah to the best of our knowledge in light of this uncertainty.

Renewable Portfolio Standard (ES-1)

BRAC priority: High
BRAC bin: B
BRAC final vote: 17
Analysis method: AURORAxmp Electric Market Model
Avoided emissions (by 2030): 79 $MMtCO_2e$
Costs: $10.2 billion (estimated net present value of all program costs)

Strategy Background

A Renewable Portfolio Standard (RPS) is a state-mandated requirement in which a percentage of a state's overall electricity-generating capacity must come from renewable energy. Under this program, utilities are required to invest in renewable energy technologies in order to meet their percentage requirement. Under some RPS programs, each utility's obligation is tradable in the form of Renewable Energy Credits (RECs).

Much interest and activity has surrounded the issue of RPS in the state of Utah. In the fall of 2007, the state convened a focus group of stakeholders to examine the issue of renewable energy; many in the group galvanized around the idea of the state passing a renewable or clean energy portfolio standard. During the 2008 legislative session, several bills were considered that called for an RPS; one of them, proposed by then Senate Majority Leader Curtis Bramble, passed. The Energy Resource and Carbon Emission Reduction Initiative (S.B. 202) sets a nonbinding goal that 20% of the electricity a utility sells in Utah must come from renewable sources by 2025.[58] The bill also seeks to shorten the permitting process for renewable energy, to include public health and other concerns in the permitting of energy generation, and to lower barriers to entry for smaller firms trying to get into the business of renewable energy generation.

Eligible resources under S.B. 202 include wind, solar photovoltaic, solar thermal, wave, tidal, ocean thermal, biomass/biomass byproduct, hydroelectric, geothermal, and waste recovery/waste heat capture energy.

Methodology

To quantify the carbon reduction potential of this strategy, we model a Utah-specific RPS policy using AURORAxmp Electric Market Model software. We operationalize the RPS variable to match recent legislation proposed in Utah under S.B. 202.[59] As discussed above, S.B. 202 proposes a 20% renewable energy target by 2025. We assume a linear increase in the amount of renewable additions per year between 2008 and 2025; we also assume that the share of renewable energy will remain constant at 20% between 2025 and 2030. The benchmarks for each five-year increment are as follows:

[58] Utah S.B. 202. http://le.utah.gov/~2008/bills/sbillamd/sb0202.pdf. Note that electricity sales from nuclear power plants and fossil fuel plants that employ carbon sequestration are exempt from the 20% goal set by S.B. 202.
[59] Ibid.

- 2.4% by 2010
- 8.2% by 2015
- 14.1% by 2020
- 20% by 2025

While we have several options for mimicking the effects of an RPS in AURORAxmp, we ultimately take the most straightforward path and force new plants online in AURORAxmp to satisfy the Bramble RPS.

Based on the reference-case generation output, we calculate the total amount of renewable generation needed to satisfy Utah's percentage benchmark each year. We then translate this generation into new capacity needed.

The major simplifications that we make in order to model Utah's RPS in a timely manner are listed below.

- All of the renewable generation that we force into the model is wind power.
- To meet Utah's RPS, we add all of this renewable capacity in Utah. This approach contrasts with Pacificorp's perspective, explained in the introduction, and with the idea that Utah could build where there is greater potential for wind power (e.g., Wyoming). This simplification does not significantly alter the analysis.
- We assume the renewable content of imported electricity to be more or less equal to the renewable content of exported electricity, as AURORAxmp does not track whether the source of imported and exported electricity is renewable or not.
- Because the model is dynamic, such a large increase in capacity causes other results to change. With this in mind, we checked the RPS and ran the model a second time in order to tweak the forced capacity as needed. Due to time constraints, we did not repeat this process to further fine-tune the capacity.

This approach has some potential limitations. Some regions with more renewable generation would not need to add as much renewable capacity in order to meet a similar RPS, while others have insufficient wind for electricity generation (wind is a proxy for all renewables). Overall, however, we decided that this was the best compromise. While we would have preferred to avoid these simplifications, we do note that they affect prices much more than levels of emissions.

By 2025, electricity generation in Utah is projected to be approximately 50,000 GWh; under the RPS, about 10,000 GWh of this generation must be renewable. In order to reach the level of 20% of the electricity sold in that year, an additional 7,800 GWh of wind-generated power will be needed to supplement the renewable generation already built in to the reference case. As we have noted earlier, in order to avoid the leakage problem, we apply Utah's strategy throughout the West. For the purposes of calculating the RPS, we do this by determining what fraction of the West's overall generation Utah accounts for, converting that to capacity, and then adding the same proportion of wind capacity throughout the West. Since Utah generates about 5% of the West's electricity, we add to the rest of West about 19 times the capacity Utah will need, approximately 56 GW.

Strategy Benefits

In reference to base-case emissions, we estimate the cumulative avoided CO_2 emissions to be as follows:

- 3.8 $MMtCO_2e$ by 2015
- 47 $MMtCO_2e$ by 2025
- 79 $MMtCO_2e$ by 2030

Renewable portfolio standards offer many benefits beyond GHG reduction, including the following:

- They reduce air pollution and waste production.
- They increase domestic energy production and thus contribute to greater energy security and diversity.[60]
- They may encourage local economic development and job growth.
- By enabling renewable energy to displace gas-turbine-generated electricity, they lower the demand for—and hence the cost of—natural gas.[61]

Strategy Costs

Strategy costs include fixed and variable renewable energy investment costs. We calculate the net present value (NPV) of all fixed costs associated with wind energy deployment between 2008 and 2030 as a result of S.B. 202 to be $10.2 billion. We assume the variable cost of production to be $.65/MWh. Using the assumptions and methodology stated above, we estimate the cost of this strategy to be $68.14 per metric ton of avoided CO_2 emissions. Additional costs of a renewable portfolio standard may include the following:

- increased costs for electricity consumers
- the additional costs associated with wind energy development and deployment (see ES-3)

Implementation Ideas

Details regarding Utah's renewable energy targets are outlined in the text of S.B. 202. Implementation ideas for meeting these goals may include the following policy design features:

- clear portfolio goals, benchmarks, policy objectives, resource options, method of accounting, timeline, and enforcement penalties
- a cost recovery mechanism for utilities

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[60] U.S. EPA Combined Heat and Power Partnership Renewable Portfolio Standards Fact Sheet. http://www.epa.gov/chp/state-policy/renewable_fs.html.
[61] Carolyn Fischer, "How Can Renewable Portfolio Standards Lower Electricity Prices?" Resources for the Future Discussion Paper, May 2006. http://www.rff.org/Publications/Pages/PublicationDetails.aspx?PublicationID=17450.

- flexible compliance mechanisms
- the coordination of portfolio mandates with other state and federal policy instruments
- a "technology tier" system to promote specific technologies
- a noncompliance penalty mechanism
- a transparent method that allows utilities to check their compliance status[62]

[62] EPA RPS Fact Sheet.

Encourage Carbon Capture and Sequestration Technologies (ES-8, ES-9, ES-10, and ES-19)

Analysis method: AURORAxmp Electric Market Model
Avoided emissions (by 2030): 5.2 MMtCO_2e (modest scenario);
73.0 MMtCO_2e (stretch scenario)

Develop CO_2 Capture and Sequestration Policy (ES-8)
BRAC priority: High
BRAC bin: B
BRAC final vote: 18

Issues for CO_2 Transmission (ES-9)
BRAC priority: High
BRAC bin: B
BRAC final vote: 10

Research and Development (ES-10)
BRAC priority: High
BRAC bin: B
BRAC final vote: 20

Retrofit Plants with CO_2 Capture (ES-19)
BRAC priority: High
BRAC bin: C
BRAC final vote: 15

Strategy Background

Carbon capture and sequestration (CCS) technologies may provide an opportunity for Utah to generate electricity from fossil fuels, particularly coal, while still reducing CO_2 emissions.[63] Utah has large coal reserves and therefore relies heavily on coal-fired power plants for energy production. CCS, which by some estimates could reduce emissions from coal-fired power plants by as much as 80%–90%, has the potential to significantly reduce Utah's carbon footprint.[64] CCS technologies are still in infant stages. They have been demonstrated a on small scale only.

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[63] Note that under the BRAC categorization scheme, "Retrofit Plants with CO_2 Capture" (ES-19) falls under the category "Improve Efficiency and Reduce CO_2 at Existing Electricity Generation Plants" (ES-D). For the purposes of our analysis, however, we classify ES-19 under "Encourage Carbon Capture and Sequestration."

[64] Bert Metz et al., eds., *IPCC Special Report on Carbon Dioxide Capture and Storage*, prepared by Working Group III of the Intergovernmental Panel on Climate Change (New York: Cambridge University Press, 2005). http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_WholeReport.pdf.

While the cost of energy produced from CCS-equipped coal plants will be more expensive than energy from traditional coal plants, some estimate that CCS technologies are more cost-effective than other emissions reduction options.[65] Furthermore, CCS and related technological improvements will continue, possibly allowing for decreased costs.

CCS involves three phases, each of which requires important enabling technologies, electricity market conditions, and supporting policies:

- *Capture*. The CO_2 must be isolated during the combustion process. Usually this CO_2 capture occurs after combustion using technology installed in the coal plant. A new plant can be built already equipped with CCS technology, or pre-existing plants can be retrofitted with appropriate technology.
- *Transport*. The CO_2 must be transported to its storage location. It is likely that early CCS projects will occur at plants that are very close to a sequestration site or an existing CO_2 pipeline.
- *Storage*. Geologic formations (e.g., saline aquifers) are proposed as locations for the storage, or sequestration, of the CO_2. In some cases, the CO_2 may also be used for enhanced oil recovery, which would then generate additional revenue for the CCS system. The Utah Geological Survey has identified a number of attractive potential sites for carbon capture and sequestration, including those near large power plants.[66]

According to a 2007 study at MIT titled "The Future of Coal," the largest sequestration project as of 2007 injects one million tons/year of CO_2 from the Sleipner gas field into a saline aquifer under the North Sea.[67] By comparison, one 500-MW coal-fired power plant produces approximately 3 million tons CO_2 per year. Thus, there is still significant need for further research, demonstration, and deployment of CCS technology, both to decrease uncertainty and to lower the costs of large-scale applications. The MIT study recommends that the U.S. government implement three to five CCS projects (each injecting about 1 million tons per year) in order to address the outstanding technical questions related to CO_2 sequestration. The report estimates that each project would cost approximately $15 million per year.

Utah has taken some steps to explore the potential of CCS. Most notably, the state has already helped secure millions of dollars for CCS research funding—$100 million to the Utah, Science Technology and Research (USTAR) initiative for this purpose alone.

In addition to these research needs, a number of policies are required to support the implementation of CCS once it is technologically viable. Therefore, we include all CCS-related BRAC strategies under this

[65] National Energy Technology Laboratory FAQ Information Portal. http://www.netl.doe.gov/technologies/carbon_seq/FAQs/benefits.html.
[66] R.G. Allis et al., "CO_2 Sequestration Potential beneath Large Power Plants in the Colorado Plateau-Southern Mountain Region, USA," *Proceedings, 2nd Annual Conference on Carbon Sequestration, Alexandria, VA, May 5–8, 2003.* http://geology.utah.gov/emp/CO2sequest/pdf/potential.pdf.
[67] MIT, *The Future of Coal: Options for a Carbon Constrained World* (Boston: Massachusetts Institute of Technology, 2007). http://web.mit.edu/coal/The_Future_of_Coal.pdf.

policy category to appropriately account for the enabling policy (ES-8), transmission (ES-9), and research (ES-10). A final BRAC policy, ES-19, is focused on retrofitting coal-fired power plants. Each of these strategies makes CCS a more viable policy option and speeds up the timeline in which Utah could pursue such a strategy. While a national policy is key to making CCS a viable technology option, states have the authority, often through their public utility commissions, to make decisions on a number of issues related to CCS policy, including utility cost recovery, power plant siting, and technology choices.[68] Further, states can set rules that are consistent with federal regulations for underground injection of CO_2 and create incentives to encourage CCS through funding programs or the state tax code.

Most states already have regulatory frameworks that in one manner or another address the capture, transportation, injection, and post-injection components of CCS.[69] To address the remaining areas that need to be resolved to create a fully enabling CCS regulatory structure, the Interstate Oil and Gas Compact Commission produced a report in 2005 that provides a template state regulatory framework.[70]

Methodology

As explained above, the policy options generally fall into two categories: 1) those that create and streamline the regulatory framework to allow for CCS, and 2) those that incentivize electricity producers' adoption of CCS technology. The quantitative analyses of the costs and carbon reduction potential of CCS in this report assume that implementation of CCS will occur once there is the appropriate regulatory structure in place in Utah. The increased cost of producing electricity using CCS technology suggests that there will need to be some kind of state or national policy before CCS is widely commercialized. Such a policy would likely either require the use of low-carbon (including CCS) electricity production or narrow the cost differential between conventional electricity production and that using CCS.

We use AURORAxmp Electric Market Model software to analyze the effects of a hypothetical CCS policy in Utah. We model two different CCS scenarios: one attributable to a modest CCS policy and one attributable to a "stretch" policy. In both scenarios we assume that existing coal plants will be replaced with CCS plants of a similar capacity. The large differences between modest and stretch scenarios try to capture some of the uncertainty associated with commercializing CCS over the next few decades. Both of these policies consider Integrated Gasification Combined Cycle (IGCC) resources with CCS. Retrofit CCS technology was removed from the modeling as per the request of the State and based on advice from some of the utilities.[71]

[68] Richard Cowart et al., *State Options for Low-Carbon Coal Policy*, Coal Initiative Reports White Paper Series (Arlington, VA: Pew Center on Global Climate Change, 2008): 17. http://www.pewclimate.org/docUploads/StateOptions-02-20-08.pdf.

[69] Interstate Oil and Gas Compact Commission, "Carbon Capture and Storage: A Regulatory Structure for States," Summary of Recommendations (2005). http://www.iogcc.state.ok.U.S./PDFS/CarbonCaptureandStorageReportandSummary.pdf.

[70] Ibid. Some state legislatures and agencies have begun establishing laws and rules concerning liability, ownership of pore space, and related issues.

[71] Conference call with Glade Sowards (Utah DEQ), Ted Rampton (Utah Associated Municipal Power Systems), Mike Peterson (Utah Rural Electric Association), Kyle Davis (PacifiCorp), and Clay MacArthur (Deseret Power), May 30, 2008.

We assume that as a result of a modest CCS policy, Utah will utilize 430 MW of CCS coal capacity in 2027, another 430 MW in 2028, and another 465 MW in 2029, for a total of 1,325 MW by 2030. The stretch CCS scenario had twice the CCS capacity, which comes online about 6 years earlier. The costs and technical characteristics are based on EIA and WCI assumptions (see Table E-1 below).[72,73] This capacity comes online as a replacement for conventional coal plant retirements, which we assume to occur within the same year. The heat rate, 9,713 BTU/kWh, is the same for both scenarios, because the more modest values from the WCI were more favorable than EIA's.

The scaling up of CCS from Utah to the West was done in proportion to the amount of coal generation within each area. In the reference scenario, Utah's share of Western coal generation is between 15–16%. In keeping with the AURORAxmp methodology, we force all of this capacity online to model a Western CCS strategy. We calculate Utah's avoided emissions the same way we do for the RPS.

Table E-1. Carbon capture and sequestration technology characteristics.

Stretch CCS	How much	When	Variable O&M $/MWh	Fixed O&M $/MW/wk	Overnight costs	HR
In Utah	2.5 GW	2022	$4.18	$736	$2,134	9,713
Rest of WECC	15 GW	2021–2023	$4.18	$736	$2,134	9,713

EIA costs from AEO 2007 assumptions

Modest CCS	How much	When	Variable O&M $/MWh	Fixed O&M $/MW/wk	Overnight costs	HR
In Utah	1.3 GW	2027–2029	$1.01	$897	$3,470	9,713
Rest of WECC	7.2 GW	2027–2029	$1.01	$897	$3,470	9,713

Specs from WCI assumptions for IGCC w/CCS high costs
Dollars are 2005 $

Strategy Benefits

Our modeling scenarios reveal that the implementation of a regional CCS policy could help Utah avoid cumulative CO_2 emissions of 5 $MMtCO_2e$ by 2030 (modest policy scenario) or 73 $MMtCO_2e$ (stretch policy scenario) by 2030.

Additional benefits include the following:

- CCS would enable Utah to continue to draw upon its large coal reserves while realizing significant reductions in total GHG.
- A portion of the CO_2 captured with CCS technologies can be utilized for enhanced oil recovery in Utah's oilfields.

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[72] AEO 2007.

[73] Economic Analysis and Modeling Support to the Western Climate Initiative: Energy 2020 Model Inputs and Assumptions. Revised July 15, 2008. ICF Consulting Canada. WCI document from ICF.

- CO_2 from CCS may be injected into inaccessible coal veins to extract coal bed methane for use in natural gas production.[74]

Strategy Costs

CCS has been described as one of the most cost-effective ways to reduce GHG emissions.[75] At a capital cost of $3,470/kW—the assumption used for the modest CCS policy scenario—we estimate the net present value of all CCS fixed costs to be $4.3 billion between 2008 and 2030. At a capital cost of $2,134/kW—the assumption used for the stretch CCS policy scenario—we estimate the net present value of all CCS fixed costs to be $5.4 billion between 2008 and 2030.

There are a number of potential disadvantages to CCS development and deployment, including but not limited to the following:

- There is uncertainty about the potential for long-term leakage of the sequestered CO_2 back into the atmosphere. Further research on storage reservoir and CO_2 injection, appropriate site selection, monitoring policies, and public education about the risk should each contribute to address this uncertainty.[76]
- Additional energy is needed to capture and store CO_2; this additional energy consumption and its impacts should be factored into decisions regarding CCS policies and deployment.[77]

Implementation Ideas

In the short run, Utah could invest in the research and development of CCS technologies, facilitate CCS pilot programs, and invest in enabling and complementary technologies.

Utah could also adopt regulations that move the investment community in the direction of CCS development, and also open the legal system to the potential for advanced CCS deployment. For instance, some states have taken steps to streamline their regulatory processes for the transportation and storage of CCS carbon. The Ohio Power Siting Board, for example, created a "one-stop" siting agency or board that coordinates the review of CO_2 disposal sites by all the applicable state, federal, and local agencies.[78] In May 2009, Montana Governor Schweitzer signed S.B. 498 into law, which gives ownership of underground pore space to surface owners and allows a carbon storage company to transfer liability to the state after 30 years of trouble-free operation.[79] In March 2008, Wyoming Governor Freudenthal signed two bills (H.B. 89 and H.B. 90) granting control of underground pore spaces to the surface owner and giving the Wyoming Department of Environmental Quality authority to regulate the long-term storage of carbon

[74] National Energy Technology Laboratory FAQ Information Portal. http://www.netl.doe.gov/technologies/carbon_seq/FAQs/benefits.html.
[75] Ibid.
[76] Martin LaMonica, "MIT: To Keep Coal, Carbon Needs to Go Underground," CNET News.com, March 14, 2007. http://news.cnet.com/MIT-To-keep-coal,-carbon-needs-to-go-underground/2100-11392_3-6167147.html.
[77] Bert Metz et al., eds., *IPCC Special Report*.
[78] Richard Cowart et al., *State Options*, 17. http://www.pewclimate.org/docUploads/stateOptions-02-20-08.pdf.
[79] http://www.netl.doe.gov/technologies/carbon_seq/refshelf/news/2009/06-09.pdf; http://data.opi.mt.gov/bills/2009/billpdf/SB0498.pdf.

dioxide. In February 2009, Governor Freudenthal signed three additional bills (H.B. 57, H.B. 58, and H.B. 80) into law that further clarify legal and regulatory issues relating to carbon capture and sequestration. The passage of these measures give Wyoming an early lead in addressing several of the challenges associated with carbon capture and sequestration.[80]

[80] http://governor.wy.gov/press-releases/governor-signs-landmark-carbon-sequestration-legislation.html; http://www.pewclimate.org/node/6428.

Combined Policy Runs in AURORA

Modest combined scenario
Analysis method: AURORAxmp Electric Market Model
Avoided emissions (by 2020): 36 $MMtCO_2e$
Avoided emissions (by 2030): 126 $MMtCO_2e$

Stretch combined scenario
Analysis method: AURORAxmp Electric Market Model
Avoided emissions (by 2020): 127 $MMtCO_2e$
Avoided emissions (by 2030): 395 $MMtCO_2e$

Background

Originally, there was interest in evaluating the BRAC strategies one at a time in order to be better able to compare their relative merits. However, most strategies would have different emission potentials and associated costs depending upon what other strategies were implemented concurrently. This is particularly relevant for strategies related to the electricity sector. Many strategies are potentially overlapping (e.g., RPS and Green Power Purchasing) or enhance one another (e.g., Carbon Cap and most other strategies). As the State was preparing its 2020 GHG emissions target, both the State and the Institute agreed to shift the focus of this report—and particularly this part of the report—to defining the avoided emissions potential for a suite of policies. In fact, it became clear that leveraging the AURORAxmp model was one of the major advantages of using such a model.

Methodology

Given the time and resources available for this project, we limited the number of combinations of strategies evaluated to two. For a timely consideration of emissions reduction potential, we chose two suites that would define the upper and lower bounds between the totally modest and stretch potential being realized for each of the strategies within the suite. The combined scenarios each include the three previously discussed strategies, while the stretch suite includes one additional strategy, Regional/State Cap-and-Trade Programs, Carbon Tax, or Hybrid (CC-6). For the stretch suite the carbon limit results in a price of $25 per ton of CO_2 or its equivalent.[81] We note that the WCI is actively pursuing some version of a cap-and-trade policy.

The Modest Combined Scenario (lower bound) includes the following strategies:

- Renewable Portfolio Standard (ES-1)
- Encourage Carbon Capture and Sequestration Technologies (ES-8, ES-9, ES-10, ES-19) (modest version)

[81] This allowance price was modeled as $25 starting in 2012, escalating at 5% per year, all in 2006 dollars.

- Energy Efficiency Measures: Combined Analysis (Includes RCI-1, RCI-8, RCI-20, and RCI-21) (modest version)

The Stretch Combined Scenario (upper bound) includes the following strategies:

- Renewable Portfolio Standard (ES-1)
- Encourage Carbon Capture and Sequestration Technologies (ES-8, ES-9, ES-10, ES-19) (stretch version)
- Energy Efficiency Measures: Combined Analysis (Includes RCI-1, RCI-8, RCI-20, and RCI-21) (stretch version)
- Carbon allowance price of $25 (CC-6)

Combining these strategies necessitated adjusting downward the quantity of renewables to meet the RPS, since demand reduction from energy efficiency and the carbon allowance price both affect the growth of renewable generation.

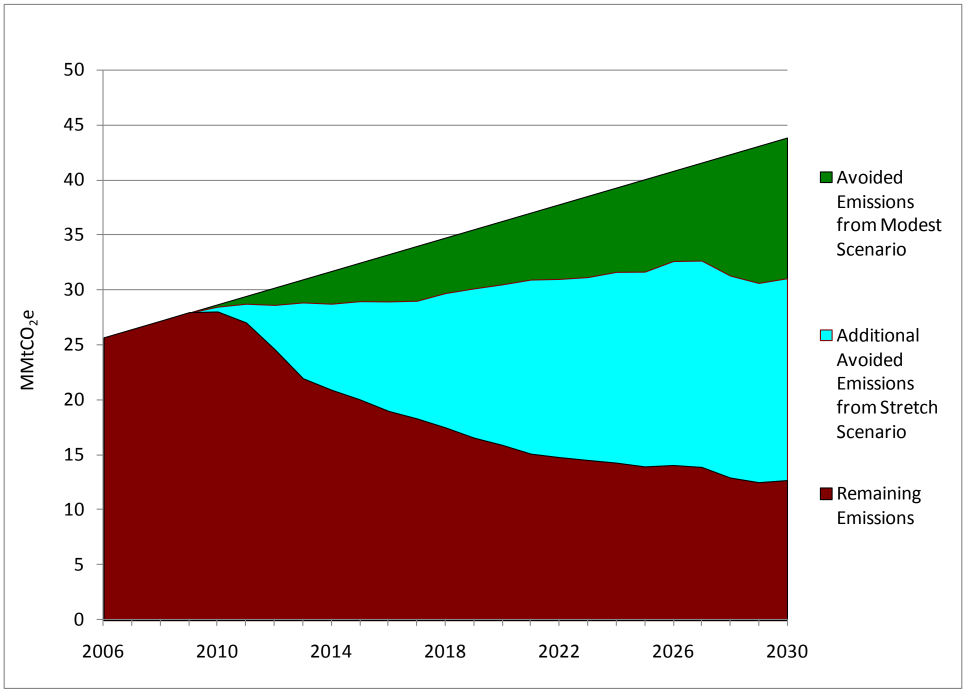
Strategy Benefits

The potential avoided emissions from these suites of policies are shown in Table E-2 and graphically in Figure E-9 below. Most of the additional avoided emissions between 2020 and 2030 are attributable to Carbon Capture and Sequestration. This is because the CCS policy is the only strategy that begins ramp up after 2020. In fact, the strategies of Energy Efficiency, RPS, and Carbon Cap, have all been fully implemented by 2020 and contribute to marginal improvements in this time frame.

Table E-2. Utah's GHG emissions from electricity supply.

In $MMtCO_2e$	2020		2030	
	Modest	Stretch	Modest	Stretch
Reference forecast	36.2	36.2	43.8	43.8
Potential avoided	5.7	20.4	12.7	31.1
% of reference avoided	16%	56%	29%	71%

Figure E-9. Electricity inventory with potential avoided emissions.



AGRICULTURE AND FORESTRY POLICY OPTIONS

The baseline produced for the agriculture and forestry sector includes both positive emissions, mostly from livestock and agricultural practices, and negative emissions (i.e., reductions in emissions) from carbon sinks due to plant/soil capture. These carbon sinks are primarily attributed to increased tree growth, and we assume a constant rate of carbon being pulled into this sink. The overall GHG contribution is small for this sector, but the carbon sink is likely to make the net emissions negative. We will examine the emission sources separately from the carbon sink in this chapter.

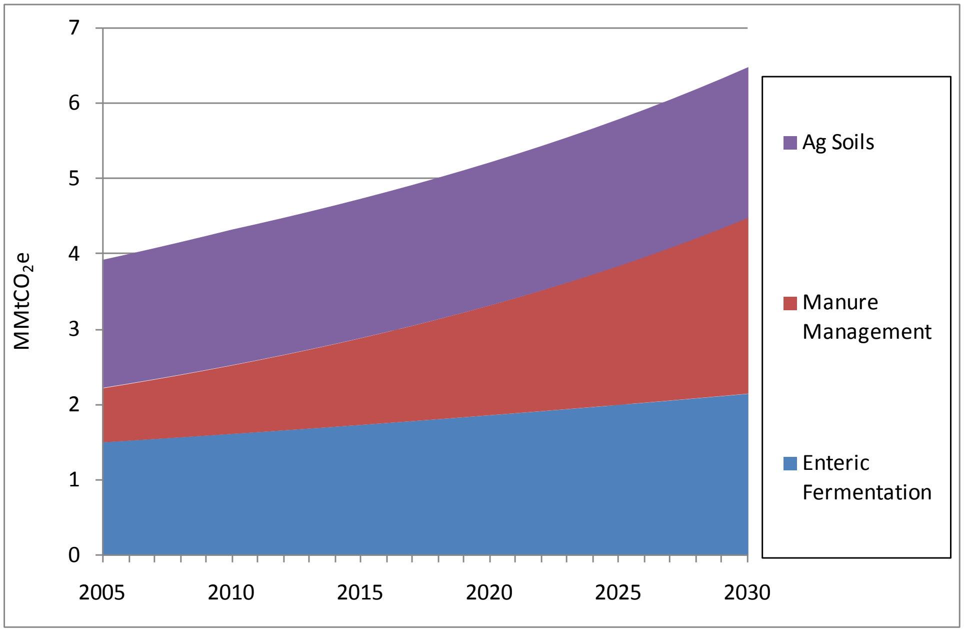
Agriculture and forestry's share of Utah's total GHG emissions was about 6.5% in 2007. This share is projected to be roughly the same in 2030. The emissions for this sector come from a wide variety of sources, such as nitrate emissions from adding nitrogen to soils or methane from animal digestion and waste. With emissions coming from a wide range of sources, precise estimation of GHG emissions are difficult to come by even though reasonable estimations are available.

To the extent possible, on the emissions side of the agriculture and forestry sector we tried to recreate the inventory that the Center for Climate Strategies (CCS) produced trough 2020 and then extrapolated these results out through 2030. In addition to the agriculture and forestry sector's emissions inventory, we considered the forestry sector of Utah to be a sink of CO_2. While the natural environment of forests and agriculture lands undeniably acts as a source to some extent, we quantified this sink by relying on a peer review of CCS's sink inventory performed by Dan Richter of Duke University. The sink attributed to Utah's forests and soils, as calculated in Richter's report, "The Carbon Budget of Utah's Forests," is 8.75 $MMtCO_2e$ currently and remains constant into the future.[82]

Figure A-1 shows CCS's projection for agricultural GHG emissions using historical growth rates as the basis for the projections, as well as the major agricultural emissions categories. We extended this projection to calculate total GHG emissions of 7.1 $MMtCO_2e$ in 2030. Considering the sector as a whole, manure management has the highest emissions growth rate. Emissions from livestock due to enteric fermentation and carbon release due to soil disturbance are both expected to slowly increase. Overall, the agricultural sector shows a steady increase in emissions, although emissions from this sector are relatively small compared to those from other sectors.

[82] http://www.climatechange.utah.gov/docs/Richter_Utah_Carbon_Budget_051908.pdf.

Figure A-1. Projections for agriculture-related GHG emissions.



The BRAC recognized the importance of this sector and identified nine strategies that could help reduce GHG emissions from agriculture and forestry. These strategies generally take one of three approaches:

- reducing methane emissions as well as creating energy by converting methane to gas energy
- producing biofuels
- increasing or at least protecting the existing forestry carbon sink

As part of this analysis, we quantified two of five livestock- and fuel-related BRAC recommendations, one aimed at reducing emissions by substituting biofuels for higher GHG-emitting fuels and another aimed at reducing emissions by capturing and using methane from manure. The four strategies that relate to maintaining or increasing the carbon sink directly should be considered in light of "The Carbon Budget of Utah's Forests" report.

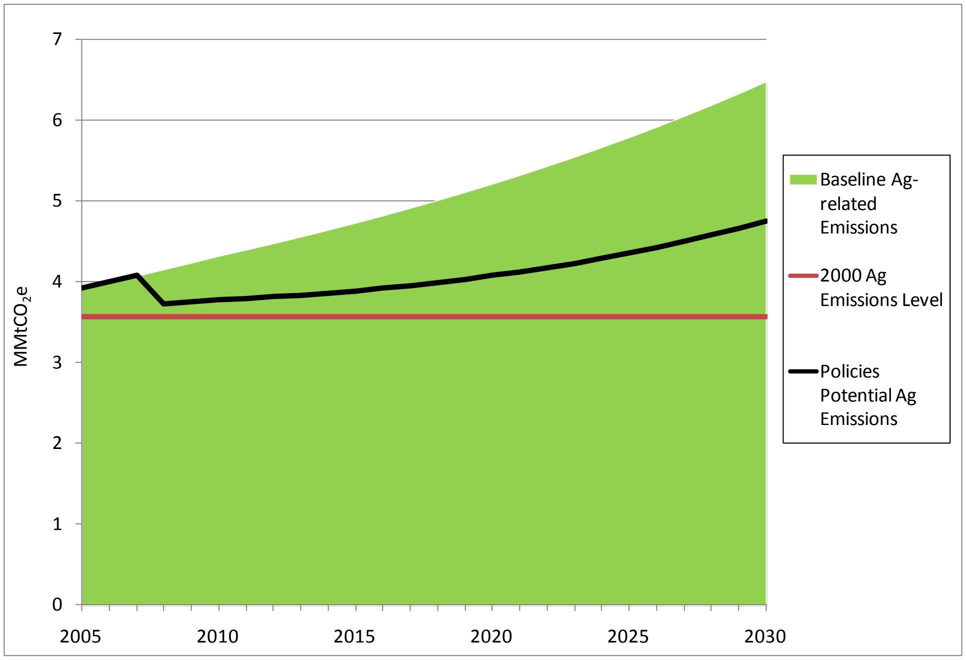
The strategies we analyzed are listed below in black, with those we did not analyze indicated in gray:

Promote Production of Biomass Fuels	**AF-1**
Improve Manure Management	**AF-2**
Change Livestock Feed and Improve Productivity to Reduce Methane Emissions	AF-3
Preserve Open Space/Agricultural Land	AF-6
Promote Urban and Community Trees	AF-9
Protect Forest Land by Reduced Conversion to Non-Forest Uses	AF-7
Increase Fire Management and Risk Reduction Program	AF-12
Increase Forest Health Risk Reduction Programs	AF-13
Expand Use of Forest Biomass Feedstocks for Energy Production	AF-15

In Figure A-2, the 2000 level of agriculture-related GHG emissions and the emissions trajectory if policies AF-1 and AF-2 are implemented are set against the projected baseline GHG emissions shown in Figure A-

1. Agriculture-related emissions could potentially be 13% lower by 2010, 22% lower by 2020, and 27% lower by 2030 given the application of these quantified strategies.

Figure A-2. Baseline, year 2000, and potential agriculture-related emissions.



Promote Production of Biomass Fuels (AF-1)

BRAC priority: High
BRAC bin: B
BRAC final vote: 20
Analysis method: spreadsheet analysis
Avoided emissions (2009–2030): 15–21 $MMtCO_2e$

Strategy Background

The potential use of biomass fuels, principally ethanol and biodiesel, has received significant national and international attention in the last few years. The Energy Independence and Security Act of 2007 increases the national Renewable Fuel Standard (RFS) and authorizes additional grant money for biofuels production and infrastructure research and development, in particular for states such as Utah that have insufficient cropland to grow feedstocks for starch-based ethanol production. Utah may be positioned to grow biomass, such as switchgrass, which can be cultivated in lower quality soil.

Continuing research and development will be instrumental in making the production of biomass fuels feasible, both technically and economically. Cellulosic ethanol production will hinge largely on technological advances. Biodiesel production currently utilizes vegetable and/or animal oils as feedstocks; though its potential in Utah will improve with advancements in biodiesel-from-algae technologies.

Methodology

For this strategy we assess the development of cellulosic ethanol capacity in the State. Based on a feasibility analysis of the amount of potential feedstock in Utah, we estimate that moderate amounts (150–220 million gallons) of cellulosic ethanol could be produced in-state, if technological advancements occur apace. We create three scenarios (A, B, and C) to explore this possibility.

Scenario A assumes that in-state ethanol capacity increases by 7 million gallons of ethanol annually from 2009 to 2030, starting from a base of zero. Scenario B maintains the same rate of capacity increases as A, but assumes that incentive costs decline by 15% annually from 2012 to 2023 and then drop to zero for the period 2024 through 2030. Scenario C differs from B in that ethanol capacity rises at the steeper rate of 10 million gallons per year and in that incentive costs fall faster, i.e., by 20% annually 2012 to 2021 and then zero through 2030.

The spreadsheet analysis we perform involves finding the incentive costs required to develop the ethanol production capacity, the reduction in GHG emissions due to ethanol use, and then the cost per $MtCO_2e$ reduced. We assume an incentive cost of $1.35 per gallon cellulosic biofuel based on Baker et al.,[83] who

[83] Mindy L. Baker et al., Crop-Based Biofuel Production under Acreage Constraints and Uncertainty, 2008. Working Paper 08-WP 460, Center for Agricultural and Rural Development, Iowa State University. http://www.card.iastate.edu/publications/DBS/PDFFiles/08wp460.pdf. Using a general equilibrium model on a national scale, the authors assess the level of tax credits required to incentivize sufficient production of cellulosic

estimate the level of tax credits necessary to stimulate biofuel production nationally. This per gallon cost is multiplied by the number of gallons of ethanol capacity in each year to yield the total annual incentive cost.

For each year through 2030, we multiply the ethanol capacity by the average fleet gas mileage of 21.3 mpg to find the quantity of vehicular miles that could be powered by biofuel. We assume that these biofuel-powered vehicle miles traveled will displace vehicular miles powered by conventional gasoline. We calculate avoided emissions by multiplying these vehicle miles by the difference in GHG emissions per mile between conventional gas and cellulosic biofuel provided by GM's 2005 "Well-to-Wheels" study.[84] We also use a 5% discount rate and discount future emissions reductions to yield net present values (NPV). We then divide NPV costs by the NPV emissions to obtain the cost per $MMtCO_2e$ avoided, the measure of cost-effectiveness of the policy.

Strategy Benefits

Table A-1. GHG emissions avoided ($MtCO_2e$).

Strategy	Scenario	2010	2020	2030	Cumulative (by 2030)	Levelized cost
AF-1	Biofuels A	0.12	0.71	1.31	15.01	$159.25
	Biofuels B	0.12	0.71	1.31	15.01	$37.61
	Biofuels C	0.17	1.02	1.87	21.45	$28.79

As shown in Table A-1, cumulative GHG emissions avoided for the 2008–2030 period reach 15 $MMtCO_2e$ for scenarios A and B and 21 $MMtCO_2e$ for scenario C. The carbon reduction potential of this policy option is dependent on estimated levels of production and/or consumption of biodiesel, ethanol, or other biofuel within Utah. We note that in-state production of biofuels precludes GHG emissions associated with transport of fuels to Utah from elsewhere.

Following are estimates of the carbon reduction potential of the most common biofuels:

- Starch-based ethanol provides an 18%–29% reduction and cellulosic ethanol a 72%–85% reduction in GHG emissions compared to conventional gasoline.[85]
- Biodiesel from soybeans contains 93% more useable energy than the petroleum equivalent and reduces lifecycle emissions by as much as 41%. National Biodiesel Board indicates that biodiesel provides a 78% reduction in GHG emissions per unit.[86]

biofuel and biodiesel to meet the mandate of 36 billion gallons of biofuels by 2022 set by the Energy Independence and Security Act of 2007. We take their result of $1.86/gallon cellulosic biofuel and subtract out the current $0.51 subsidy to ethanol to arrive at $1.35.

[84] Norman Brinkman et al., Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions, 2005. http://www.transportation.anl.gov/pdfs/TA/339.pdf.

[85] Ibid.

Other benefits associated with this strategy include:

- economic opportunities for in-state biofuel producers
- additional value added to agricultural crops or crop residue
- potential economic impacts on established agricultural industries
- stimulation of potential markets for other biomass feedstock (e.g., forestry and crop residues, manure)
- energy security increases with greater in-state biofuel production
- in-state production of biofuels (vs. importation from other states) might mean an increase in overall state GHG emissions due to emissions released during the biofuel production process, although net national emissions would decrease because less energy would be used in transportation

Strategy Costs

The costs of this strategy are unclear. On one hand, much of the research and development of this strategy will likely be done on the national level. Yet, State funds may be directed toward specific areas and applications judged especially important or in which Utah has a comparative advantage. Keeping those issues in mind, we calculate that the reduction of one $MtCO_2e$ would cost $159 under Scenario A, $38 under Scenario B, and $29 under Scenario C. This cost reflects the incentive cost times the number of gallons and the emissions improvement.

Incentive packages may be essential to get the biofuel industry off the ground within Utah, even though cost estimates are speculative. Some states have provided significant investments along these lines already. For example, Pennsylvania has provided incentives valued at $17.4 million for a 108 million-gallon ethanol plant, which includes a cellulosic pilot plant. This is equivalent to $160,000 per million gallons ethanol in plant capacity. In Colorado's assessment of ethanol production, the state based its incentives on the cost difference between producing starch-based and cellulosic ethanols, which it calculated to be $0.23 per gallon (EIA). Colorado based its biodiesel incentives on the cost difference between producing fossil- and soy-based diesel fuels, which it calculated to be $0.34 per gallon.[87]

Any calculation of the societal costs or externalities associated with this strategy should take into account the following considerations:

- Tradeoffs between food and fuel crops may lead to higher livestock feed prices, which will in turn lead to higher meat, dairy, and other food prices.

[86] Jason Hill et al., "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels," *Proceedings of the National Academy of Sciences* 103 (2006): 11206–11210. http://www.pnas.org/cgi/reprint/0604600103v1.
[87] Anthony Radich, "Biodiesel Performance, Costs, and Use," 2004. http://www.eia.doe.gov/oiaf/analysispaper/biodiesel.

- Higher levels of crop production may conflict with acreage needed for no-till production or conservation management programs.
- New production of crops for biodiesel or ethanol on previously uncultivated land may cause N_2O emissions and the release of substantial amounts of soil carbon.
- There is a lack of feedstock collection and delivery infrastructure.
- Limited water availability would represent a serious constraint on production.
- Available cropland and waste feedstocks are limited.
- Potential price volatility of ethanol may disincentivize private/public investment in biofuel production technology and infrastructure
- Federal legislation (Energy and Farm Bills) may have an effect: The Energy Independence and Security Act of 2007 modified the RFS and now requires that 36 billion gallons of renewable fuel be produced in U.S. by 2022.

Implementation Ideas

This BRAC strategy could be redefined to focus specifically on ethanol or biodiesel production, as other state assessments have (e.g., Arizona, New Mexico, and Colorado). This would simplify a quantification of costs and benefits.

Utah could enhance the ability of the State to secure research and development funding by taking the following steps:

- by further developing institutional research capacity to attain specialties in certain aspects of biofuel production or transport
- by indentifying matching funds for federal funding from the State's budget and the private and non-profit sectors

Improve Manure Management (AF-2)

BRAC priority: Medium
BRAC bin: B
BRAC final vote: 13
Analysis method: spreadsheet analysis
Avoided emissions (2009–2030): 10 MMtCO_2e

Strategy Background

Utilization of anaerobic digesters has been suggested as a means of capturing the fugitive methane emissions generated under anaerobic conditions, usually when manure is held in storage, such as a lagoon. Manure digesters have been utilized to provide optimal conditions to facilitate methane production on a continual basis from the manure waste stream. Anaerobic digestion would only otherwise occur on intermittent intervals, given the variations in temperature and bacteria populations, and would produce fugitive methane emissions contributing to climate change. Only 2%–15% of methane will escape as fugitive gas once digesters are in place to capture the methane.

The EPA Agstar program has been instituted to assist with implementing an anaerobic digester. The EPA notes that the "facilities best suited for biogas digester systems typically have stable year-round manure production, and collect at least 50% of the manure daily."[88] Utilizing digesters to capture marketable methane from confined dairy and hog operations is feasible because of the operational setup which allows for continual manure inputs to the anaerobic digester. Attempting to implement a digester system for beef feedlot, poultry, and turkey operations is not as feasible without significant changes to infrastructure and additional capital costs. Most feedlot operations do not have a manure recovery system that is suited for an anaerobic digester, and even when there is a system in place, the recovered manure often contains too many non-organic contaminants.[89] While poultry manure produces methane comparable to dairy or hog manure, it is not ideal for most anaerobic digestion designs, because it has higher solids content. Consequently, a considerable amount of water is needed to lower the solids content in order for the waste stream to reach optimal operating parameters.[90] However, current federally-backed research with the egg-layer industry in Utah may reveal other methods to reduce the amount of methane.[91] Finally, turkey growers do not remove manure on a regular basis (only after successive flocks are grown and removed) to create a continual feedstock for digestion.[92]

[88] http://www.epa.gov/agstar/pdf/manage.pdf.
[89] E-mail exchange with Spencer Watts, Andigen, LC, March 28, 2008.
[90] Ibid.
[91] Telephone Conversation with Howard Thomas, Water Quality Specialist, Utah Farm Bureau, March 14, 2008.
[92] http://www.osti.gov/energycitations/servlets/purl/794292-6l279H/native/794292.PDF.

Methodology

In order to achieve a viable anaerobic digester system, conventional wisdom suggests that an operation of at least 750 Animal Units (AU) is required.[93] An AU represents 1,000 lbs of body weight, no matter the species; 0.74 dairy cow, 9.09 feeder hogs, and 2.67 breeding hogs, are each equivalent to 1 AU.[94] In Utah, there are approximately 40 dairies and 10 hog operations with 750 or more AUs, consisting of over 50,000 cows and about 770,000 hogs (of which about 90% are feeder hogs).[95] For our analysis, we assume that all of the operations with more than 750 AU decide to implement digesters.

To calculate the reduction in GHG emissions, we find the annual quantity of BTUs of biogas (methane and CO_2) captured by the digester and thus preempted from entering the atmosphere. Dairy cow waste produces 26,000 BTU per day per AU and swine waste 17,400 BTU per day per AU.[96] We assume that 85% of bio-gas is captured by the digesters. We then convert the total BTUs captured into equivalent units of emissions avoided and then discount to the present using a 5% discount rate, in order to be able to calculate a levelized cost below.

If a system can be devised to capture the methane from chicken layers and turkeys, then potentially more GHG could be captured via these digesters. Also, it should be noted that Circle 4 hog farms unsuccessfully implemented a digester at one of their barns to convert manure to methanol (then biodiesel) and discontinued its use because they found it would not be economically feasible.[97]

Strategy Benefits

Table A-2. GHG emissions avoided ($MMtCO_2e$).

Strategy	Scenario	2010	2020	2030	Cumulative (by 2030)	Levelized cost
AF-2	Manure Management	0.44	0.44	0.44	10.01	$2.45

The principle benefit is the reduction in GHG emissions (largely methane) from anaerobic conditions in manure lagoons and piles. As with costs, the reduction potential depends on what state programs are implemented and how aggressive the campaign is.

A main reason for support for this strategy is its benefits additional to it GHG reduction potential. These co-benefits include:

- reducing vulnerability to energy price spikes

[93] E-mail exchange with Conley Hansen, March 2008.
[94] Definition of Animal Units at USDA Natural Resources Conservation Service. http://techreg.sc.egov.usda.gov/NTE/TSPNTE2/AnimalUnits.html.
[95] Communication with Mark Peterson, Utah Farm Bureau, April 2008.
[96] Bio-gas production of livestock. http://www.ext.colostate.edu/pubs/farmmgt/05002.html.
[97] "Smithfield questions biogas economics," Ontario Farmer (Canada), Tuesday, February 26, 2008.

- offsetting energy demand for farms
- reducing peak demand
- improving public health

Strategy Costs

There are two types of costs in this analysis: the costs of installing a digester and the costs of maintaining it. Installation costs for both the digester and a generator are $750 per AU. We assume the total installation cost to be amortized over 10 years with an interest rate of 10%. We assume maintenance costs to be $0.02/kWh produced by the digester. We sum up these costs and subtract the benefits relating to additional electricity generation. Because hog and dairy farms use electricity in their daily operations (at a cost of about $0.075/kWh), the electricity generated via the methane digesters can offset farm electricity needs and thus allow farms to save money on their electricity bills. If the quantity of electricity generated exceeds farm electricity needs, then the surplus electricity can be sold back to the grid at a price of $0.035/kWh, providing the farm additional income.[98]

Subtracting the benefits from the costs, we arrive at the overall annual cost for all years through 2030, which we then discount back to present. Dividing the NPV of the costs by the NPV of the emissions avoided, we calculate that each avoided metric ton of CO_2e would be $2.45.

Implementation Ideas

The existing rules make it hard to operate digesters in a cost-effective manner. Most systems capable of efficient operation would have to be larger than the 25 kW limit legislated by the Net Metering statute.[99] In addition, the avoided electricity cost is not sufficient to make the operations economically efficient. Prices in the $0.10 to $0.13/kWh range are needed to make a return on investment.

In this light, the State may want to consider the following:

- reevaluating the existing rules;
- increasing the tax credits available for anaerobic digesters in addition to the sales tax credit currently offered; and/or

[98] Note that Public Service Commission revised Utah's net metering program in early 2009. Under the new policy, residential customers will receive credits for any excess power generation produced equal to the retail price of kilowatt-hours (~$0.075/kWh). Large commercial and industrial customers will have the choice between the avoided cost-based rate and an alternative rate. See http://utahcleanenergy.org/news/net_metering_victory/21809. This change could make digester installation somewhat more financially attractive, but not change the economics significantly.

[99] For a 750-head dairy farm, one would need a 120- to 135-kW generator (http://www.state.mn.us/mn/externalDocs/Commerce/MN_Biogas_Potential_Report_041003013143_biogasfinal2.pdf). E-mail exchange with Spencer Watts, Financial and Operations Analyst, Andigen, LC, March 31, 2008.

- subsidizing the production of electricity from manure until electrical prices increase.[100]

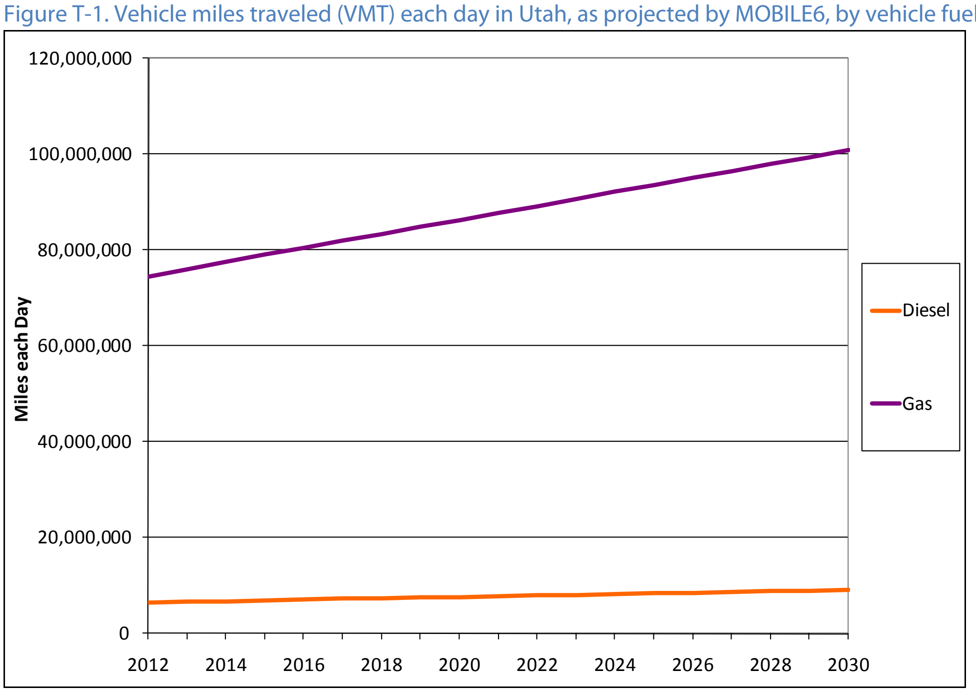
[100] Robert Burns of Iowa State University notes that "typically, energy produced from the anaerobic digestion of animal manures in the United States has not been economically competitive without subsidization at some level." Robert Burns, College of Agriculture and Life Sciences, Iowa State University, Communication Service, News Releases, May 7, 2007.

TRANSPORTATION AND LAND USE POLICY OPTIONS

Approximately 80% of Utah's population lives along the Wasatch Front.[101] Moreover, Utah's population growth projections anticipate an additional one million residents living in the Wasatch area by 2020. This type of population growth is expected to fuel urban expansion as people continue fill in urban and expand suburban neighborhoods. In order to accommodate urban expansion, more freeways will be created, which in turn, will likely stimulate even more suburban growth along the outer edges of the Wasatch front.[102]

Historically speaking, population growth has traditionally increased vehicle miles traveled (VMT). In fact, in many instances, growth of VMT outstrips population growth. From 1966 to 2000, per capita VMT along the Wasatch Front have increased from 5,030 per year to 9,380 miles per year. [103,104] Notably, VMT stemming from suburban growth are greater than VMT associated with urban growth. The VMT reference case forecast for Utah is shown in Figure T-1.

Figure T-1. Vehicle miles traveled (VMT) each day in Utah, as projected by MOBILE6, by vehicle fuel.



[101] Blue Ribbon Advisory Council on Climate Change: Report to Governor Jon M. Huntsman, Jr., October 2007. http://www.deq.utah.gov/BRAC_Climate/final_report.htm.

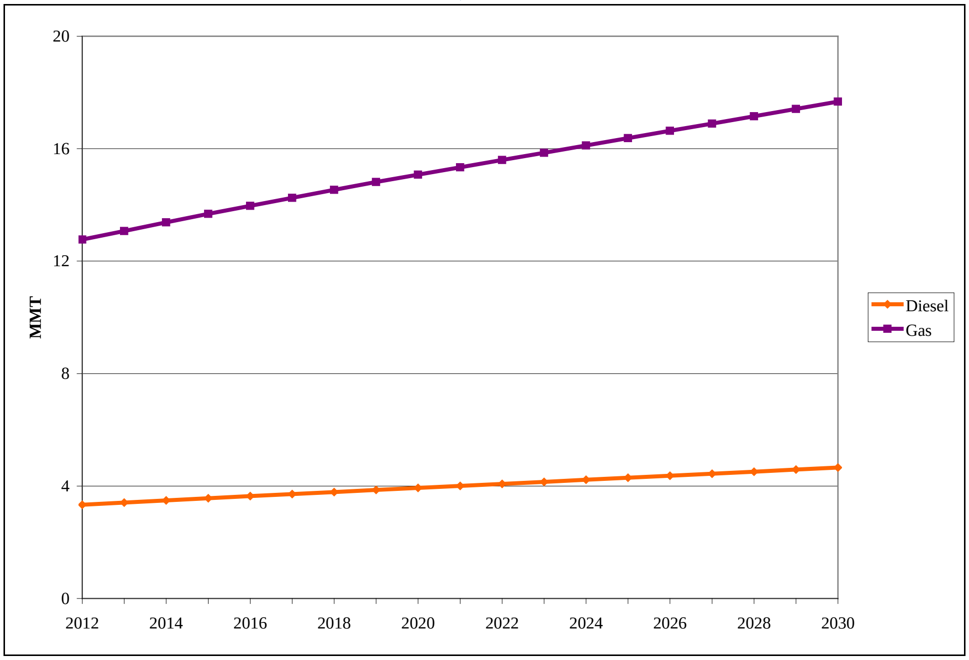
[102] Quality Growth Efficiency Tools (QGET) Databook 1997. http://www.governor.state.ut.us/DEA/QGET/DataBook/8.HTM (accessed Feb. 22, 2008).

[103] Ibid.

[104] QGET, *2003 Baseline Scenario*, May 2003. http://governor.utah.gov/dea/2003BaselineWEB.pdf (accessed Feb. 22, 2008).

The transportation sector is the second largest source of GHG emissions in Utah.[105] We constructed this reference case using the EPA's MOBILE6 model in collaboration with the Utah DEQ's Division of Air Quality. The MOBILE6 model predicts emissions from cars, trucks, and motorcycles, and it is used across the country by the EPA, primarily in order to monitor criteria pollutants listed under the Clean Air Act. For the analysis of Utah's future GHG emissions, Utah-specific assumptions were applied to the model. These assumptions (including population growth) were verified by the EPA and the State during other planning procedures. The reference case for vehicle emissions is shown in Figure T-2.

Figure T-2. GHG emissions forecast for Utah, by Mobile6.



The BRAC identified 12 specific strategies to reduce this sector's contribution to Utah's GHG footprint. Reducing GHG emissions in this sector generally take one of two tacks. First, the State could encourage driving choices that consume less fossil fuel. This may mean improving fuel efficiency or relying on less carbon intensive fuels. Second, the State might consider strategies for this sector that reduce demand for driving (i.e., reduce VMT). These strategies include switching modes of transportation away from private vehicles (e.g., switching to mass transit) or reducing the need to travel as much (e.g., through quality growth planning).

[105] Transportation emissions as discussed in this report refer to car and truck emissions, not jet fuel or aviation gas, as the strategies focus on those measures.

The strategies we analyzed are listed below in black, with those we did not analyze indicated in gray:

Develop and Implement Aggressive Mass Transit Strategy	**TL-1**
Quality Growth Program	TL-2
Trip Reduction, Rideshare, Vanpool, and Telecommuting	**TL-4**
"Buy Local" Program	TL-6
Promote Low-Carbon Fuels and Vehicle Technologies	TL-7
State Fleet Lead By Example	TL-8
Clean Car Program	**TL-9**
Idle-Reduction Program	**TL-10**
Vehicle Speed Reduction	TL-11
Education Program	TL-13
Explore Funding Options for Suite of Options	TL-14
Develop Congestion Pricing Programs	TL-15

Develop and Implement Aggressive Mass Transit Strategy (TL-1)

BRAC priority: High
BRAC bin: B
BRAC final vote: 19
Analysis method: Spreadsheet
Avoided carbon emissions (by 2030): up to 4.2 $MMtCO_2e$

Strategy Background

Utah's long-term plans include more aggressive, planning, development, and implementation of mass transit on the Wasatch Front, including greater integration of the mass transit system and greater funding.

Utah's transportation system already includes several forms of mass transit: the mass transit along the Wasatch Front, operated by the Utah Transit Authority (UTA), consists of a bus system, a light rail system, and a commuter rail line. Following are a few statistics about each.

Buses

- In 2005, UTA buses were used for over 75 million passenger miles and 22.4 million passenger trips.[106]
- Bus service has been UTA's primary service since creation. However, the light rail seems to have displaced some of the bus ridership. Currently, the bus system picks up fewer passengers per mile than UTA's other systems.[107]
- The bus system was completely redesigned in 2007. In the summer of 2008, UTA launched a Bus Rapid Transit Route, which is expected to decrease travel time through traffic signal prioritization and dedicated bus lanes.[108]

Light rail (TRAX)

- In 2005, UTA light rail was used for over 76 million passenger miles and 14.3 million passenger trips.[109]
- Starting in 1999, TRAX ran from Sandy to downtown Salt Lake City. The rail system has since expanded east to the University of Utah and University Medical Center. The Mid-Jordan Line, extending to Murray/Daybreak, has been funded, is under construction, and expected to be

[106] American Public Transportation Association (APTA), *Public Transportation Fact Book 58th Ed.*, May 2007, 49. http://www.apta.com/research/stats/factbook/documents/factbook07.pdf. Utah Transit Authority, "Comprehensive Annual Financial Report for Fiscal Year Ended December 31, 2007." http://www.rideuta.com/files/CAFR2007.pdf.
[107] Office of the Utah Legislative Auditor General, *A Performance Audit of the Utah Transit Authority*, Jan. 2008, ii. http://www.le.state.ut.us/audit/08_03rpt.pdf.
[108] http://www.rideuta.com/projects/BRT/default.aspx.
[109] APTA Fact Book, 76.

completed by 2011-2012.[110] Several other extensions have been proposed, including lines to the Salt Lake City Airport, Draper, and West Valley City.

- TRAX had approximately 40,000 daily riders in 2007 on its 18 miles of track.
- By most accounts, TRAX is considered a success.

Commuter rail (FrontRunner)

- The initial phase of FrontRunner opened April 28, 2008, offering service from Ogden to Salt Lake City. With the additional of the Pleasant View-Ogden leg, opened in September 2008, the rail line runs 44 miles from Pleasant View to Salt Lake City. The second phase, scheduled for operation in 2012, will run from Salt Lake City to Provo. Future phases are planned to extend the commuter rail from Brigham City in the North to Payson in the south, and some rail lines and rights-of-way have been purchased.
- In the opening month of FrontRunner's completion, daily ridership averaged 6,400 people. The following month, daily ridership rose to 7,800.[111]

Besides this traditional mass transit, the UTA also operates a Rideshare program (explained in next chapter—Trip Reductions, Rideshare, Vanpool, Telecommuting), which promotes carpooling/vanpooling, telecommuting, biking/walking, and park-and-ride programs and initiatives. In 2005, the vanpool program alone was used for over 48 million passenger miles.[112]

Utah's planned future transportation system includes an expanded role for mass transit. The Wasatch Front Regional Council[113] (WFRC) published a Regional Transportation Plan that recommends adding 240 miles of public transit service by 2030, consisting of light rail (31 miles), commuter rail (22 miles) bus (184), and streetcar (3 miles) service.[114]

Existing costs of UTA services[115]:

- For light rail, capital expense per vehicle mile is $9.86, while operating expense is $8.18; for buses, capital expense per vehicle mile is $0.98, and operating expense per vehicle mile is $5.62.
- Total cost per passenger mile is $0.74 for UTA buses, $0.62 for TRAX, and $0.08 for vanpool. Frontrunner is expected to be one of the more expensive services offered.

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[110] http://www.rideuta.com/projects/midJordanLightRail/overview.aspx.
[111] Chris Vanocur, "UTA's FrontRunner a Huge Success." http://www.abc4.com/news/local/story.aspx?content_id=a408a961-d1a6-45bd-96e8-6f5cf2c89616.
[112] APTA Fact Book, 83.
[113] The Wasatch Front Regional Council (http://www.wfrc.org) is responsible for transportation planning for the Salt Lake and Ogden/Layton urban area; Mountainland Association of Governments (http://www.mountainland.org) is responsible for the transportation planning of the Provo/Orem area.
[114] Wasatch Front Regional Council (WFRC), *Regional Transportation Plan: 2007-2030*. http://www.wfrc.org.
[115] Performance Audit of UTA, 46.

- Transit fares only cover a portion of the true cost of transit. Capital costs are borne by the public, not just transit users (as with highway capital). For example, the Salt Lake County Council voted in 2006 to impose a sales tax increase to pay for TRAX expansion.[116]
- While light rail and vanpools reduce NO_x emissions, buses—which are large emitters of NO_x—more than offset these reductions. Overall, however, UTA transit NO_x emissions have little effect on Utah air quality relative to other NO_x sources.

UTA's budget and planned expenditures[117]:

- UTA is already expected to spend about $11 billion in construction costs over the next 23 years for new transit projects. An additional $7.6 billion will be needed for operation and maintenance of those projects. These figures do not include projects requested by communities but not yet approved.
- From 1997 to 2007, UTA's total annual expenses increased from $77 million to $201 million, and the primary funding source has shifted from the federal government to local sales taxes.
- Operating expenses increased 110% from 1997 to 2007, while capital expenses increased 450%.

Methodology

Specifying how aggressive the expansion of mass transit would be to evaluate this strategy was a challenge. Therefore, we decided to create three scenarios based on the percentage of the population that would switch to mass transit: modest, medium, and aggressive. The WFRC's adopted "Regional Transit Plan: 2007–2030" (RTP) projects mass transit growth to reach 5.6% by 2030. Our modest scenario is short of the RTP target, while our aggressive scenario reaches about twice that growth rate.

Our spreadsheet approach simply calculates the VMT that switch to transit each year and converts reductions in miles driven to gallons of gas saved based on EIA's 2007 Annual Energy Outlook[118] forecast for light-duty stock fuel efficiency (miles per gallon). Saved gallons are converted to avoided CO_2 emissions based on gasoline emissions rate of 19.4 lbs/gal.[119]

We do not include calculation of increased emissions from increasing bus and rail service as the extent and mix of this is highly uncertain, and the State and BRAC had not chosen particular implementations to evaluate. In addition, we have not captured the avoided emissions from reducing congestion, which would have required a more sophisticated analysis than time permitted. That said, the RTP estimates that 1.27 gallons of gas are saved per car-hour of avoided congestion.[120] Another study of national transit benefits

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[116] Weber, Davis, and Utah counties have passed similar tax measures in the past.
[117] Ibid., i.
[118] http://www.eia.doe.gov/oiaf/archive/aeo07/index.html.
[119] EPA. *Emission Facts: Calculating Emissions of Greenhouse Gases: Key Facts and Figures*, February 2005. EPA420-F-05-003. http://www.epa.gov/otaq/climate/420f05003.pdf (accessed Sept. 2008).
[120] Ibid.

estimates that public transportation overall leads a 43% reduction in CO_2e missions over personal vehicles, taking into account transit emissions as well as reduced congestion.[121] Because many factors will depend on the sort of transit scenarios Utah chooses to pursue, we recommend further study to zero in on the exact emissions effects of various transit growth scenarios.

Overall assumptions included the following:[122]

- Only 80% of total VMT are within reach of any mass transit program.
- Commuting comprises 30% of Utah VMT.
- Another 30% of Utah's non-committing VMT can be reached by a transit program.
- By 2030, 5%, 12%, and 24% of commuting VMT switch to transit in the conservative, medium, and aggressive scenarios, respectively.
- By 2030, 5%, 9%, and 12% of non-commuting VMT within reach of program switch to transit in the conservative, medium, and aggressive scenarios, respectively.

Strategy Benefits

Table T-1. Vehicle miles traveled (VMT) and emissions ($MtCO_2e$) avoided from state promotion of mass transit.

	2020		2030	
	VMT (millions)	$MtCO_2e$	VMT (millions)	$MtCO_2e$
Modest	148	61,300	289	114,000
Medium	283	117,000	607	240,000
Stretch	468	194,000	1,040	412,000

This strategy also offers the following benefits:

- Congestion reduction. UTA transit currently removes 2% of personal vehicles from the roadways overall, and 4.5% of personal vehicles during peak times when congestion is highest. This translates to about 42,000 fewer vehicle trips (21,000 round trips) daily.[123] This congestion reduction trend should continue and become more valuable as the number of drivers and miles rise over time.
- Job creation. The capital investments necessary for transit expansion will create construction and technology jobs in Utah, and presumably the infrastructure created will be an asset to the community.

[121] Davis, T. and M. Hale. *Public Transportation's Contribution to U.S. Greenhouse Gas Reduction*, SAIC, Sept. 2007. Accessed Sept. 2008. http://www.apta.com/research/info/online/documents/climate_change.pdf.
[122] Assumptions reached in consultation with UTA, personal communication with Mick Crandall, March and April 2008.
[123] Ibid.

Strategy Costs

The cost of increasing transit use was is captured in this analysis. Because it is uncertain how this strategy would be implemented, we recommend a focused analysis of the costs and most effective options for switching drivers to transit, should the State decide to prioritize transit. Furthermore, as with emissions, the cost calculation will be affected by which other transportation strategies are pursued.

Implementation Ideas

To ensure success, mass transit options must be convenient, reliable, and affordable. These objectives could be achieved by doing, for example, the following:

- expanding or improving existing programs or creating new ones to reach a greater number of potential transit riders, e.g., by expanding the UTA Eco Pass program, which allows employees of participating companies to ride TRAX or buses;[124]
- increasing utilization of existing programs, e.g., by educating the general public about transit options or providing incentives for increased utilization of mass transit; and
- creating more desirable services, e.g., by making the capital investments necessary to increase the reliability of the bus and light rail systems.

To be successful from a cost/benefit standpoint, the mass transit options must maintain adequate ridership. Optimized fares and enhanced subsidies will help encourage an optimal ridership rate; a detailed analysis should be undertaken to determine the optimum rates for daily fare and monthly passes. An audit of the UTA published in 2008 identified deficiencies in the collection of rider data.[125]

Mass transit also requires the cooperation and development skills of the federal, State, and local governments. The federal government provides grants for many of the capital expenses, though those grants have declined in recent years (prior to the American Recovery and Reinvestment Act of 2009). The State could assist with the coordination of transit plans, obtaining rights-of-way, and traffic signal priority. Local governments can sponsor rider initiatives and promote transit-oriented growth. Options that compliment mass transit, such as those referred to in the Trip Reduction strategy, including shared-ownership vehicles (e.g., Zipcars, Freedom cars), bike carriers, and pedestrian-friendly city planning, should be evaluated concurrently.

Mass transit is a long-term strategy that will be most successful if developed in conjunction with quality growth land-use planning principles. A long-term strategy will need to be adaptive to changing rider preferences, population shifts on the Wasatch Front, and emerging economic factors. This strategy will also require adequate and consistent funding to meet aggressive goals.

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[124] http://www.rideuta.com/ridingUTA/payingFare/discounts.aspx.

[125] Office of the Utah Legislative Auditor General, *A Performance Audit of the Utah Transit Authority*, Jan. 2008, 8–16. http://www.le.state.ut.us/audit/08_03rpt.pdf.

Trip Reductions, Rideshare, Vanpool, Telecommuting (TL-4)

BRAC priority: High
BRAC bin: A
BRAC final vote: 20
Analysis method: Spreadsheet analysis
Avoided carbon emissions (by 2030): Up to 3.4 $MMtCO_2e$

Strategy Background

The current Employer-Based Trip Reduction Plan is designed to reduce ambient ozone within Davis and Salt Lake Counties (Utah Administrative Code [R307-320]). The program calls for reducing commuters' VMT collectively by 20% in companies with over 100 people. The program specifically sets a goal of reducing the "drive-alone rate" by 20% based on the 1990 census data for modes of travel in each county.[126]

UTA Rideshare is a program, focusing primarily on Salt Lake City, which offers a number of services that commuters can take advantage of independently. These programs may be offered through their employers to incentivize alternative commuting options. These programs include:

- Discount Pass Programs. An Eco-Pass is a company-sponsored annual transit pass that a company provides to each employee. Pricing is determined by UTA based on the number of employees and other factors.[127] In 2007, over 50 employers provided Eco-Pass to their employees (collectively approximately 19,000 employees). The related programs ED Pass (for educational institutions) and MED Pass (for medical facilities) had enrollments of 164,000 and 8,600, respectively, in 2008.[128]
- Vanpools. UTA Rideshare offers an interest-free van purchasing program for commuters willing to drive other commuters to work each day. Savings may be approximately $3,500 to $5,000 over the cost of a dealer-financed van.[129] Over 400 vans are now leased through this program, many of which are leased by government and military facilities in the area.[130]
- UTA Guaranteed Ride Home Program. This program supports the Eco-Pass Program and the UTA Van Lease Program by providing a free ride home to the program's participants in the event of an emergency.[131]
- Commuter Choice. This UTA program allows employers to provide up to $115 per month (or up to $1,380 per year) in eligible transportation costs tax-free to an employee for use on public transit

[126] http://www.airquality.utah.gov/Air-Quality-Board/Packets/2005/July-05/pdf/X/X.e.pdf (accessed Sept. 2008).
[127] http://www.rideuta.com/ridingUTA/payingFare/discounts.aspx (accessed Sept. 2008).
[128] http://www.wfrc.org/cms/UPWP/UPWP-09.pdf (accessed Sept. 2008).
[129] http://www.utarideshare.com/etc/reports.htm.
[130] http://www.wfrc.org/cms/UPWP/UPWP-09.pdf (accessed Sept. 2008).
[131] http://www.utarideshare.com/programs/guaranteedRideHome.htm.

buses, trains, and vanpools.[132] The incentive behind this program is that the eligible commuter costs are paid for on a pre-tax basis either by the employer or employee.

- Carpooling. UTA Rideshare helps Utah commuters find carpool partners through its computerized matching service.[133]
- Bicycling. UTA supports bicycle commuting by equipping every UTA bus with a bicycle rack and by allowing bicycles on TRAX trains.[134]

Methodology

We evaluate this strategy an expansion of the Employer-Based Trip Reduction Plan. We evaluate employers with over 100 employees, based on size and location, for program cost, VMT reduction potential, and employee cost benefit.

Based on census data for Davis, Salt Lake, Utah, and Weber counties, there were 1,100 establishments with over 100 employees and they are segmented into size classes of 100–249, 250–499, 500–999, and 1,000 or more. [135] We evaluate three scenarios which differ by the degree of establishment participation in an expanded trip reduction plan: the low case assumes 5%, the medium case 20%, and the high case 40% participation. By applying these percentages, we calculate the number of participating establishments in each size class for each scenario.

We use the Best Workplaces for Commuters (BWC) Business Savings Calculator[136] to estimate the annual costs to employers, benefits to employees, and VMT reductions. This model includes trip reduction strategies such as incentivizing transit use, vanpooling, walking, cycling, and telecommuting. Input data specific to the four-county study area was drawn from a conversation with UTA employees, including the estimate that 80% of area businesses are located in the central business district and the other 20% in suburban office parks. The model was run eight times, each for four size classes (using the midpoints 175, 375, 750, and 1,200) at either of two employer locations.

To calculate the effects of this strategy over time, we assume that firms grow at 2.44% annually. We use a 5% discount rate to calculate present value of employer costs plus employee benefits. As with the previous strategy, we convert avoided VMT to avoided gallons using EIA's 2007 AEO light-duty vehicle stock fuel efficiency forecast, and gallons to CO_2 using the GHG emissions rate (19.4 lbs/gallon).

[132] http://www.utarideshare.com/programs/CommuterChoice.htm.
[133] http://www.utarideshare.com/programs/Carpool.htm.
[134] http://www.utarideshare.com/programs/Bicycle.htm.
[135] Utah: 2004 County Business Patterns, CBP/04-46, June 2006. http://www.census.gov/prod/2006pubs/04cbp/cb0400aut.pdf (accessed Sept. 2008).
[136] This model was developed by the U.S. EPA. http://www.bestworkplaces.org/resource/calc.htm (accessed May 2008).

Strategy Benefits

The benefits to employees outpace the program costs for this strategy under all three scenarios. Employee benefits include the value of incentives encouraging alternative commuting means and gas and auto maintenance cost savings. Potential employer benefits would be parking cost savings, building space cost savings, a reduction in recruitment/training costs, and by some accounts even increased worker productivity.

Table T-2 shows BWC calculator parameters and results for the central business district. Annually all of the costs, VMT reductions, and benefits are added up across all the eligible establishments to arrive at total strategy effects for each of three scenarios. Avoided VMT and emissions are shown in Table T-3.

Table T-2. Annual values from BWC business savings calculator.

	Central Business District			
Number of employees in establishment	175	375	750	1,200
Reduction in # driving	58	130	250	400
Net employer cost	($70,000)	($153,000)	($311,000)	($497,000)
Benefits to employees	$156,000	$336,000	$671,000	$1,076,000
Cost-benefit	$86,000	$183,000	$360,000	$579,000
Reduced commute VMT per establishment	348,000	726,000	1,452,000	2,009,000

Table T-3. Avoided Vehicle Miles Traveled (VMT) and associated CO_2 emissions.

	2020		2030	
	VMT (millions)	$MtCO_2e$	VMT (millions)	$MtCO_2e$
High	305	155,000	388	198,000
Medium	152	77,400	194	98,800
Low	38	19,300	48	24,700

Strategy Costs

Costs to employers are incentive costs, administrative costs, equipment costs for home offices and bicycle racks/lockers. Over the study period, cumulative undiscounted employer strategy costs are $177, $708, and $1,416 million for low-, medium-, and high-participation cases. Cumulative undiscounted employee benefits exceed costs and are $383, $1,531, and $3,062 million, respectively.

Implementation

Utah may wish to strengthen its current Employer-Based Trip Reduction Program to provide greater GHG and air quality benefits. This strategy may be achieved by requiring employers to undertake a number of steps, including performing a survey of its employees and formulating and implementing a trip reduction plan. The trip reduction plan may include strategies such as employer-subsidized transit passes, telecommuting programs, work-site parking fee programs, or on-site daycare facilities.

As the BRAC noted, the challenge with crafting programs for trip reduction, such as those recommended in the SIP, is in meeting employees' diverse and changeable needs. Furthermore, a program such as the

SIP requires substantial support from the responsible government agency for approving plans and monitoring participation.

Clean Car Program (TL-9)

BRAC priority: High
BRAC bin: B
BRAC final vote: 16
Analysis method: MOBILE6 Vehicle Emission Modeling Software
Avoided carbon emissions (by 2030): up to 83 MMtCO_2e

Strategy Background

California's Assembly Bill 1493 (Pavley Bill), passed in 2002, set forth the nation's first law addressing automobile GHG emissions. As directed by the legislation, commonly called the "Pavley Law," the California Air Resources Board (CARB) developed regulations to achieve the maximum feasible cost-effective reduction of GHG emissions from passenger vehicles.

These resulting standards, applicable to all new passenger cars and light trucks beginning in the model year 2009, require a 23% fleetwide GHG emission reduction by 2012 and a 33% reduction by 2016 (Pavley Phase I Rules). Planned implementation of revised, more stringent standards will increase the minimum reduction requirement to 43% by 2020 (Pavley Phase II Rules). The CARB elected to incorporate the Pavley regulations into the state's existing Low Emission Vehicle (LEV) program. Taking on LEV structure, the Pavley rules establish two separate fleet-average standards, one for passenger cars/light trucks and SUVs (PC/T1), and another for heavier trucks and SUVs (T2).[137]

The California standards incorporate four main global warming emissions elements: 1) GHGs from direct vehicle exhaust, 2) CO_2 from air conditioner operation, 3) refrigerant system efficiency and emissions reductions, and 4) "upstream" emissions associated with fuel production and distribution. In addressing these concerns, rather than requiring radical changes in vehicle manufacturing, the Pavley rules emphasize off-the-shelf emissions reductions technologies that are available today or are expected to become available in the future. Regulated automakers are allowed the flexibility to choose any combination of technologies across their vehicle fleets in satisfying fleetwide emission requirements.

Other states have followed California's lead in this area. So far, 17 states have adopted or have announced plans to adopt the California regulations.[138] States that join the Western Climate Initiative (WCI) commit to adopting California's vehicle emissions standards.

[137] Assembly Bill (A.B.) 1493. http://www.arb.ca.gov/cc/ccms/documents/ab1493.pdf.

[138] These 17 states are Arizona, California, Colorado, Connecticut, Florida, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, and Washington. California's standards are also being considered by Minnesota, Nevada, Tennessee, and Texas. See Pew Center on Global Climate Change, *States Poised to Adopt California Vehicle GHG Standards* at http://www.pewclimate.org/what_s_being_done/in_the_states/vehicle_ghg_standard.cfm.

Under the federal Clean Air Act (CAA), California may set its own motor vehicle emissions standards, provided that those standards are at least as stringent as the federal standards and are authorized by a waiver from the EPA.[139] Other states may then adopt California's standards.

Despite the many waivers granted to California in the past, significant litigation has challenged California's Pavley regulations. Car makers sued California in 2004, challenging the state's authority to regulate vehicle emissions. The state of Vermont was sued but prevailed, with the judge finding that the regulations were not invalid, while the state of New Mexico was sued in December of 2007, with the outcome still pending.

In 2007, the Supreme Court ruled that the EPA has power to regulate GHGs, and a Federal District Court ruled that the California standards are feasible and not preempted by federal fuel economy standards.[140] Nonetheless, in December 2007, the EPA denied California's request for a waiver. In January 2008, California filed a petition in the Ninth Circuit Court of Appeals to challenge the EPA's denial, and 17 states joined California in its petition.[141] After continued wrangling in 2008, President Obama directed the EPA to review the denial of California's waiver request in January 2009. Based upon this review, the EPA ultimately granted a waiver on June 30, 2009.[142] Almost concurrently, the Obama Administration announced that it will propose GHG emissions standards for light-duty vehicles.[143] Under a deal developed in consultation with the major automobile manufacturers, the United Auto Workers, environmental groups, and several states, EPA and the U.S. Department of Transportation will develop emissions and fuel economy standards that harmonize with the provisions of the Pavley I GHG tailpipe standards by 2016. As a result, all U.S. states—including Utah—will effectively implement this policy option. Although this policy shift occurred after this analysis was completed, the analysis results are still valuable in that they show the GHG reduction potential associated with the adoption of GHG tailpipe standards as compared to a business-as-usual approach.

The maximum GHG emissions reductions under this strategy will not be fully realized until older vehicles (those sold before the new emissions regulations were enacted) are gradually replaced by newer vehicles. Thus, this is an option from which it will take many years to realize the full benefits.

Methodology

We project GHG emissions from Utah vehicles using EPA's MOBILE6 Vehicle Emission Modeling Software. The Utah Division of Air Quality (DAQ) uses this model for emissions inventory development, air quality control strategies (e.g., inspection and maintenance programs or use of alternative fuels), and evaluation of special fleets. DAQ came up with a reference case that closely matches the Utah Emissions

[139] Fuel efficiency standards may only by set by the federal government.

[140] Massachusetts v. EPA, 549 U.S. 497 (2007); Central Valley Chrysler-Jeep, Inc. v. Goldstene, 2008 U.S. Dist. LEXIS 23909 (E.D. Cal 2008).

[141] Office of the Attorney General, State of California, California's Motor Vehicle Global Warming Regulations. http://ag.ca.gov/globalwarming/motorvehicle.php.

[142] http://www.epa.gov/OMS/climate/ca-waiver.htm.

[143] http://www.epa.gov/OMS/climate/regulations/420f09028.pdf.

Inventory using stock, turnover, fuel, and emissions characteristics that are current for Utah's version of MOBILE6 as of spring 2008. During the course of this project the Energy Independence and Security Act of 2007 (EISA) was adopted. The new CAFE standards that were a part of EISA are not included in the reference forecast; however, for the sake of comparison we also use MOBILE6 to evaluate the new CAFE standards within this strategy.

A number of significant aspects of evaluating Pavley with MOBILE6 are briefly described below:

- Timing. The calculations in this strategy are based on the California standards but are delayed three years, in light of the fact that California does not yet have a waiver and that Utah would still need legislation to implement these standards. Thus, implementation of the standards in Utah would begin with model year 2012 and end with model year 2019.
- Applicability. The model applies the standards to light-duty gasoline passenger vehicles and trucks up to a gross vehicle weight rating (GVWR) of 8,500 lbs, which is less than the 10,000-lb GVWR under the California standards, a difference accounting for about 4% of vehicle miles traveled (VMT) in Utah.
- Turnover. Vehicle turnover is estimated based on vehicle age data from the DMV, categorized by county and vehicle type.
- Vehicle type. Utah applied vehicle type mix "VMT fractions" data that were based on the MOBILE6 data for years 2012 through 2030. We modified the MOBILE6 data to conform to local vehicle axle count data prepared by the Utah Department of Transportation. The MOBILE6 model predicts an increase in the fraction of large passenger vehicles, such as SUVs, through 2020. Changes in consumer preferences in response to fuel prices may mean that the model overstates emissions and benefits (though this may be true for the reference scenario as well).
- Reference scenario. The baseline for the model uses pre-2007 CAFE standards.
- MPG/CO_2e. There is a high correlation between fuel economy in miles per gallon (mpg) and emissions. For most vehicles, the relationship is linear, though the relationship is curvilinear when including all vehicles (including heavy-duty vehicles). One reason for the relatively smaller fuel savings under Pavley in Utah compared to California is that Utah developed its own correlation between CO_2 emission factors (EF) and fuel economy (mpg) based on the Pavley CO_2 standards. California reported that 2020 model-year passenger cars and light duty trucks (PC/LTI) achieve a CO_2 EF of 175 grams per mile, which corresponds to a fuel economy of 50.8 mpg. Utah's correlation showed only 40.9 mpg at 175 grams per mile.
- *Scenarios*. Two alternative emissions scenarios, Pavley and 2007 CAFE, are compared to the reference case.
- *Phase II*. The Phase II Pavley targets are not included in this analysis. Phase II targets would lead to significant additional post-2020 avoided emissions.

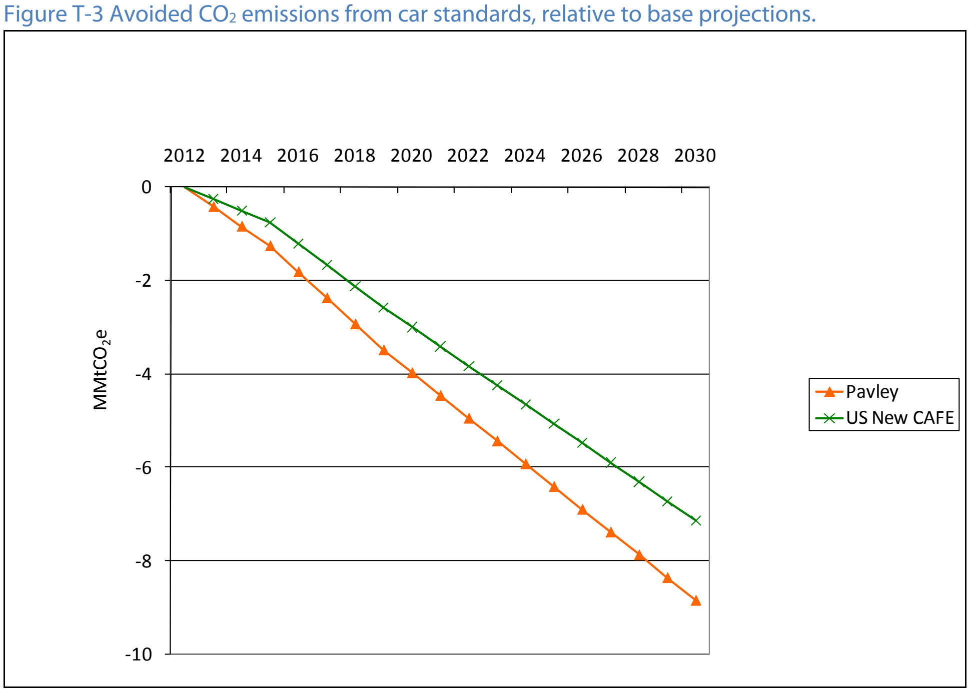
Strategy Benefits

This strategy has a high potential for avoiding CO_2 emissions, cost savings, and associated energy security and air quality benefits. According to the MOBILE6 model, and based on the assumptions and inputs described above, CO_2 emissions in Utah under the California standards would be 19% less than under the old CAFE standards by 2019 and 40% less by 2030. By contrast, CO_2 emissions will be 14% less under the new CAFE standards than the old CAFE standards by 2019, and 32% less by 2030. Emissions results are compared in both Table T-4 and Figure T-3 below:

Table T-4. Annual Utah vehicle emissions: baseline, Pavley, and EISA.

Year	Old CAFE ($MMtCO_2e$/year)	Pavley ($MMtCO_2e$/year)	% reduction (relative to old CAFE)	2007 CAFE ($MMtCO_2e$/year)	% reduction (relative to old CAFE)
2012	16.1	16.1	—	16.1	—
2015	17.3	16.0	7.5%	16.5	4.6%
2019	18.7	15.2	18.7%	16.1	13.9%
2030	22.3	13.5	39.5%	15.2	31.8%

Figure T-3 Avoided CO_2 emissions from car standards, relative to base projections.



Other benefits of this strategy include:

- Cost benefits. In the Utah Energy Efficiency Strategy analysis, adopting Pavley was found to be highly cost-effective. They found that savings in fuel costs over the lifetime of the projected eligible vehicles sold in Utah would equal about $1.41 billion (present value). At 2006 price levels, this led to a net economic benefit of $1.16 billion (2006 dollars) over the life of the vehicles purchased in 2009–2015,[144] and if fuel prices stay above 2006 levels then the benefits would be even higher. Because of substantial cost-offsetting benefits, Utah can expect this strategy to yield a net positive effect on its economy. Lower-cost clean car technologies will provide for significant savings across Utah's economy; savings from reduced fuel costs alone would be $1.41 billion.[145] With projected savings ($ 1.41 billion) well above state investment expenditures ($250 million), Utah should realize a large net economic benefit ($1.16 billion).[146] Actual net benefit to Utah may considerably greater; the above analysis doesn't consider the economic benefits of increased personal income and employment as well as other associated cost-offsetting factors. New technology demand and operating cost savings benefit Utah economy. California estimates an $8.5 billion increase in personal income and 83,000 new jobs by 2030.[147] Savings on operating costs translate into expenditures on other goods/services.

- Energy security. If the California standards were applied by Utah, 291 million gallons of fuel would be saved per year by 2019 (compared to 236 million gallons of fuel saved per year under the new CAFE standards). By 2030, 687 million gallons of fuel would be saved per year under the California standards (compared to 590 million gallons of fuel saved per year under the new CAFE standards).

- Air quality. California's vehicle standards are aimed at vehicle emissions, not just fuel efficiency. Thus, many pollutants besides CO_2, such as NO_x, SO_x, ozone, and benzene, which can cause asthma and other human respiratory illnesses, will be diminished. CARB estimates reduced emission of hydrocarbons and NO_x by as much as 10 tons per day in 2030.[148] Furthermore, because passenger cars and light trucks are such a large segment of emissions in Utah, reducing vehicle emissions will facilitate compliance with the Clean Air Act and other statutes and regulations, thus reducing regulatory pressure on businesses and industries in Utah.

In other studies conducted in several western states, the adoption of a clean car program has consistently been ranked as one of the most cost-effective GHG emissions reduction strategies. This option is expected to have a large impact on total emissions, with projections ranging from 1.9% to 6.5% of total statewide emissions.

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[144] This assumes an average 15-year vehicle life and that gasoline prices remain at their 2006 levels. This cost savings figure is likely conservative due to the likelihood of sustained increased fuel costs.
[145] Ibid.
[146] Ibid.
[147] CARB Staff report, 158.
[148] UEES Report.

Strategy Costs

As part of its technology evaluation, CARB estimated for California the average fleetwide incremental cost of control to meet the Pavley GHG emission standards.[149] Their cost estimates take into account the phase-in of the standard and the specific starting point of the six largest individual manufacturers. We assume here that Utah's program will begin in 2012, but CARB thought that the introduction of these technologies by manufacturers would begin in 2009 to coincide with California's regulations. Therefore, the additional cost of a new vehicle in Utah will coincide with the CARB annual cost of control estimates, beginning in 2012.

Table T-5. Increased cost of new vehicles due to Pavley standards.

		Average cost of control	
Tier	Year	PC/LDT1 (Passenger cars and small trucks/SUVs)	LDT2 (Large trucks/SUVs)
Near-Term	*2009*	*$17*	*$36*
(Utah strategy	*2010*	*$58*	*$85*
assumes that	*2011*	*$230*	*$176*
regulations will not begin for 3 years, so these CARB estimates will begin 3 years later)	2012	$367	$277
Medium-Term	2013	$504	$434
	2014	$609	$581
	2015	$836	$804
	2016	$1,064	$1,029

Source: California Environmental Protection Agency Air Resources Board, 2004.

[149] California Environmental Protection Agency Air Resources Board. 2004. Report to the Legislature and the Governor on Regulations to Control Greenhouse Gas Emissions from Motor Vehicles. http://www.arb.ca.gov/cc/reports/ab1493_legreport.pdf.

- California has estimated that the clean car standards will add about $1,000 to the cost of a new car (though California also estimates that savings to the consumer over the life of the vehicle will be about $2,500). Some have argued that CARB's estimates are overly optimistic. For example, auto manufacturers estimate that the added costs will be greater.
- An initial cost consideration is compliance costs which will be borne by consumers in the form of higher vehicle prices. Increasing stringency will elevate vehicle prices over time. [150]
- New technologies will provide for significant decreases in fuel and operating costs, which are expected to fully offset compliance costs and actually generate savings among individual consumers.
- Studies predict average consumer savings of $5–11 per $1 in costs, with individual savings as high as $2,000 or more possible over vehicle lifetimes.[151]
- Expected payback times, even at gasoline prices that were current in 2006, are considerably short (1.2 to 3.1 years in California) and will continue to shorten as gas prices go up.[152]
- Reductions in gasoline tax revenues represent a significant initial government cost.
- For Utah, compensating tax losses will require an estimated investment expenditure of approximately $250 million.[153]
- Higher sales taxes due to increased vehicle costs may partially offset the impact of reduced gas tax revenues.

Implementation Ideas

- The current strategy does not contemplate any corresponding fiscal support programs such as the California Clean Car Discount Act (CCCDA, A.B. 493).
- Incorporation of CCCDA feebates could lead California to achieve 25% greater GHG reduction than it could with the Pavley standards alone.[154]
- Given the expected trends in transportation sector growth, further action to control transportation sector emissions may be necessary in the future. Accordingly, the current strategy should provide for ongoing assessment and, to the extent feasible, allow for amendment and/or addition of new standards where advisable.

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[150] California Air Resources Board (CARB), Staff Report on Climate Change, August 6, 2004, 150. http://www.arb.ca.gov/regact/grnhsgas/isor.pdf.
[151] Ibid., 158.
[152] California Clean Cars Campaign, Factsheet. http://www.calcleancars.org/factsheets/staffproposal.pdf.
[153] UEES Report.
[154] "California's Clean Car Program Would Cut Pollution, Save Drivers Money," *Science Daily*, May 24, 2007. http://www.sciencedaily.com/releases/2007/05/070521174955.htm.

Idle Reduction Program (TL-10)

BRAC priority: High
BRAC bin: B
BRAC final vote: 18
Analysis method: spreadsheet
Avoided emissions (by 2030): 12,000 tons CO_2 (school buses); 859,000 tons (heavy-duty trucks)

Strategy Background

School buses

In 2006, a strong school bus idle reduction program began in Utah through Utah Clean Cities and the National Energy Foundation (as well as other partners, including the Nevada Office of Energy). The Department of Education gave a $100,000 grant to develop a student curriculum and bus driver training program. The program is being implemented in three pilot school districts: Cache County, Washington County, and Salt Lake. The Utah Board of Education has already adopted the curriculum into its standards; it is anticipated that the curriculum will be applied to all Utah school districts in the near future. (Plans are underway to expand it nationwide as well.) Expansion to other school districts should be of minimal to no cost, as the model curriculum and training materials will be available for free from the Clean Cities Coalition. As of February 2008, over 400 bus drivers in Utah had received the training and pledged to reduce their idling by at least five minutes per day. Broad support for the program is reported, in part because of its focus on education and voluntary pledges rather than fines.[155]

The U.S. EPA's Clean School Bus USA program provides implementation information (e.g., posters) and a sample school bus idling policy.[156] The program notes that in addition to an education-based approach (such as the Utah Clean Cities initiative described above), there are other options, such as 1) upgrading ("retrofitting") buses with better emission-control technologies and/or fueling them with cleaner fuels and 2) replacing the oldest buses in the fleet with new, less-polluting buses.

Heavy-Duty Trucks

Most of the idling for trucking occurs overnight and at the loading/unloading point. To allow drivers to turn off their engines while at rest stops, two categories of technologies can be applied: on-board systems and truck stop electrification.

On-board systems are devices installed on the truck that allow the driver to utilize the technology at any location. These include the following:

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[155] Robin Erickson, Director Utah Clean Cities, personal communication, March 2008.
[156] http://epa.gov/cleanschoolbus/antiidling.htm (accessed Sept. 2008).

- Auxiliary power units. These are small diesel engines installed on a truck to supply air conditioning, heat, and electrical power.
- Automatic engine shut-down systems. These sense sleeper temperature and automatically turn the engine on when the sleeper is too warm or cold.
- Fuel-fired heaters. These provide heat to the cab and the engine block, while using only a fraction of the fuel that would be used by idling the vehicle's primary engine. These kinds of systems are available from some manufacturers as factory options or can be retrofitted on existing trucks.

Truck stop electrification requires installation of technology at a truck stop. Using single system electrification, no additional technology may be required on the truck. In single systems, heating, ventilation, and air conditioning (HVAC) systems are contained in a structure above the truck parking spaces. A hose from the HVAC system is connected to the truck window, and a computer touch screen enables payment to the company operating the equipment. To accommodate the HVAC hose, a window template must be installed in the truck. The Shore Power (on-board) Systems provide electrical outlets that trucks can plug into, but in order to do so, the truck must be equipped with an inverter to convert 120-volt power, an electrical HVAC system, and the hardware to plug into the electrical outlet.

One truck stop in Utah, the Sapp Brothers Travel Center in Salt Lake City, has installed truck stop electrification. In 2007 the travel center was retrofitted to provide power to 51 semi-truck parking spaces using a plug-in window adapter. This pilot project was a cooperative effort between IdleAire—the device's manufacturer—and the Utah Department of Transportation. UDOT funded 80% of the project's installation cost. At a cost of $850,000 this project is estimated to save $580,000 per year and 175,000 gallons of diesel.[157]

During the BRAC process, the Farm Bureau was concerned that in rural areas, there might be limited electrification, leading to "unintended consequences" or harm for farmers.[158] Such a concern would be higher if this strategy were implemented through a state-wide anti-idling regulation that did not take such considerations into account.

Methodology

For school bus idling, a spreadsheet analysis was used to calculate total idling time and emissions per bus. This analysis assumes 180 days of school, 32 minutes of idling per day,[159] and 2,424 school buses (the number currently serving Utah schools). After implementing this strategy, idling is expected to be

[157] Information on this case study, including the quick fact data, is drawn from the Utah Energy Efficiency Strategy, 107-8.
[158] Blue Ribbon Advisory Council on Climate Change: Report to Governor Jon M. Huntsmen Jr., October 2007. http://www.deq.utah.gov/BRAC_Climate/final_report.htm.
[159] CARB estimates school bus idling. http://www.arb.ca.gov/msei/onroad/latest_revisions.htm#sbus_idle (accessed Sept. 2008).

reduced only when loading and unloading at school, leading to almost 15 minutes less idling and 1/8 of a gallon less of diesel consumed per bus. A CO_2 emission factor of 4.7 kg/hour was used for school buses.[160]

For the heavy-duty truck idle reduction program, this analysis assumes the use of off-board electrification systems. While on-board systems may be less expensive, Utah cannot control what equipment is on out-of-state trucks that enter Utah.[161] We assume Utah would build 1,250 spaces over five years, with truck spaces being used on average 12 hours per day. The CO_2 emissions factor of 22.2 lbs/hour was used for heavy-duty trucks[162].

Strategy Benefits

After all 1,250 spaces are built, heavy-duty trucks would avoid 45,000 metric tons of CO_2e each year. Avoided emissions for school buses are much smaller—about 560 metric tons of CO_2e per year. Other benefits include the following:

- reduced air pollution (particularly particulate matter and nitrogen oxide)
- less noise
- health benefits due to lowered exposure to air and noise pollution (especially for school children and truck and bus drivers)
- cost savings from lower fuel use

Strategy Costs

School buses

Reducing school bus idling requires no new technology. Further, the Utah Clean Cities school bus program has already covered, through the federal grant, the startup costs for a program that likely can be implemented statewide. Therefore, costs for this program are expected to be minimal, unless the nature of the strategy is changed from the behavior-based one that is currently being pursued. (Alternative strategies range from retrofitting school buses with anti-idling technology to purchasing new buses that run on an alternative fuel.)

Fuel savings at $4.00/gallon leads to an annual savings of $216,000. Obviously, fuel prices have swung widely throughout the study period of this report. It is uncertain whether the lower prices of today will prevail or whether we will return to higher prices of the recent past.

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[160] Hearne, J. "School Bus Idling and Mobile Diesel Emissions Testing: Effect of Fuel Type and Development of a Mobile Test Cycle," Rowan University, Department of Mechanical Engineering, Draft M.S. Thesis, Oct. 2003. http://users.rowan.edu/~marchese/hearne041004.pdf (accessed Sept. 2008).
[161] UEES Report.
[162] NESCAUM, 2002. GHG Case Study, The Hunts Point Truck/Trailer Electrification Pilot Project. http://www.nescaum.org/projects/greenhouse-gas-early-action-demonstration-project/greenhouse-gas-case-studies/huntspointghgcase.doc/.

Heavy-duty trucks

Federal financing may be available, for example through the US EPA's SmartWay Transport Partnership, which provides affordable loans to owner-operators and small trucking companies for the installation of "upgrade kits."[163]

Overall cost savings of $3.3 million per year by 2014, assuming diesel at $4.00/gallon and cost of electrification $1.50/hour.

Implementation Ideas

The BRAC Report concluded that "a school and school district program should be the priority due to the low cost, ease of implementation through district networks, high visibility, large impact, and significant co-benefits." Though there would be GHG emissions reductions associated with decreased school bus idling, the program's most appealing benefits may be the health impacts for students.

Possible implementation approaches include the following:

- *A statewide anti-idling rule*. This approach could apply to heavy-duty trucks and/or school buses. Alternatively, municipal anti-idling rules could be implemented, as has been done already in Salt Lake City, Salt Lake County, and Park City.
- *A statewide school bus anti-idling campaign*. Continued state support for the expansion of the Utah Clean Cities' anti-idling education and training program into remaining Utah school districts. The program could be bolstered through state support of additional measures, such as the retrofitting of buses with anti-idling technology.
- *Promotion and expansion of anti-idling technology deployment for heavy-duty trucks*.
    - Truck stop electrification (to support off-board technology)
        - The Utah Energy Efficiency Strategy Report recommends the creation of a low-interest loan program to support installation of electrification technology in Utah truck stops.
    - Technology in trucks (e.g., auxiliary power units)
        - The EPA SmartWay Transport Partnership provides financing to truckers for installation of the technology. The EPA is looking for state partners for assistance in offering these financing opportunities.
        - A grant program in Wisconsin, through the state's department of commerce, is providing freight motor carriers with funding to cover up to 50% of the purchase and installation costs of idling reduction units for newer truck tractors.[164]

[163] http://www.epa.gov/smartway/index.htm.
[164] http://www.commerce.state.wi.us/BD/BD-CA-Diesel-Grant-Program.html.

Awardees are selected at random from the pool of applicants, from the program's 2007–2008 total available funding of $2 million.

- *An idle reduction education program*.
    - This approach overlaps with the BRAC strategy of Education Program (TL-13).
    - The current school bus idle reduction efforts center primarily on education, rather than funding or mandate. Such an approach is likely more appropriate for school and other municipal buses, or other short-distance transport vehicles (including personal vehicles). While education could provide a component of an approach to lower idling in long-distance trucks, adoption of new technology becomes more important here because of drivers' energy-generation needs at rest stops.
- The program could be implemented through voluntary or mandated idling times.

Combination of Transportation Policies

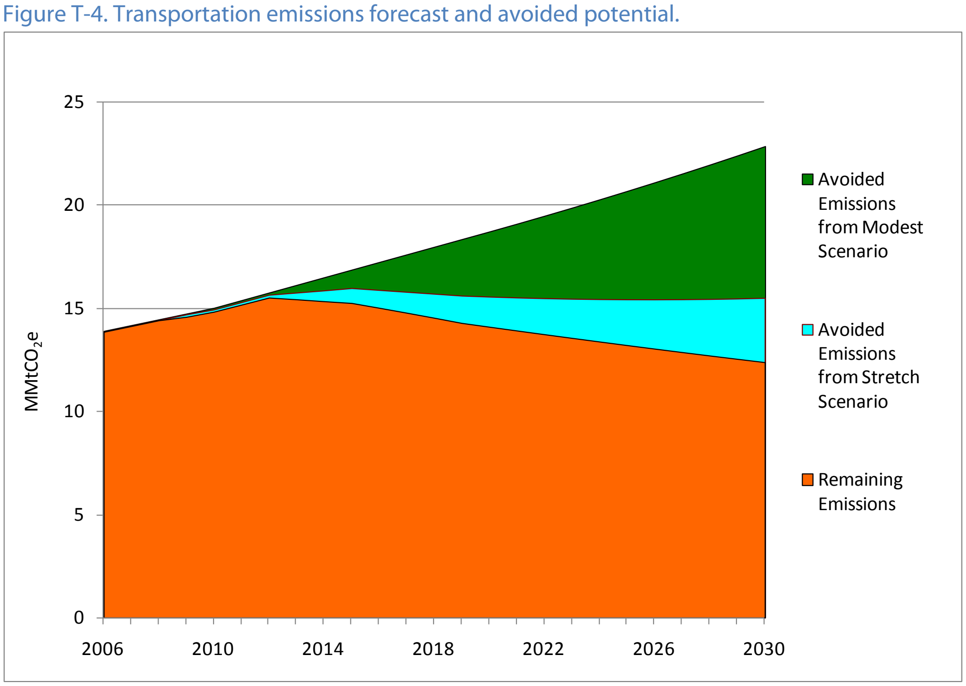
Modest combined scenario
Analysis method: spreadsheet analysis and MOBILE6
Avoided emissions (by 2020): 13 $MMtCO_2e$
Avoided emissions (by 2030): 67 $MMtCO_2e$

Stretch combined scenario
Analysis method: spreadsheet analysis and MOBILE6
Avoided emissions (by 2020): 21 $MMtCO_2e$
Avoided emissions (by 2030): 98 $MMtCO_2e$

Methodology

For a timely consideration of emissions reduction potential, we limit the number of combinations of strategies to be evaluated to two. The modest and stretch scenarios for transportation both include policies for fuel economy standards, idle reduction, mass transit, and employer-based trip reduction programs. The idle reduction policy is the same in modest and stretch scenarios, while the other three are represented in different ways. The modest scenario combines the avoided emissions from new CAFE standards, and the modest analyses of trip reduction and mass transit. Meanwhile, the stretch scenario represents the adoption of California Clean Car standards, and avoided emissions from stretch version of employer trip reduction and aggressive mass transit, as well a carbon cap. When added up, the combined transportation stretch and modest scenario forecasts are shown relative to the reference forecast in Figure T-4 below. As we have previously reminded the reader, we are presenting results in a range, precisely because of the uncertainties related to degree of overlap and the ability to reach the target penetrations.

Figure T-4. Transportation emissions forecast and avoided potential.



Transportation emissions in this analysis only consider those from gas and diesel. (Jet fuel and others are considered as part of "other emissions" in this report.) The transportation strategy with the highest avoided emissions potential is the Clean Car Program (TL-9). Table T-6 shows the components of stretch and modest transportation policy suites and the avoided potential associated with each component. We have chosen a slowly rising elasticity of emissions reductions to represent the affect of a carbon cap on transportation emissions. We do not estimate overlap between emissions standards and Mass Transit or Trip Reduction policies, as the amount is rather small especially before 2025.

Table T-6. Summary of transportation policy avoided GHG emissions.

In $MMtCO_2e$	2020		2030	
	Modest	Stretch	Modest	Stretch
Mass transportation	0.06	0.19	0.11	0.41
Trip reduction	0.02	0.15	0.03	0.20
CAFE or	2.99	–	7.13	–
Pavley	–	3.96	–	8.83
Idle reduction	0.04	0.05	0.05	0.05
Carbon cap ($25 allowance)	NA	+5% (0.22)	NA	+10% (0.95)
TOTAL	3.12	4.58	7.31	10.43

COMBINATION OF POLICIES ACROSS ALL SECTORS

Modest combined scenario
Avoided emissions (by 2020): 64 $MMtCO_2e$
Avoided emissions (by 2030): 235 $MMtCO_2e$

Stretch combined scenario
Avoided emissions (by 2020): 172 $MMtCO_2e$
Avoided emissions (by 2030): 561 $MMtCO_2e$

In this section, we will briefly explain how we put all of the sectoral analyses together to come up with a total range for avoided emissions potential. Other emissions, while not called out in this report, have a small potential included in this final synopsis. For the stretch scenario, jet fuel was considered to improve by 20% (in line with the Governor's efficiency goals).

For the strategies as defined in this report, the likely avoided emissions fall into the range shown in Figure C-1 (between the bold lines). Our work attempts to deal with the inherent uncertainty by evaluating a range for the depth and success of implementation of the strategies. Modest interpretations of these strategies are combined to form the combined modest policy emissions trajectory. Likewise, "stretch" interpretations of each of the 16 strategies are combined to form the combined stretch policy emissions trajectory. The solution space between the lines is the emissions range that we believe the State can reach before considering additional measures.

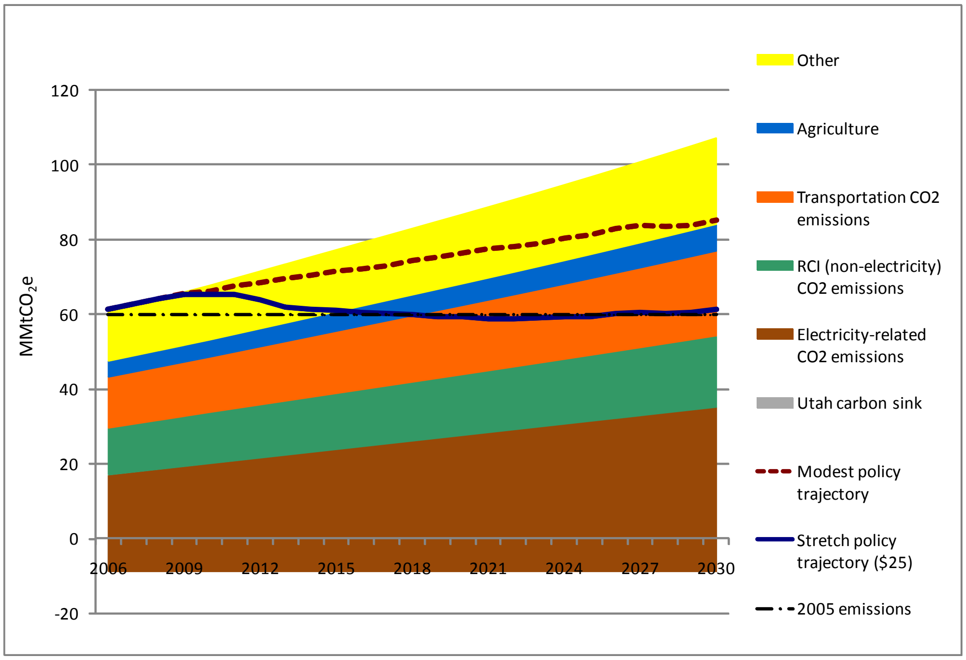
The avoided emissions attributed to each sector are summarized below in Table C-1. Overlapping measures across sectors have been deemed to be small. This table shows that stretch policies lead to more than twice the avoided emissions as modest policies do.

Table C-1. Summary avoided emissions from combined measures.

In $MMtCO_2e$	2020		2030	
	Modest	Stretch	Modest	Stretch
RCI (natural gas)	1.0	1.7	1.3	3.1
Electricity (RCI & ES)	5.7	20.4	12.7	31.1
AF	1.2	1.2	1.8	1.8
TL	3.1	4.6	7.3	10.4
Other (jet fuel)	–	0.5	–	0.6
Total	11	28	23	47
% less than reference	13%	32%	21%	43%

When these avoided emissions are overlain on the initial Utah emissions forecast from the inventory, the result is Figure C-1. A modest program would reduce the emissions growth rate by almost half over the next ten to twenty years, while the stretch program would reduce emissions below current levels and keep them close to 2005 levels over the next 20 years. Of course, based on economics and demographics, we expect Utah to continue growing beyond 2030. Therefore, over the next ten years, the State should reassess longer-term policies (such as CCS and California Car Standards) to determine whether the future avoided emissions are still likely to satisfy longer-term goals.

Figure C-1. Utah GHG emissions forecast, overlain with avoided potential.



The gray area ("Utah carbon sink") is not visible as it is behind the brown area ("Electricity-related CO_2 emissions") in the portion of the chart that is below zero. This is done in order to illustrate how sinks and sources offset each other.

The strategies with the largest avoided emissions potential are clean car, carbon capture and sequestration, energy efficiency, renewable portfolio standards, and a carbon cap. The State has been working on all of these, which is commendable, but achieving significant avoided emissions will take continued focus and energy.

For now, Utah's GHG emissions reduction target is to reach 2005 GHG emissions levels by 2020. This analysis indicates this is within the solution range without adding any other policy. Of course, to keep track of the State's progress, it will be imperative to follow the implementation of the carbon cap. Recall, for our work, we assume a $25 allowance price adjusting for inflation, but this is our best estimate, and is highly uncertain. Once a cap is set, it would be wise to revisit allowance price uncertainty and its effect on avoided emissions. Some of the other important caveats to remember to build off this work in a constructive manner are listed below.

- Reference projections should be re-evaluated. If they turn out to have been high, it will be easier to reach 2005 targets, and vice versa.
- Some of the strategies may require legislative action, while others require effective programs and education.

- Even though these analyses may seem deterministic, the timing and program design are non-trivial and will determine the extent of avoided emissions from each strategy.
- Avoided electricity emissions should be quantified in a consistent manner when evaluating progress. This is essential because of the impacts of electricity imports/exports and the regional nature of the electricity grid (i.e., electricity flows freely across state lines).
- Electricity emissions will be affected by actions that other states take. Therefore, coordinated approaches are more likely to lead to larger avoided emissions.
- Emissions reduction measures associated with the "other emissions" category should be further evaluated. Progress in this emissions category may reduce the need to achieve the amount of avoided emissions from the policy options analyzed in this report, or can help to attain greater emissions reductions.
- Emissions are temporally important. Going forward, emissions are likely to continue to increase without further action. As such, further emissions reduction measures will be necessary to keep emissions from rising in synch with energy demand.
- The other 56 strategies were not left out because they are not important. The enabling strategies (e.g., GHG registry, Research and Development, Education Program) in particular should be considered early in the process by the State as they may be critical towards facilitating the adoption of other measures.

In June 2008, Governor Huntsman announced Utah's GHG emissions reduction goal of reducing GHG emissions to 2005 levels by 2020. This report illustrates that this goal is feasible. We say this although this report examined a subset of the policy options recommended by the BRAC and although the BRAC put forward a subset of the universe of potential emissions reduction measures. Furthermore, given the rate of technological innovation, there is a subset of approaches that currently are unknowable but yet potentially helpful in meeting the State's emissions reduction goal. In sum, there are a large number of measures the State may take to meet its goals. This is not to say that achieving these goals will be easy or cost-free. It undoubtedly require focused effort, but we have little doubt that the State's goal is reasonable and obtainable.

Lastly, we note that currently Congress and the Administration are exploring various avenues to regulate greenhouse gases with both new and existing legislation. We are optimistic that the Governor's efforts to think about what sorts of strategies make sense for Utah both politically and economically will show returns as federal climate policies emerge in the future.



An Evaluation of Utah's Greenhouse Gas Reduction Options

An analysis performed by the
Nicholas Institute for Environmental Policy Solutions
for the State of Utah

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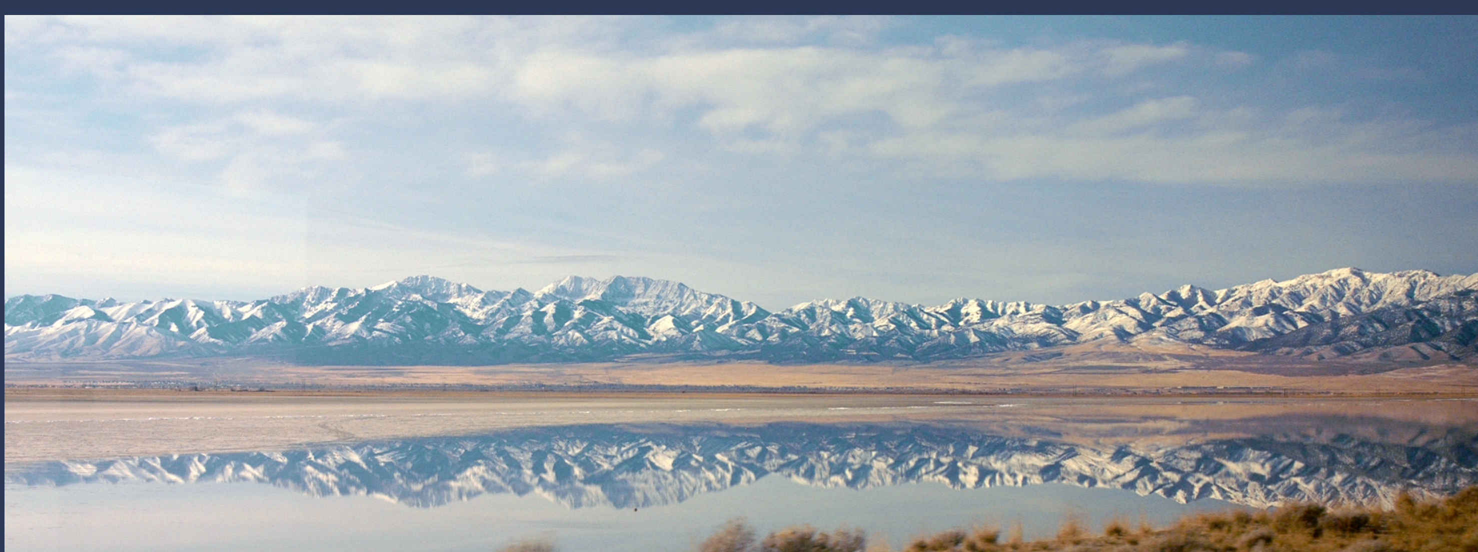



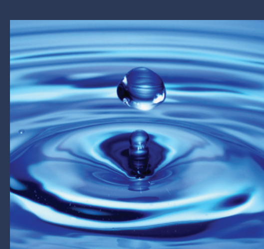

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