ASSESSMENT OF LIFESTYLE IMPACTS OF ALTERNATIVE SAMI AIR QUALITY STRATEGIES

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INTRODUCTION

This study is a qualitative assessment of potential impacts on household lifestyles of strategies developed by the Southern Appalachian Mountains Initiative (SAMI) to improve air quality in eight southeastern states. The lifestyles assessment is part of a broader integrated assessment that addresses the steps needed to complete a full examination of incremental air quality improvements. The major areas of the integrated assessment include atmospheric modeling, emission inventory development, environmental effects, socioeconomics, and policy recommendations. This study is one element of the socioeconomics area.

PURPOSE

The purpose of this study is to assess qualitatively the effects of implementing the SAMI strategies on the well-being of households residing in the SAMI region. Improving air quality requires restrictions on emission generating activities of both consumers and producers. Restricting consumer activities affects household well-being directly because individuals must seek alternatives to activities (including the consumption of goods and services) that are targeted by emission reduction strategies. Restricting the activities of producers affects households' well-being indirectly through effects on prices and employment.

Air quality improvements resulting from implementing the SAMI strategies are also likely to affect lifestyles. Examples include potential improvements in health, visibility, and opportunities for recreation. Some of these benefits have been estimated and described in other components of SAMI's integrated assessment and are not described further in this report. Instead, we focus on how restrictions on both consumer and producer activities affect lifestyles.

We emphasize that our assessment of the SAMI strategies is qualitative. We do not provide quantitative measures of lifestyle impacts in this report.

Strategies B1 and B3

SAMI is assessing two emission reduction strategies, B1 and B3. Both strategies call for emission reductions from a wide variety of sources including mobile onroad, mobile nonroad, area, and industrial point sources. Both strategies also call for reduced emissions generated by both consumer and producer activities. SAMI plans a phased in implementation period, with larger emission reductions occurring over time through the year 2040. In general, strategy B3 calls for larger emission reductions than strategy B1.

Benchmark Years of Assessment

SAMI is assessing the impacts of strategies B1 and B3 for two future benchmark years, 2010 and 2040. Ideally, our assessment should be conducted relative to a baseline that includes the effects of future "on the way" strategies that are planned by other agencies outside the scope of the SAMI initiative. We emphasize that establishing this baseline is difficult and that there is some overlap between elements of the SAMI strategies and emission reduction strategies planned by other agencies. To the extent that this overlap exists, we will overstate the impacts of the SAMI strategies.

SUMMARY OF FINDINGS

The following is a brief summary of our findings. We provide more detailed descriptions of the potential impacts of the SAMI strategies on the well-being of households in Sections 3 and 4 of this report.

Direct Impacts on Consumers

The SAMI strategies affect consumers directly through policies designed to reduce emissions from vehicles and residential fuel combustion. Reduced vehicle emissions are to be achieved by more stringent emission controls for onroad vehicles, the gradual market penetration of onroad zero emission vehicles (ZEVs), reductions in the growth of onroad vehicle miles traveled (VMTs), and substituting ZEVs for nonroad gasoline lawn, garden, and recreational vehicles. Plans for reducing emissions from residential fuel combustion include efficiency improvements for residential natural gas combustion, and substituting natural gas for residential wood and coal combustion. Each of these measures will affects household well-being by requiring changes in consumer behavior. Ultimately, the effects on lifestyles will depend on the relative advantages and disadvantage of the substitute goods and activities. However, to the extent that consumers make informed choices, restrictions on consumer behavior are likely to cause net negative effects on household welfare because the substitute goods and services were not chosen in the first place.

Consumers will incur additional costs associated with higher emission standards for onroad vehicles and replacing conventional vehicles with ZEVs. It is possible that future technological advances will improve the performance of ZEVs. However, given the current state of technology, the performance of ZEVs is inferior to that of conventional vehicles. There are also safety concerns about ZEVs.

From the perspective of consumers, there are both potential advantages and disadvantages associated with strategies to reduce VMT growth rates. Potential advantages include the amenities and lower expense of telecommuting, the lower expense of ridesharing and public transportation, and the convenience of high occupancy vehicle lanes. Reducing VMT growth rates will also reduce highway congestion. Potential disadvantages include possible loss in worker productivity, loss of workplace amenities, the inconvenience of ridesharing and public transportation, lost opportunities to combine commutes with shopping trips and other errands, and the tax burden of subsidies to public transportation. Reducing VMT growth rates may also affect non-commuting activities such as shopping trips and leisure travel. We note that some reductions in VMT growth rates might occur voluntarily. For example, if voluntary telecommuting becomes more widespread in the future, some reductions in emissions from onroad vehicles will occur independently of the SAMI strategies. However, if these voluntary VMT reductions are not sufficient to meet the emission reduction targets of the SAMI strategies, involuntary reductions in VMTs will involve the trade-offs described above.

Nonroad ZEVs have lower operating costs than gasoline vehicles. However, the upfront cost of ZEVs is higher, and ZEVs may, in some cases, have inferior performance relative to gasoline vehicles.

As noted above, the SAMI strategies call for reducing emissions from residential fuel combustion through efficiency improvements for natural gas combustion and substituting natural gas for residential wood and coal combustion in stoves, fireplaces, and furnaces. There are also potential advantages and disadvantages associated with these strategies. The potential advantages include cleanliness, convenience, reliability, and efficiency improvements. Potential disadvantages include the upfront costs of efficiency improvements, the costs of switching to natural gas, and loss of aesthetics and aromatics. Localized unavailability of natural gas supplies is another potential problem.

Indirect Impacts: Price and Employment Impacts

Our analysis of potential price and employment impacts focuses on ten "case study" industries. These include electricity generators, textiles, paper and paperboard, chemicals, primary metals, natural gas transmission, coal mining, liquid fuel providers, and railroads. Each of these industries is expected to be affected by the SAMI strategies.

The SAMI strategies have the potential for causing price increases in the following industries: electricity generators, textiles, paper and paperboard, chemicals, primary metals, and natural gas transmission. Each of these industries is expected to incur higher production costs and may attempt to pass on some of these costs through price hikes. We emphasize, however, that their ability to do so will be limited by the availability of substitutes and by competition from producers outside the SAMI region.

Coal prices are more likely to decrease than increase. The demand for coal is likely to fall because the SAMI strategies call for switching away from coal combustion to fuels with lower emissions, particularly natural gas.

Price effects for railroads, trucking and liquid fuel providers are uncertain. The demand for rail services is likely to increase because of converting truck traffic to rail. However, this effect will be offset, at least partially, by lower demand for coal traffic. The trucking industry is expected to incur increased operating costs because of higher emission standards and conversion to heavy duty ZEVs. These higher costs will tend to increase prices in the industry. In contrast, converting truck traffic to rail will decrease demand for trucking services, and tend to depress prices. The demand for liquid fuel will likely fall because of market penetration of ZEVs and reductions in VMT growth rate. However, the reduction in demand, especially under strategy B3, is substantial enough to change the structure of the industry, reduce spatial competition, and possibly increase distribution costs. Accordingly, we conclude the effects of the strategies on liquid fuel prices are uncertain.

Employment losses resulting from the SAMI strategies could occur in the following industries: electricity generators, textiles, paper and paperboard, chemicals, and primary metals. As noted earlier, each of these industries is expected to incur higher production costs as a result of the strategies. Higher prices could reduce the demand for their products, causing firms to reduce output and employment. Also, some firms in these industries could become unprofitable and close down operations.

Employment losses in the coal mining, liquid fuel provider, and trucking industries are also possible because of reduced demand. The trucking industry is also expected to experience higher operating costs as a result of the strategies.

The employment impacts on the natural gas transmission and railroad industries are uncertain. As noted earlier, the natural gas transmission industry is expected to incur higher operating costs. However, the demand for transmission services is likely to increase as a result of fuel switching strategies. Railroads will pick up new traffic diverted from trucking, but are likely to lose coal traffic.

Of the ten case study industries, projected baseline employment for the SAMI region is largest in the trucking industry. However, employment in the coal mining industry is concentrated largely in two states, Kentucky, and especially West Virginia. This raises the potential for adverse impacts on local economies.

While our analysis focuses on employment losses, we note that the SAMI strategies are also likely to generate some positive employment impacts. Examples include potential employment gains in the tourist industry (due to improved air quality) and increases in employment associated with manufacturing, installing, operating, and maintaining emission controls. While some of the employment gains from emission controls might be temporary, such as those associated with one-time retrofitting, other employment gains associated with operating and maintaining equipment will be more long lasting.

Comparison of Strategies B1 and B3

Across all sources, strategy B3 calls for larger emission reductions than B1. As a result, we expect that strategy B3 will have larger negative impacts on households.

Temporal Issues

Because SAMI is evaluating the effects of the strategies in two future benchmark years, 2010 and 2040, it is useful to summarize temporal issues related to our assessment of impacts on households. Restrictions on consumer activities and price impacts tend to be smaller in the long run. Over time, consumers have better opportunities to adapt and to find substitutes for higher priced goods and services. Employment effects also tend to diminish over time. While durations of unemployment spells are likely to vary considerably depending on individuals' circumstances, the economy tends to absorb available labor resources in the long run. We note, however, that some of the replacement jobs, like some of those in the service sector, might pay lower wages than jobs lost in mining and manufacturing. Also, employment impacts may be exacerbated in the long run if producers outside the SAMI region, both domestic and abroad, increase capacity in industries affected by the strategies.

Another temporal issue involves how the impacts of the SAMI strategies change over time. Both strategies B1 and B3 call for progressively larger emission reductions over time, suggesting larger impacts on households. However, estimates of incremental costs relative to on the way strategies planned by other agencies decline between 2010 and 2040 for some affected emission sources. Specifically, estimated incremental costs for electricity generators and other point sources fall between 2010 and 2040 under strategy B1. This suggests that the incremental price and employment effects attributable to strategy B1 might decline between 2010 and 2040 for these industries.

Finally, we note the considerable uncertainty in assessing impacts for the future. Uncertain technological advances could mitigate some of the impacts of the strategies by providing more environmentally friendly consumer goods and more efficient low-emission production technologies. Consumer preferences also change over time, making it difficult to assess, even qualitatively, the effects of strategies that place restrictions on household behavior. The pace at which agencies outside the SAMI region adopt strategies for emissions generated by producers is also uncertain. Potential controls on producers outside the SAMI region are another source of uncertainty. The employment impacts of the SAMI strategies are likely to be mitigated if producers outside the region face similar emission controls.

ORGANIZATION OF REPORT

Section 2 of this report provides background information including a description of the SAMI strategies and how they affect consumers and producers. In Section 3, we assess the potential impacts of those elements of the strategies that place restrictions on consumer activities and goods. We assess potential indirect effects of changes in prices and employment in Section 4. Finally, the appendix to this report provides industry definitions for the baseline employment projections in Section 4.

SECTION 2

BACKGROUND

The discussion that follows provides background information that is useful for interpreting the results of the analyses that follow in later sections of this report. Immediately below, we describe the purpose of the lifestyles analysis and explain the role it plays in an integrated assessment of policies designed to improve air quality. Next, we provide a brief summary of the SAMI strategies. In the final part of this section, we present a taxonomy that distinguishes how various elements of the SAMI strategies might affect lifestyles.

PURPOSE OF THE LIFESTYLES ANALYSIS

The purpose of this analysis is to provide a qualitative description of the changes in lifestyles that might occur *as a result of the implementation* of the SAMI strategies. Policies designed to improve air quality affect households' welfare by reallocating resources. Specifically, additional resources are allocated to the production of cleaner air while other resources are diverted from the production of goods and services. This reallocation of resources creates both benefits and costs for households. Examples of benefits associated with cleaner air include improved health, better recreational opportunities, and improved visibility. Examples of costs (or adverse consequences) include income losses from unemployment (caused by disruptions in labor markets), the consequences of higher prices for consumer goods and services, and restrictions on household behavior (e.g., limits or bans on burning wood in stoves or fireplaces).

Benefit-cost analyses are often conducted to assess the economic efficiency of strategies to improve air quality. In theory, benefits should be measured as society's willingness-to-pay for the beneficial effects of improved air quality. Costs, on the other hand, should be measured as society's willingness to accept the loss in goods and services forgone as a result of diverting resources to producing cleaner air. A strategy that produces benefits in excess of costs is said to be economically efficient in the sense that the beneficiaries of cleaner air *could potentially* compensate those who incur costs and still be better off.

In practice, however, the compensation scheme described above does not typically occur. Because the benefits and costs associated with policies aimed at improving air quality are not evenly distributed among members of society, a benefit-cost analysis is not sufficient for a complete assessment of the consequences of policies designed to improve air quality. The distribution effects of the policies should also be considered. This lifestyles analysis is intended to partially fill this gap. Specifically, we focus primarily on the adverse distributional impacts that might be incurred by households from implementing the SAMI strategies, and not the benefits of cleaner air. These adverse impacts can be characterized as "lifestyle changes".

The negative focus of the lifestyles analysis should not be construed as suggesting that the SAMI strategies will not improve some aspects of households' lifestyles. Indeed, several of the analyses conducted as part of SAMI's overall evaluation focus on impacts that will improve household welfare. These include studies of the effects of the strategies on fishing and hiking, visibility, and ecosystems. We also emphasize that, apart from the benefits of improved air quality, implementing the SAMI strategies may have some positive effects on lifestyles. Examples of these include increased employment from producing, installing, operating and maintaining emission controls, and reduced highway congestion resulting from strategies to reduce onroad vehicle use.[1]

Finally, we emphasize that this lifestyles analysis is, by design, *qualitative.* Our objective is to give policymakers a sense of the types of lifestyle changes that might occur as a result of the SAMI strategies. However, we do not provide quantitative estimates of lifestyle impacts.

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[1] See Sections 3 and 4 of this report for a discussion of these potential effects.

SUMMARY OF SAMI STRATEGIES

The SAMI strategies are broad-based in that they target a wide range of economic sectors and activities and several pollutants.[2] Currently, SAMI is assessing two strategies, which it refers to as B1 and B3. Strategy B3 is the more stringent of the two in that it calls for larger reductions in emissions relative to baseline conditions. As a result, we expect that B3 will generally result in larger changes in lifestyles than B1. SAMI has selected two future benchmark years, 2010 and 2040, for its assessment of the B1 and B3 strategies.

Table 2-1 provides a summary of the economic sectors and activities targeted by the SAMI strategies. For example, one targeted sector is onroad mobile sources. The SAMI strategies call for light-duty vehicle (LDV) emission standards, reductions in growth rates of LDV vehicle miles traveled, sulfur limits on heavy-duty vehicle (HDV) diesel fuel, and HDV emission standards. As Table 2-1 indicates, other targeted sectors include non-road mobile sources, area sources, industrial point sources, and electricity generators.

TAXONOMY OF POTENTIAL EFFECTS ON LIFESTYLES

Some of the goods that consumers purchase and use, and some of the activities in which they engage generate emissions and contribute directly to air quality degradation. Purchasing an automobile and driving it to work is one example. Some aspects of the SAMI strategies target these emission generating goods and activities. These elements of the strategies will potentially affect lifestyles directly by changing the nature of goods that consumers can purchase and use (e.g., requiring or encouraging consumers to purchase low or zero emission vehicles), or by banning or limiting activities (e.g., banning wood burning in stoves or fireplaces).

[2] See Pechan (2001a) for an emissions inventory of the SAMI region.

Table 2-1

SUMMARY OF SECTORS AND ACTIVITIES TARGETED BY SAMI STRATEGIES

EMISSION SOURCE
MOBILE SOURCES—ON-ROAD
Light-Duty Vehicle (LDV) Emissions Standards
LDV Reduction in Vehicle Miles Traveled (VMT) Growth Rate
Heavy-Duty Vehicle (HDV) Diesel Fuel Sulfur Limits
HDV Emission Standards
MOBILE SOURCES—NON-ROAD
Airport Service Equipment
Gasoline Lawn and Garden and Recreational Vehicles
Gasoline Sulfur Limits for Nonroad Engines/Vehicles
2007 Highway Vehicle Standards Applied to Nonroad Engines/Vehicles
Zero Emission Technology for Nonroad Engines/Vehicles
Clean Aircraft Engines
AREA SOURCES
Area Source Fuel Combustion (NOx, SO2)
Other Area Sources (PM10, PM2.5, Ammonia, VOC)
INDUSTRIAL POINT SOURCES
Industrial Boilers
Gas Turbines
Internal Combustion Engines
Cement Kilns
ELECTRICITY GENERATION SOURCES

Source: Pechan (2001a)

Consumers also contribute to air quality degradation indirectly in that the production of some goods and services they purchase generate emissions (e.g., emissions generated in the production of electricity for industrial use). Many elements of the SAMI strategies target emission generating industries. These elements of the strategies are likely to affect lifestyles indirectly. Reducing emissions generally requires producers to incur costs. Producers will attempt to pass on at least some of these costs to consumers by way of higher prices, thereby affecting lifestyles indirectly by reducing the purchasing power of households' incomes.[3] In some cases, producers may reduce output levels or shutdown operations altogether. This will generate unemployment (at least temporarily), reduce income for some households, and indirectly necessitate lifestyle changes.

In the discussion that follows below, we develop a taxonomy in which we characterize the various elements of the SAMI strategies according to whether they target consumer behavior directly or whether they will affect consumers indirectly by targeting producers of goods and services. While this taxonomy is useful for characterizing the potential effects of the strategies on lifestyles, we note it is not always clear cut. In particular, some elements of the strategies are likely to affect both consumers and producers. The taxonomy follows the major headings shown in Table 2-1.

Taxonomy of Effects: On-road Mobile Sources

Table 2-2 is an application of the taxonomy described above for elements of the SAMI strategies that target on-road mobile sources. The first column in this table lists the SAMI strategy element; the second column identifies the economic sector—consumer or producer—that is directly targeted by the strategy element.[4] For example, one part of the SAMI strategies calls for reducing emissions from light-duty vehicles (LDVs) by a phased-in requirement for vehicles to satisfy "Phase 2 Standards"[5] and phased-in market penetration of zero-emission vehicles (ZEVs). These elements of the strategy target the consumer sector directly in that they change the nature of goods that consumers can

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[3] Some aspects of the SAMI strategies that target consumers directly may also cause consumers to pay higher prices for goods and services. For example, estimates show that zero-emission vehicles (ZEVs) are more expensive than conventional vehicles. Thus, encouraging or requiring consumers to switch from conventional automobiles to ZEVs will increase the price that consumers pay for personal transportation. See Section 3 of this report.

[4] The SAMI strategy elements are taken from Pechan (2001a).

[5] See Pechan (2001b) for a discussion of Tier 2 Standards.

Table 2-2

SUMMARY OF SECTOR IMPACTS: ON-ROAD MOBILE SOURCES

Strategy Element	Sector Directly Targeted
LIGHT-DUTY VEHICLE (LDV) EMISSIONS STANDARDS	
Tier 2 Standards	Consumer*
Zero Emission Vehicles	Consumer*
LDV REDUCTION IN VEHICLE MILES TRAVELED (VMT) GROWTH RATE	
Regional Telecommuting Options	Consumer
Ridesharing	Consumer
Employee Transit Passes	Consumer
High Occupancy Vehicle Lanes	Consumer
Employee Commute Option Programs	Consumer
HEAVY-DUTY VEHICLE (HDV) DIESEL FUEL SULFUR LIMITS	Producer
HDV EMISSION STANDARDS	
2007 Emission Standards	Producer
Shift Heavy Duty to Rail	Producer
Zero Emission Vehicles	Producer

Note: * Direct effects on some producers are also possible.

purchase and use.[6] The second element of the SAMI strategies listed in Table 2-2, reducing the growth rate of vehicle miles traveled, also affects consumers directly in that it affects household travel patterns.[7] Since some LDVs are used for business purposes, LDV emission standards and reductions in the growth rate of VMT will also directly affect some producers. Also, as we explain in Section 4 of this report, reducing VMT growth rates may affect producers to the extent that it affects business activities. Note

[6] Note that these elements of the strategies indirectly affect producers to the extent that they affect the market faced by vehicle manufacturers.

[7] Some reductions in the future VMT growth rate may occur voluntarily. If this occurs, some reductions in emissions will occur independently of the SAMI strategies. We discuss this issue later in Section 3 of this report.

that measures listed in Table 2-2 focus reducing VMTs in commuting to the workplace. It also possible that the strategies will result in some reductions in non-commuting VMTs will occur (e.g., leisure travel, shopping trips, and other errands).

The final two elements of the strategies listed in Table 2-2 deal with reducing emissions for heavy-duty vehicles. Since these vehicles are used primarily for business purposes, we identify the producer as the sector most likely to be affected directly. As a result, these elements of the strategies are likely to have indirect impacts on lifestyles.

Taxonomy of Effects: Non-road Mobile Sources

Table 2-3 shows the economic sectors targeted by SAMI strategies to reduce emissions from non-road mobile sources. Strategies to increase market penetration of non-road zero emission vehicles and to reduce sulfur levels in gasoline for lawn, garden, and recreational vehicles will target the consumer sector directly. Some direct consumer impacts are also possible for strategies to reduce emissions from diesel engines and aircraft.

Taxonomy of Effects: Area Sources

Table 2-4 summarizes sector impacts for strategies designed to reduce emissions from area sources. Reducing residential wood burning will directly affect the consumer sector. Strategies to reduce emissions form natural gas and to encourage fuel switching from coal to natural gas will affect both consumer and producer sectors. Other strategies to reduce emissions form area sources primarily target the producer sector.

Table 2-3

SUMMARY OF SECTOR IMPACTS: NON-ROAD MOBILE SOURCES

Strategy Element	Sector Directly Targeted
AIRPORT SERVICE EQUIPMENT Zero Emission Vehicles (ZEVs)	 Producer
GASOLINE LAWN & GARDEN AND RECREATIONAL VEHICLES Zero Emission Vehicles (ZEVs)	 Consumer
GASOLINE LAWN & GARDEN AND RECREATIONAL VEHICLES, AND MARINE VESSELS Reduce Gasoline Sulfur Levels	 Consumer
ALL DIESEL ENGINES, DIESEL COMMERCIAL MARINE VESSELS, DIESEL RECREATIONAL MARINE VESSELS, AND DIESEL LOCOMOTIVES Reduce Diesel Sulfur Levels	 Producer*
DIESEL CONSTRUCTION, FARM, LOGGING, INDUSTRIAL EQUIPMENT, AND COMMERCIAL MARINE ENGINES 2007 Highway Vehicle Engine Standards	 Producer
SPARK IGNITION, COMPRESSION IGNITION, MARINE, AND LOCOMOTIVE ENGINES ZEVs	 Producer
AIRCRAFT Clean Aircraft Engines	 Producer*

Note: * Some direct consumer impacts possible.

Table 2-4

SUMMARY OF SECTOR IMPACTS: AREA SOURCES

Strategy Element	Sector Directly Targeted
INDUSTRIAL NATURAL GAS COMBUSTION	
Efficiency Improvements	Producer
Low-NOx Burner and Other Technologies	Producer
Fuel Switching, Efficiency, Technology Improvements	Producer
COMMERCIAL & RESIDENTIAL NATURAL GAS COMBUSTION	
Efficiency Improvements	Both
Mitigation Measures Including Fuel Switching, Efficiency, Technology Improvements	Both
RESIDENTIAL WOOD COMBUSTION	
Public Awareness and Education, and Mandatory Curtailment	Consumer
Switch to Natural Gas Logs	Consumer
UNPAVED ROAD DUST	
Paving	Producer*
Chemical Stabilization	Producer*
INDUSTRIAL, CHEMICAL, & RESIDENTIAL COAL COMBUSTION	
Conversion to Natural Gas	Both
FUGITIVE DUST (Mining & Construction)	
Site Watering, Chemical Treatment, Wind Barrier Fencing, Bans on High Wind Days	Producer
AGRICULURAL CROPS	
Soil Conservation Plans	Producer
Mitigation Measures	Producer
AGRICULURAL LIVESTOCK	
Treating Access Roads and Feed Lane Access Areas	Producer
MANAGED BURNING	
Increase Fuel Moisture	Producer
Mitigation Measures	Producer

Table 2-4 – Continued

Strategy Element	Sector Directly Targeted
OPEN BURNING	
Restrictions or Bans	Producer**
LIVESTOCK	
Chemical Additives	Producer
Mitigation Measures	Producer
FERTILIZERS	
Public Awareness, Education, Voluntary Management	Producer
Mitigation Measures	Producer
ALL CHEMICAL & ALLIED PRODUCTS	
Control of Process Vents	Producer
Control of Equipment Leaks	Producer
ALL SOLVENT USE	
Reformulation	Producer
STORAGE AND TRANSPORT	Producer

Note: * Responsibility for controlling dust on public roads will fall on state and/or local governments.
** Some direct consumer impacts possible.

Taxonomy of Effects: Industrial Point Sources

All of the SAMI strategies aimed at reducing emissions from industrial point sources will, of course, target the producer sector directly. Table 2-5 lists these sources.

STUDY LIMITATIONS

Below we identify the major limitations of this study. We urge readers to considers these and other caveats described elsewhere in this report when interpreting the findings of this report.

Table 2-5

SUMMARY OF SECTOR IMPACTS: INDUSTRIAL POINT SOURCES

Strategy Element	Sector Directly Impacted
INDUSTRIAL BOILERS	Producer
GAS TURBINES	Producer
INTERNAL COMBUSTION ENGINES	Producer
CEMENT KILNS	Producer
ELECTRICITY GENERATORS	Producer

Perhaps the most notable limitation of this study is that our assessments are qualitative. We do not provide quantitative estimates of the impacts of the SAMI strategies, but instead, qualitatively describe probable effects on households.

SAMI is evaluating the effects of the strategies extended period of time through year 2040. There is considerable uncertainty in assessing the impacts of the various elements of the strategies in the distant future. The pace of technological development is a major source of uncertainty. As we note on several occasions in this report, technological advances might produce more effective and less costly methods of controlling emissions. It is also possible that future technologies will yield new and better substitute products for environmentally unfriendly goods. Examples include less costly and better performing non-road and on-road vehicles that are more environmentally friendly than those currently available. To the extent that this occurs, the negative impacts of the strategies on household will be lessened. Changing consumer preferences over time also complicates our assessment of the impacts of the SAMI strategies on lifestyles.

Our assessment of the indirect effects of the strategies on households, price and employment impacts, is limited to ten case study industries. While these industries have been selected because of potentially large impacts, the SAMI strategies will also affect point sources in other industries. Also, there are likely to be some backward and forward linkages to producers who are either suppliers to or customers of industries that are expected to incur compliance costs.

Finally, our assessment should be conducted relative to a baseline that includes the effects of future “on the way” strategies that are planned by other agencies outside the scope of the SAMI initiative. We emphasize that establishing this baseline is difficult and that there is some overlap between elements of the SAMI strategies and emission reduction strategies planned by other agencies. To the extent that this overlap occurs, we will have overstated the impacts of the SAMI strategies.

SECTION 3

DIRECT CONTROLS ON HOUSEHOLDS

This section examines the economic impacts of direct controls on households. Although regulatory efforts are often focused on producers of goods, there are instances where consumer activities are responsible for degradations in air quality. The demand by consumers for transportation services is a noteworthy example of such activities.

We begin the section with an overview of consumer choice theory. The discussion examines factors that affect choices and, in particular, how choices made by consumers reveal information about their preferences. The basic theory of consumer choice is then extended to consider how consumer decisions may be altered when constraints (such as restrictions on emission generating activities) are imposed. An assessment of lifestyle impacts should consider not only "how" choices are affected, but also describe the likely impacts on households' well being.

These aspects of the effects of direct controls placed on consumers are discussed here in qualitative terms. We identify consumer responses to these constraints as involving consideration of alternative or substitute goods for consumption in lieu of the directly controlled good. We emphasize how such adjustments to external constraints must reduce consumer well being relative to circumstances prior to the controls when consumers, through their economic choices, reveal preferences for goods and activities with particular sets of characteristics. This discussion provides a basis for further qualitative assessment of the potential impact of SAMI strategies on consumers.

CONSUMER CHOICE THEORY

Consumer choice theory is a useful framework for qualitatively assessing the impacts of strategies to improve air quality on consumer lifestyles. Immediately below, we explain how consumers make choices in the marketplace. Next, we examine conditions that result in changes in consumer welfare and how consumers attempt to mitigate losses in welfare. Finally, we describe several strategies for changing consumer behavior in a manner consistent with the goal of improving air quality and discuss the distributional consequences of these strategies.

Consumer Choices in the Marketplace

Consumer theory holds that individuals participate in markets to acquire the satisfaction derived from the consumption of goods and services. Economists commonly refer to satisfaction as "utility". The amount of utility that an individual can obtain is limited by income and time constraints. The role that the income constraint plays is straightforward: it limits the amount of goods and services that the consumer can acquire, and as a result, limits consumer welfare. The time constraint affects consumer welfare by limiting the amount of income that the consumer can earn and by limiting leisure time available for activities that generate utility.

Because of the income and time constraints, the consumer faces complicated choices. He or she must evaluate the amount of satisfaction that can be obtained from a large number of goods and services available in the market, consider the prices of these in relation to available income, and make choices. Consumer choice theory holds that rational consumers select the "basket" of goods and services that generate the most utility. Economists believe that consumers solve this utility-maximization problem incrementally by purchasing, on the margin, the good or service that is the best bargain in the sense that it yields the most extra satisfaction per dollar spent. In short, individuals select the lifestyles that are most desirable to them, subject to their income and time constraints.

The Value of Information

All consumers make regrettable choices because they must make decisions with imperfect information. Uninformed decision-making does not imply irrationality. Rather, information is costly to obtain, often requiring investment in money or time.

Information can also be acquired through experimentation—consumers who try alternative lifestyles by purchasing different goods and services, or by engaging in new activities clearly obtain knowledge that may be useful for making decisions in the future. However, such experimentation is costly, requiring individuals to make monetary outlays and to accept risk. The key point here is that consumer welfare can be improved with knowledge that permits more informed lifestyle decisions.

Lifestyle Changes and Mitigating Behavior

Changes in market conditions facing the consumer can be considered lifestyle-changing events in that they affect consumer welfare by changing the amount of satisfaction that can be obtained. Suppose that the consumer has selected a basket of goods and services from the market consistent with the principle of utility maximization. Suppose further that one of the goods that the consumer has selected (or would have selected) is taken off the market and is no longer available for consumption. The consumer, attempting to mitigate the loss, must now search for a substitute, rearrange his or her choices, and select a new, second basket of goods and services. The question is: What has happened to consumer welfare?

The theory of revealed preference tells us that, unless a perfect substitute is available in the market, the consumer has suffered a welfare loss (i.e., a degradation in lifestyle). We know this because, by selecting the original basket of goods and services, the consumer has revealed his or her preference for it relative to the second basket (since the alternative basket could have been chosen in the first place).[8] The cost to the consumer can be measured as his or her willingness to accept the alternative basket of goods and services instead of the initial selection (or alternatively, the amount of extra income that the consumer would need to achieve the initial level of utility). This cost will clearly depend on the quality of substitute goods available. Note that the consumer would suffer a welfare loss even if the substitute good were less expensive. By not

[8] It is possible that the consumer's initial choice was uninformed and, as a result, the alternative selection leaves the consumer better off. The likelihood as this happening depends on the quality of information that the consumer originally had about the substitute good.

selecting the substitute in the first place, the consumer reveals that the original selection was a better "bargain" in that it provided more extra utility per dollar spent.

We emphasize that revealed preference tells us that the *current* basket of goods and services is preferred to all other available and affordable combinations. However, consumer preferences change over time. The fact that the SAMI strategies will affect *future* choices of goods and services makes it difficult to assess the effects of the strategies on lifestyles, even on a qualitative basis.

The example we have just described, reducing choices available to consumers in the marketplace, is just one example of a market driven, lifestyle-changing event. Changes in the prices of goods and services will also affect consumer welfare. Price increases reduce consumer welfare because, with a fixed income, consumers can afford to purchase fewer goods and services. Consumers also attempt to mitigate the effects of price increases. They do this by adjusting their selections of goods and services by seeking alternative substitute goods, much in the same way that they seek alternatives when goods are no longer available in the market. Price decreases enhance lifestyles because consumers can afford more goods and services, allowing them to acquire higher levels of utility. Finally, increases and decreases in disposable income will, respectively, improve and lower consumer welfare.

Changing Consumer Behavior: Policies to Improve Air Quality

Some of the goods and services selected by consumers generate emissions that degrade air quality. Suppose the goal of the regulatory agency is to change consumer behavior in a manner that is consistent with improving air quality. Several options available to the regulatory agency are:

- Command and Control—the regulatory agency bans outright or limits the consumption of the good or service generating emissions.

- Tax—the regulatory agency imposes a tax on the good or service generating emissions in an attempt to discourage its use.

- Subsidy—the regulatory agency subsidizes the consumption of an environmentally friendly good or service.

- Public Information Program—the regulatory agency implements a public information program informing consumers of the benefits of environmentally friendly substitute goods and services.

Below we describe how each of these regulatory options affects consumer welfare. We acknowledge that consumers' lifestyles will improve to the extent that they enjoy the benefits of improved air quality. However, our primary concern here is the distributional impacts associated with the implementation of regulatory options, and not the effects of cleaner air. Another issue is the effectiveness of the regulatory options. We offer no comments on this issue and assume that the goals of the regulatory agency can be achieved by implementing the regulatory options.

Command and Control

Unless perfect substitutes are available or the consumer's initial choice was uninformed, the command and control option will reduce the consumer's welfare. This follows from revealed preference. If the consumer selects the emission generating good in the first place (i.e., in the absence of the regulatory constraint), the consumer reveals his or her preference for it relative to available substitutes. Of course, this is not to say that the welfare loss need be large. The loss in welfare will be small if the consumer is relatively indifferent to differences in the characteristics and prices of the substitute and original goods. In short, relatively small changes in lifestyles will occur if relatively good substitutes are available.

Taxes on Polluting Goods and Services

Taxes raise the effective prices of emission generating goods and service to consumers. Consumers suffer welfare losses because they must rearrange their choices of goods and services from their initial selections. Note that consumers' welfare falls even if they choose to pay the tax and continue to consume the emission generating good because, with a fixed income, they must reduce expenditures on other goods and services.[9] Again, the loss in welfare will depend on the quality and prices of available substitutes.

The tax option also has indirect distributional impacts. The tax on the polluting good will increase government revenues, thereby enabling it to reduce other taxes or to increase the amount of public goods and services it provides.[10] The net distributional effect among consumers will depend the distribution of tax reductions and how consumers value publicly provided services, the polluting good, and the substitute goods selected after the tax is imposed.[11]

Subsidies on Environmentally Friendly Goods and Services

A subsidy can be viewed as a negative tax. As a result, both the direct and indirect transfer effects of the subsidy are the opposite of those of the tax. Since the subsidy lowers the price of the environmentally friendly good, the subsidy has the direct effect of improving the welfare of consumers who switch away from the polluting good. The improvement in welfare will depend on the size of the subsidy and how the consumer values the attributes of the substitute good relative to the attributes of the polluting good.

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[9] One could argue that because the tax option affords more flexibility to those consumers who place a relatively high value on the polluting good, it is superior to the command and control option. Moreover, those consumers who switch to substitutes are no worse off than they would be under the command and control option.

[10] Of course, government revenues will not increase if the tax is 100 percent effective in eliminating purchases of the good upon which the tax is levied. In this case, nobody pays the tax.

[11] Note that the overall welfare effect of the tax is not neutral, even for a consumer who receives a tax rebate equal to the tax paid on the polluting good. Because the tax has raised the price of the polluting good, the consumer can no longer afford his or her initial basket of goods and services that was revealed preferable to all other affordable combinations.

The subsidy also generates indirect transfer effects. To pay for the subsidy, the government must either raise taxes or reduce spending on public goods and services, thereby reducing the welfare of the public at large.[12]

Public Information Programs

The welfare effects of the public information program depend on the degree to which consumers' initial choices were uninformed. If consumers initially purchased polluting goods because of poor information, then the program will improve the welfare of those individuals who switch to environmentally friendly goods.

The public information program is also likely to involve indirect transfer effects. To pay the costs associated with the program, the government must either raise taxes or reduce spending on other public goods and services.

MITIGATING BEHAVIOR AND APPLICATIONS TO SAMI STRATEGIES

This section describes alternative (or substitute) activities that may be chosen by consumers when regulatory actions constrain their choices and thereby their lifestyles. The alternative choices for specific constraints are identified and the characteristics of the alternatives are described. The alternatives are then evaluated in terms of their potential welfare consequences for the consumer. An extended discussion of these welfare impacts, and the associated distribution effects, is provided for one alternative, telecommuting. The discussion explains aspects of the telecommuting decision that lead to reduced consumer welfare relative to the current situation. The evaluation of welfare impacts focuses on the instruments typically available to regulators for promoting behavioral changes: command and control, taxes, subsidies, and information dissemination. Similar discussions apply to each of the other alternatives mentioned in

[12] Like the tax, the overall welfare effect of the subsidy is not neutral, even for a consumer who receives a subsidy equal to the tax increase. The tax cannot be avoided, but to take advantage of the subsidy, consumers must move from their original baskets of goods and services that were revealed superior to other combinations.

this section. We provide extended discussion only for telecommuting to limit the degree of repetition. The important point is that a regulatory constraint that limits consumers' choices will result in a loss (reduction) in consumer well-being relative to a situation without the regulatory constraint.

Because consumers are generally end-users of manufactured products, most air pollution reduction actions do not directly affect day-to-day consumer activities.[13] An exception is consumer use of vehicles to produce transportation services. Private automobiles and other transportation modes are a part of everyday life for consumers. Vehicles are needed to get to work, shop, recreate and other routine activities. Air pollution control regulations designed to affect consumer transportation decisions are often an important part of an air quality improvement strategy. These strategies may be designed to reduce total vehicle miles traveled by individuals or to reduce the amount of emissions generated per mile traveled. In this section, we identify several approaches used to reduce emissions from consumer transportation. These include incentives to promote behavioral changes in transportation choices, technology changes made to existing vehicle designs, and development of new vehicle types with lower vehicle emissions per mile traveled. Each of these options is explored in the Pechan (2001b) analysis of the emission reduction costs of alternative SAMI strategies.

In terms of the volume of emissions potentially reduced in the consumer sector, mobile source emission reductions are by far the largest. However, there are several other end-use decisions that might also be impacted by regulatory actions. These include the choice of lawn mowers and other gardening/recreational equipment, the use of home wood stoves and fireplaces, and fuel choices for home heating. We also summarize the alternative/substitute choices available to consumers in these other cases, the characteristics of the alternatives and welfare impacts.

[13] Recycling of consumer waste streams is an example of pollution reduction strategies that are more end-user oriented.

Transportation Regulations

We review three types of regulatory approaches that are applied in the mobile source sector:

- Incentives to promote desired consumer behavior.
- Technology changes to the existing vehicle fleet.
- Development of new vehicle emission reduction technology.

Incentives to Promote Desired Consumer Behavior

Incentives to alter consumer behavior have become a preferred approach for achieving regional reductions in the growth rate of vehicle miles traveled (VMT) (Pechan, 2001b and ICF, 2001). Examples of incentive programs that might alter an individual's transportation decision include:[14]

- Encourage telecommuting;
- Provide substitute transportation (busses, trains, subways) with adequate service and reliability;
- Reduce fares on alternative transportation modes;
- Promote ride-sharing programs and infrastructure;
- Provide High Occupancy Vehicle (HOV) travel lanes;
- Introduce road pricing (tolls, marginal cost pricing by time-of-day);
- Increase parking costs;
- Increase the gasoline tax;
- Improve non-motorized transportation infrastructure (sidewalks, bike paths);
- Encourage flextime (Off-hour commuting, decreased work/travel days).

[14] The first five incentives listed are analyzed by Pechan (2001) in terms of the expected cost of emission reductions for selected SAMI emission reduction strategies. All of the listed incentives are identified in ICF (2001) as options for affecting consumer transportation decisions.

These incentives influence individual consumers to select a transportation option that will reduce vehicle miles traveled and therefore emissions. However, establishment of incentive programs by a regulatory agency is not costless. The promotion of telecommuting to realize air pollution reduction benefits is discussed below to demonstrate the consequences of altering individual behavioral choices. The discussion highlights important economic outcomes that impact consumer welfare under alternative regulatory options.

We also note that some of the strategies to reduce VMTs can work against each other. For example, implementing flextime makes ridesharing more difficult because fewer people commute on the same schedule. Also, significant increases in telecommuting reduces public transportation use, causing the fixed costs of the infrastructure to be spread over fewer passengers.

Regional Telecommuting Options

We have emphasized in previous discussions in this report that the welfare effects of policies aimed at altering behavior depend of the quality of available substitutes. In this case, the pollution generating activity is working at a job that involves commuting. The environmentally friendly activity is telecommuting.

As a substitute activity, telecommuting offers several clear benefits to the employee relative to commuting to the workplace. These benefits include:

- Avoiding vehicle operating and maintenance costs associated with commuting;
- Avoiding the aggravation of the commuting experience;[15]
- Avoiding travel time that the employee can spend with family or in other valued leisure activities;

[15] Here we ignore the theoretically possible but unlikely case of an individual who regards the commuting experience as an amenity.

- Potential savings on work-related expenses such as spending on clothing.

However, there are several possible difficulties with telecommuting, including its potential effect on productivity. One could argue, with merit, that telecommuting improves worker morale and, as a result, increases worker productivity. However, in some cases, lack of face-to-face contact with colleagues and clients, and lack of access to equipment, administrative services and other services in the workplace could reduce productivity. Also, the pool of potential telecommuters is limited in that some jobs are not amenable to telecommuting (e.g., manufacturing and some service jobs). Telecommuters also forgo the option to combine their commutes with other trips such as taking children to daycare and school and running other errands.

We note that some reductions in VMT growth rates might occur voluntarily. For example, if voluntary telecommuting becomes more widespread in the future, some reductions in emissions from onroad vehicles will occur independently of the SAMI strategies. However, if these voluntary VMT reductions are not sufficient to meet the emission reduction targets of the SAMI strategies, programs designed to encourage further reductions in VMTs will be required. Immediately below, we assess the welfare implications of several options for promoting increased telecommuting. These options, which include command and control, taxes, subsidies, and public information programs, focus primarily on reducing travel to the workplace. It is possible, of course, that programs could be designed to reduce non-commuting VMTs.

VMT Reduction Options: Telecommuting Command and Control

The command and control option could be used to promote telecommuting by requiring employers over a given size to require a certain percentage of their employees to telecommute. Revealed preference suggests that if both the employer and the employee preferred telecommuting, they would negotiate such a working arrangement freely in the absence of any policy. As a result, employees who are forced to telecommute because of policy requirements are likely to incur welfare losses. The size of the welfare loss will depend on employees' willingness to trade-off earnings for the benefits of telecommuting.

Occupational choice theory is a special case of consumer choice theory that looks at how individuals select jobs. This theory holds that an individual selects the employment situation that provides the most utility (satisfaction), subject to his or her human capital constraint.[16] This employment decision involves trade-offs between earnings and job attributes (including non-pecuniary amenities). In the setting of interest, the individual must choose between commuting to the workplace and telecommuting. If an individual makes an informed choice to commute to work, revealed preference tells us that the individual prefers commuting to telecommuting. This could be because the employee values higher earnings (because of, say, higher productivity at the workplace) than the benefits of telecommuting. In any event, a welfare is likely to occur if workers who would otherwise commute to the workplace are required to telecommute, assuming that individuals make informed decisions.[17]

One might argue that an employee originally chose the commuting option at the employer's insistence. However, this will not be the case if the employer and the employee are free to negotiate the terms of employment. Suppose that the employer objects to the telecommuting arrangement because it reduces worker productivity.[18] If this is the case, the employee could negotiate for a lower salary (as compensation for the loss in productivity) in exchange for the benefits of telecommuting.[19] The employee would clearly have an incentive to negotiate for lower earnings if he or she placed a

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[16] Human capital is the set of skills and experience that enables individuals to perform jobs.

[17] We suspect that, in most current settings, telecommuting is available as an option to the employee and that future increases in telecommuting are possible. However, if voluntary increases in telecommuting are not sufficient to achieve SAMI's emission reduction targets, then programs designed to encourage additional telecommuting must be implemented.

[18] We presume that, absent institutional barriers, the employee and the employer would readily agree to the telecommuting option if they both preferred it to commuting to the workplace.

[19] Lower productivity will reduce the employer's demand for labor, and in the long-run, reduce the compensation that the employer is willing to pay.

higher value on the attributes of the telecommuting option. By not negotiating such an arrangement in the first place, the employee reveals a preference for commuting to the workplace. We acknowledge that institutional constraints might prevent free negotiations of working arrangements. Employee welfare could improve to the extent that implementation of the VMT reduction strategy breaks down inefficiencies associated with institutional arrangements.

VMT Reduction Options: Commuting Taxes

The commuting tax is another option for promoting telecommuting. For example, such a tax could take the form of an occupational tax that some municipalities levy on individuals who commute to central city offices from the suburbs.[20]

Because the commuting tax raises the cost of commuting, it will reduce the welfare of affected employees. With agreement between employer and employee, some employees will change behavior, avoid the tax, and enjoy the benefits of telecommuting. However, the arguments offered above regarding occupational choice suggest that these employees will suffer a net welfare loss.

To the extent that some employees choose to pay the tax and continue commuting to the workplace, government tax revenues will increase. This will result in a transfer of benefits to individuals who enjoy either lower taxes or increased availability of public goods and services.

VMT Reduction Options: Telecommuting Subsidies

One subsidy option is a tax rebate awarded to employees (or employers) who agree to telecommute in lieu of commuting to the workplace. A second option is to

[20]Strictly speaking, the occupation tax (such as the one levied by the city of Philadelphia) is not a commuting tax per se in that all workers (i.e., workers living both inside and outside of the city) pay the tax. However, the occupation tax raises the cost of commuting for individuals living in the suburbs, thus creating incentives for arrangements like telecommuting business centers.

promote the formation of regional telebusiness centers located away from center cities and close to residential areas.[21]

In either case, the subsidy will have the effect of improving the welfare of employees who switch working arrangements from commuting to telecommuting. However, the transfer effect of the subsidy is negative. To finance the subsidy, the government will have to increase taxes or reduce the amount of public goods and services provided.

VMT Reduction Options: Telecommuting Information Programs

The preceding discussion has assumed that the involved economic agents—employees and employers—are well informed about the benefits of telecommuting relative to the conventional commuting arrangements. To the extent that decisions on commuting arrangements are uninformed, a public information program on the benefits of telecommuting could improve employee (and employer) welfare. The cost of the program will be distributed to taxpayers.

Other Incentive Options

Other incentive options have been identified by regulatory agencies as alternative means of achieving reductions in total vehicle miles traveled. Examples include substitute transportation modes, fare reductions for public transportation, ride-sharing programs, preferred travel lanes and flexible commuting times.[22] These incentives make available alternatives that can produce environmental benefits relative to the environmental outcomes associated with current driving habits and patterns. As mentioned above, if consumers do not select these alternatives in the first place, then they

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[21] See Pechan (2001), Table II-6, p. 10 for a list of such programs.

[22] Several programs of this nature have been adopted in the Atlanta area including high occupancy vehicle lanes, encouraging workers to take rapid transportation during the ozone season, flex-time, bus line expansion, preferential parking for car and van pools, ridesharing information, subsidies for transit users, and employers subsidized lunches to reduce mid-day trips. See Pechan (2001b).

reveal a preference for status quo transportation. Imposing these transportation alternatives on consumers will therefore lead to a reduction in consumer welfare.

The downside to the alternatives listed above is that they restrict the flexibility that driver's enjoy having access to their private vehicle and the option to travel to desired destinations on their own schedule. Regulatory agencies attempt to make the alternatives more attractive for marginal drivers (i.e., those drivers who may not require significant changes to find an alternative to be a preferred mode of travel) by improving schedules, raising comfort or safety attributes, lowering direct costs and providing information about availability. The incentives can also be made more attractive by increasing the costs of current travel options. For example, imposing tolls on roadways, increasing the cost of parking and increasing the gasoline tax may encourage drivers to more seriously consider alternatives. While a successful transition to adoption of these incentives will provide environmental benefits for society, these benefits come at a cost. The development costs of incentive infrastructure and the use of taxing authority will lead to a welfare loss to society. More detailed analysis of benefits and costs is needed to determine whether net benefits are positive or negative.

External Benefits of VMT Reductions: Reduced Congestion

In addition to lowering emissions from on-road vehicles, policies designed to reduce VMT will also produce benefits associated with lowered highway congestion. These include lower vehicle operating costs, reduced travel time, and avoiding the aggravations of traffic congestion. These external benefits will accrue primarily to drivers who do not change to an alternative transportation option.[23] These drivers are the classic free riders discussed in the environmental economics literature.

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[23] Reduced congestion can also benefit consumers who choose an alternative transportation mode through shorter commute times and greater safety.

Technology changes to the existing vehicle fleet

Technology changes to the existing vehicle fleet are reflected in the recently adopted Federal Tier 2 Regulations. Pechan (2001b, II.A.1) reports the incremental cost of upgrading existing emission control technology to meet Federal Tier 2 requirements to achieve 0.07 g/mi NO_x for tailpipe emissions. Pechan assumes that manufacturers will pass through price increases to consumers (with no reduction in demand)[24], that there will be no increase in vehicle operating costs as a result of these regulations. There are additional equipment costs. Including the cost of an upgraded evaporative system and an improved exhaust emission control system, the annual cost for Tier 2 compliance is on the order of $70.00 per vehicle (Pechan, 2001b). Pechan does not provide discussion of the annual maintenance costs for the new technology relative to current technology. There is also no discussion of the impact of new technology on any aspects of vehicle performance. Given the mandated nature of the regulations, consumers who choose to drive gasoline-fueled vehicles will absorb this cost increase. This mandated control strategy will therefore leave consumers less well-off relative to the status quo. The cost increase will fall on those consumers who purchase production year models that incorporate the Tier 2 technology.

Development of New Vehicle Emission Reduction Technology

Development of new vehicle emission reduction technology is a key compliance strategy for the Federal Government and States, such as California, which have serious mobile source air pollution problems. These vehicles are referred to as Low Emission Vehicles (LEV's) or Zero Emission Vehicles (ZEV's). The ZEV's can be classified by type of alternative fuel. In addition to electric vehicles (EV), other fuel types include Compressed Natural Gas (CNG), Ethanol, Methanol, Liquefied Natural Gas (LNG), and Liquefied Petroleum Gas (LPG) (ARB, 2002). Fuel cell technology is an alternative power source for electric vehicles and may be commercially available in several years.

[24] In reality, some portion of the costs of Tier 2 requirements is likely to fall on vehicle manufacturers. To the extent that market demand for vehicles is somewhat rice sensitive, manufacturers will no be able to pass on the full costs of the regulation to consumers.

Per vehicle mile driven, these alternative vehicles produce fewer emissions and thus contribute to better air quality, all else equal. In addition, with less demand for gasoline (and consequently, imported oil), there is a potential national security benefit. However, there is a welfare trade-off for consumers in the selection of these alternative fuel vehicles. Among the characteristics that have been noted by the California Air Resources Board (ARB, 2002) are:

- Driving range before recharge varies by model and is sensitive to battery type and vehicle speed. In general, the average range is about 80 miles, with an overall range of 25 to 150 miles at speeds averaging 45 mph.

- Fuel economy for the Nissan Altra model is listed as 26 (city) to 29 (hwy) in units of kWh/100 miles.

- The Altra is a front-wheel drive vehicle that achieves a peak horsepower of 83hp/62 kW. The specs list the 0-60 acceleration time as 12 seconds.

- The battery type for the Altra is Lithium-ion. Twelve batteries are on the vehicle and it takes approximately 5 hours to recharge at 220 volts using an inductive charger. Other common battery types include Lead Acid and Nickel Metal Hydride (NiMH). The life expectancy of the Lead battery is about three years. The life expectancy of the NiMH battery is reported to be about 100,000 miles. The Lead acid battery is the most common and least expensive of alternatives. The space required for the batteries is substantial and affects trunk space and passenger seating room.

- Electric vehicles require about 40 kWh to fully recharge after being driven about 80 miles. A gas- powered vehicle might normally require 12 gallons of gas after 300 driving miles. Assuming a cost of $0.09/kWh and $1.00/gal gas, the costs for 300 miles driven are very comparable ($13.50 for EV verses $12.00 for gasoline. However, there is a cost for the charging system needed to "re-fuel" the vehicle on a regular basis.

- There are safety concerns associated with the alternative fuels, including explosions. Thus, heavy-duty storage tanks are necessary. Other concerns involve corrosion potential. Electric vehicles may produce severe shocks and chemical burns.

- According to the California Air Resources Board (ARB), ZEV's are significantly more expensive than conventional vehicles in terms of purchase price and life cycle costs, on the order of $7,500 in present value terms (see Table II-4, Pechan report).

The alternative fuel vehicles are not a perfect substitute for the current vehicle fleet. In addition to cost considerations, the vehicles provide less performance quality in several respects. Therefore, to achieve desired penetration rates for these vehicles and contribute to air quality improvement, regulatory agencies will need to provide consumer incentives to promote substitution. To date, incentives have taken the form of subsidies to offset cost differences and programs that allow drivers of ZEV's to use preferred parking, High Occupancy Vehicle lanes (with only a driver on-board) and publicly provided recharge stations. For example, the Federal Government offers a tax credit of 10% (up to $4,000) on the purchase of low emission vehicles (This incentive is being phased out); the luxury tax for automobiles is eliminated for alternative fuel vehicles; and California offers rebates in selected cities that are applied to the purchase or lease of alternative fuel vehicles. Because of the newness of the ZEV technologies most current incentive proposals are directed to government or commercial fleets.[25] Even though incentives may offset the perceived differences between vehicle types and leave an individual consumer indifferent between a ZEV and a gasoline-powered vehicle, societal welfare will be reduced. This occurs because the subsidies come at the expense of either higher taxes imposed on (say) all drivers or through reduced provision of other public goods and services.

We acknowledge that our assessment of ZEVs is limited to a single model, the Nissan Altra. We also acknowledge that the relevant issues are the performance and costs of ZEVs that will be available in the future. It is possible that technological advances will both improve the performance and lower the costs of future ZEVs. However, we have not reviewed the literature on expected characteristics of future ZEVs.[26]

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[25] In the SAMI eight State region, three States (Virginia, West Virginia and Kentucky) currently have an incentive program for public fleets. The other States do not yet have incentive programs in operation.

[26] It is also possible that technological advances will improve the characteristics of conventional gasoline powered vehicles.

Gasoline-Powered Lawn and Garden Equipment and Recreational Vehicles

EPA is implementing regulations to reduce emissions from small spark ignition engines such as lawn mowers. Manufacturers must prepare a statement of conformity that certifies product compliance with the emission standards, including sulphur emissions. The regulations are estimated by EPA to increase the cost of equipment by $5-7 per unit (EPA420-F-98-025.1998), but durability of equipment and fuel efficiency are expected to improve. The net cost effect on users is expected to be minimal.

An alternative to the new low emission mower is an electric mower. Pechan (2001b, Chapter III, p. 29) compares the cost of a conventional gas-powered lawn mower to a cordless electric mower. The analysis assumes that performance characteristics remain unchanged between the alternative choices.[27] Therefore, the only differences are private costs of purchase and operation. Pechan (2001b, Chapter III) reports the purchase price of an electric mower to be about $375.00. This compares with $150.00 to $400.00 for a standard gasoline mower (Home Depot and Sears, 2002). Price variations for the gas mowers reflect differences in horsepower and cutting diameter. Pechan (2001b) states that the electric mower has a clear operating cost advantage. Nevertheless, an incentive (subsidy) for electric mower purchase (in combination with a trade-in of an existing gas mower) is described as a feasible alternative to promote emission reductions.[28]

Wood Burning Stoves

EPA has issued guidelines for reducing pollution from home wood burning stoves (primarily $PM_{2.5}$ and NO_x). The guidelines identify redesign options for the burning systems in wood stoves that lead to reductions in emissions. The guidelines are not requirements and the level of adoption of the newer stoves, and comparative costs, are

[27] Possible non-performance differences exist that may make non-gas fueled mowers less preferred by end-users. These differences include cutting swath and uniformity.

[28] We would expect that subsidies for electric mowers will be unnecessary if they are both less costly and offer the same or better performance compared with gasoline powered mowers. However, subsidies might be required if consumers view the performance of electric mowers as inferior, even if they are less costly.

not reported. An alternative to redesign is to substitute a natural gas fueled stove for a wood burning stove. Based on demand patterns, consumers apparently prefer wood burning stoves over the natural gas fueled stoves. This may be due to perceived advantages in aesthetics and aromatics. The reviewed literature did not present data on equivalent heating potential of the alternatives, so operating cost differences are not known (EPA, 2002).

Some communities (e.g., Telluride, CO) have combined performance standard requirements with incentives to encourage adoption of the alternate fuel stoves. Telluride offered a rebate of $750 to partially offset costs associated with replacement of an inefficient (in emission terms) wood stove with a natural gas stove (purchase costs for a gas stove range from $800 to $1200, Pechan 2001b, Chapter IV, p. 47). The community also devised a plan that restricted stoves in new construction to the holding of a permit. Permit allocations were severely restricted so that a market for permits developed to efficiently allocate the pollution rights associated with the available permits.

Although the incentives have been successful in promoting use of the natural gas fueled stoves and in reducing pollution, there are costs to end-users of the switch to the substitute fueled stove and issues about local availability of natural gas.

Household Fuel Switching

Pechan (Chapter IV, 2001b) includes an assessment of SAMI emission reduction strategies for alternative future year projections of residential fuel mix. The analysis addresses both issues of increases in energy efficiency (see below) and trends toward use of cleaner fuels (e.g., natural gas as opposed to coal or oil). Pechan relies on scenarios evaluated in the *Annual Energy Outlook* (EIA, 2000) to forecast future year patterns in energy use.[29] In the residential sector, it is anticipated that per capita energy use will stabilize as increases in energy efficiency offset increased demand. This stabilization

[29] The fuel use mix considered in EIA (2000) does not reflect future regulatory constraints imposed for environmental reasons.

will require continued advances in residential energy efficiency and substitution to alternative fuels such as natural gas, or conversion to all-electric homes.[30]

Pechan does not provide descriptive evidence of the operating or performance characteristics of alternative fuels. But markets for alternative fuel types appear highly competitive. For example, providers of different fuel types highlight positive characteristics of their fuel in advertisements and other information dissemination activities. Characteristics that are often mentioned include safety, stability of price, stability of availability, reliability and environmental friendliness (cleanliness). With reasonably competitive markets, consumers will experience a decline in their welfare if they are constrained to use a fuel type in their residence that differs from their unconstrained preference.

TEMPORAL ISSUES

This section has examined substitute goods considered by consumers when their choices are constrained by regulatory policy. The discussion emphasized some of the more common substitution opportunities that have been identified in the literature. The welfare consequences of these substitutions can be improved to the extent that opportunities for substitution are expanded. The long time horizon for SAMI policy actions makes it likely that circumstances will change and consumers will find welfare-enhancing ways, relative to current known options, to alter their market decisions. There are two ways this could occur.

First, with more time to complete substitutions, consumers may have more opportunity to be made aware of available choices. This could involve costly search on the part of the consumer, up to the point where the expected gains to the consumer are positive. Or, information may be provided free to consumers (e.g., through advertising) in order to increase awareness of the characteristics of a substitute product.

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[30] Shifts to all-electric homes will tend to increase emissions from electricity generators.

Second, technology is likely to change over time. This may have the effect of making products available that are closer substitutes in the minds of consumers than products currently available. For example, future development of ZEV's may lead to a substitute vehicle that is closer to the current gas-powered vehicles in terms of performance characteristics. Again, such a technological development would be welfare-enhancing for the individual relative to the options described in this section.

Third, consumer preferences tend to change over time. Revealed preference tells us that consumers prefer the *current* selection of goods and services to other affordable combinations. The fact that consumer preferences change over time makes it difficult to assess, even qualitatively, the effects of future constraints on consumer behavior.

Finally, the stringency of the SAMI strategies affecting consumer behavior increase over time. Most of the elements of strategies B1 and B3 affecting households directly call for larger restrictions on consumer behavior in 2040 than in 2010.

SECTION 4

CONTROLS ON PRODUCERS: INDIRECT IMPACTS ON HOUSEHOLDS

As noted earlier in Section 2 of this report, several elements of the SAMI strategies call for reducing emissions that occur during the production of goods and services. While these measures impact producers directly, they are likely to affect households indirectly through price and employment impacts. This section of our report provides an assessment of these potential indirect effects of the strategies on lifestyles.

Immediately below, we develop an analytical framework for assessing potential price and employment effects. Next, apply the framework to the SAMI strategies to draw qualitative conclusions about potential price and employment effects. The final part of this section is a summary of temporal issues related to the indirect effects of the SAMI strategies.

EMPLOYMENT AND PRICE IMACTS: ANALYTICAL FRAMEWORK

The discussion that follows provides a context for understanding how elements of the SAMI strategies that target producers of goods and services affect lifestyles. As noted earlier in Section 2 of this report, strategies aimed at reducing emissions from the production of goods and services affects consumers indirectly through impacts on employment and prices.

It is useful to distinguish two types of polices targeting producers. These are:

- Policies that increase producers' costs by requiring them to reduce emissions that occur during the production process.

- Polices that reduce that demand for emission generating goods by encouraging switching to goods that generate fewer emissions.

As the discussion that follows indicates, each of these two policies has different impacts on lifestyles.

Indirect Lifestyle Impacts: Increases in Producer Costs

As we discussed earlier in Section 2 of this report, several elements of the SAMI strategies are designed to reduce emissions that occur during the production or transportation of goods. Reducing emissions from industrial boilers and electricity generators are examples of these. These strategies are likely to affect lifestyles to the extent that they increase the prices of consumer goods and/or reduce employment and household income. Figure 4-1 illustrates the process through which these impacts occur.

As Box (2) in Figure 4-1 indicates, controls on producer emissions are likely to increase costs for producers targeted by the air quality strategy. Box (3) shows that, as a result, controlled producers are likely to charge higher prices for their goods and/or reduce output and employment.

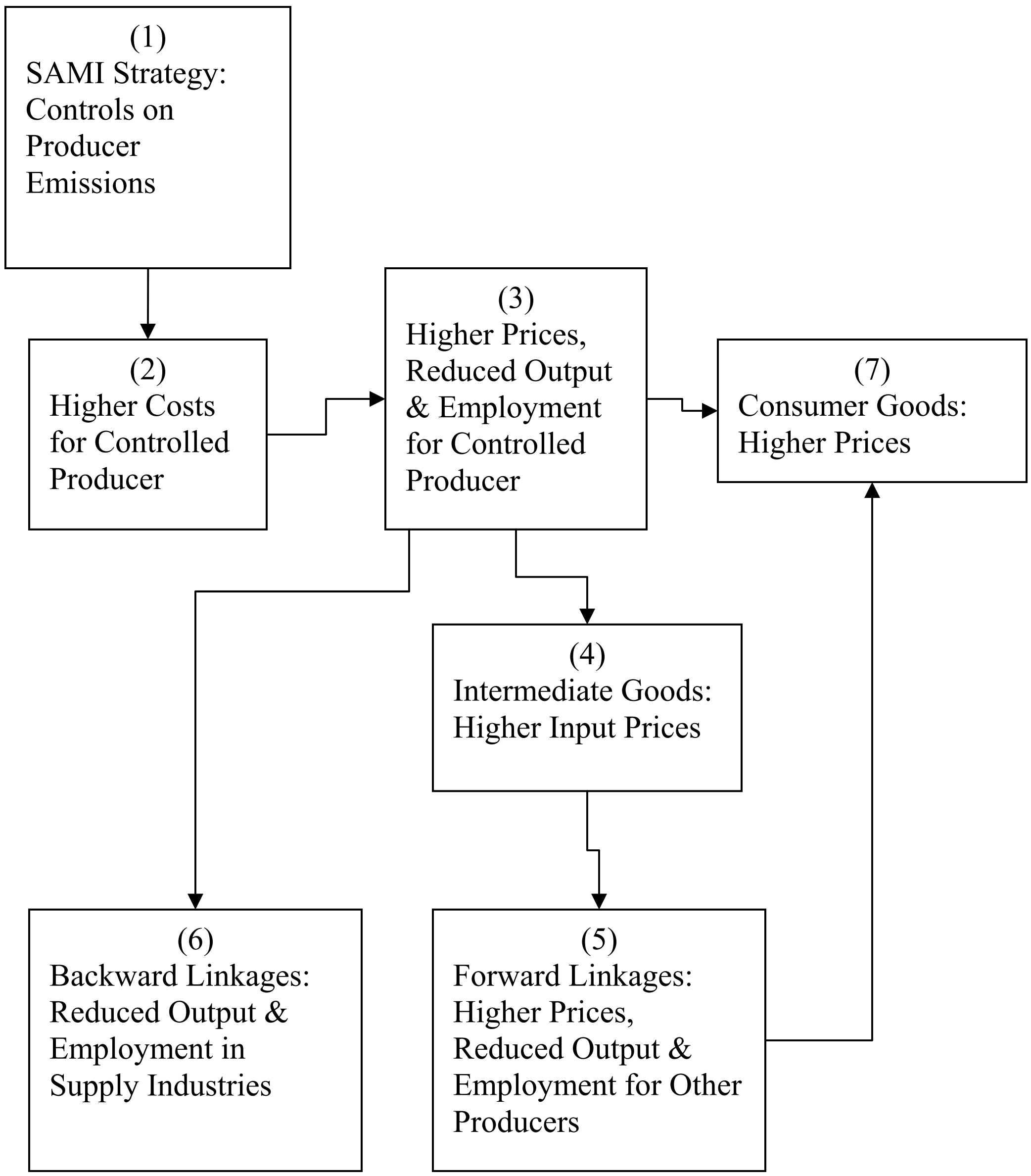
Determinants of Price Increases

Producers will *attempt* to pass on the higher production costs to buyers in the markets that they serve. However, their ability to do so will be limited by the nature of the demand for the goods they produce. Buyers will attempt to resist prices increases by reducing the quantities of goods they purchase. Generally, the more elastic the demand for the goods they produce, the less producers will be able to shift the burden of the cost increases to buyers by increasing prices.[31]

[31] Demand (or price) elasticity is defined as the percentage change in the quantity demanded for a good resulting from one percent change in the good's price.

Figure 4-1

Lifestyles Impacts of Controls on Emissions Generating Production



There are three important determinants of demand elasticity. These are:

- Availability and quality of substitutes—the better the available substitutes, the more elastic the demand for the good.
- Relative expense of the good—the more expensive the item is relative to the buyer's budget, the more elastic the demand for the good.
- Time—demand for most goods tends to be more elastic over time because buyers have more opportunities to find and develop substitutes.

Buyers attempt to mitigate the effects of price increases by seeking substitute goods and services. In some cases, buyers find substitutes from other industries. Switching from coal to natural gas in the face of raising coal prices is an example. This type of substitution pattern will limit the ability of coal producers to pass on control costs to buyers, thus mitigating price increases and the consequential effects on lifestyles.

In other cases, buyers can find substitutes from alternative producers within the same industry. For example, the threat of buyers switching to goods produced outside the SAMI region, either domestically or internationally, is likely to limit the ability of some producers within the SAMI region to raise prices when they incur emission control costs. Again, this type of substitution pattern will also mitigate the effects of price increases on lifestyles.

The effect of competition outside the SAMI region on mitigating price increases will depend importantly on whether other regions adopt emission control strategies similar to those being considered by SAMI. If other regions, including nations in which international competitors are located, also adopt strategies to reduce emissions, then producers in regions outside the SAMI region will attempt to pass on control costs to buyers. To the extent that this occurs, producers within the SAMI region will be better able to increase their prices.

We would also expect that the effects of competition from outside the SAMI region to be different in the shot-run and the long-run. In the short-run, the limited capacity of non-SAMI producers will likely make it easier for SAMI producers to raise prices. In the long-run, however, higher prices may encourage some producers outside the SAMI region to increase their supplies by expanding capacity. This long-run reaction is likely to dampen prices that SAMI producers can charge.

Determinants of Output and Employment Reductions

Increases in production costs tend to cause affected firms to reduce output. As firms raise prices in attempt to shift the burden of compliance costs, buyers tend to reduce the quantity of the good they are willing to purchase. As a result, both output and employment fall. The magnitude of the output reduction for a given price increase depends on how sensitive buyers are to price increases (i.e., demand elasticity). If demand is relatively elastic (e.g., because good substitutes are available), a given price increase will result in a relatively large reduction in output. Also, some producers who are unable to pass on costs to buyers become less profitable close down operations altogether. In either case, when producers reduce output, their demand for labor falls and, as a result, employment also falls.

It is possible that some producers in the SAMI, even those that face direct emission control costs, will increase output and employment. The change in output for a directly affected firm will depend on the *net change in price*, defined as the difference between the change in price and per unit emission control costs. If price rises by more than the per unit controls costs faced by a firm, the net price the firm receives will increase, and the producer will have an incentive to increase output.[32] We note however, imposing compliance costs on producers will have the overall net effect of reducing industry-wide output. This follows because higher prices will reduce market demand for affected products.

[32] Price increases could exceed per unit control costs because of variations in compliance costs across producers in the region. Firms that face relatively low compliance costs relative to their competitors might enjoy net price increases.

We emphasize that the distributional consequences of price increases and output reductions are quite different. Price increases typically affect a large number of buyers. As result, the burden of emission control costs tend to be distributed more evenly over a large number of households when prices rise. However, the effects of reductions in output tend to be concentrated in a smaller number of households; namely, those households whose members lose jobs. Households whose members become unemployed incur losses in wage income and consequential effects on lifestyles. In addition to lost wage income, the SAMI strategies may also affect income for other stakeholders (e.g., proprietors or stockholders) in affected firms to the extent that compliance costs affect profits.[33]

Figure 4-1 focuses on employment losses resulting from implementing the SAMI strategies. This does not imply that no positive employment effects will result from implementing the SAMI strategies. For example, increased tourism that might occur as a result of cleaner air would result in higher employment in the tourism industry. One might argue that lost income from the negative employment impacts of the strategies might reduce spending on tourism. However, because income effects are likely to be spread over a large number of goods and services purchased by households, the negative income effects on tourism are likely to be small[34]; also, some tourism business might be generated from travelers from outside the SAMI region. We emphasize, however, that we have not conducted an assessment of the extent to which air quality improvements resulting from the SAMI strategies will promote tourism.

Some offsetting positive employment impacts are likely to occur as a result of jobs created by requirements to produce, install, operate, and maintain emission controls. While some of these potential gains might be temporary, such as those associated with one-time retrofitting of existing plants, other employment gains such as those associated

[33] The regional distribution of losses in non-wage income will depend the extent to which proprietors and stockholders reside within or outside the SAMI region.

[34] The magnitude of income effects will depend on the size of the income loss and the income elasticity of demand for specific goods and services.

with operating and maintaining emission controls are likely to be more long lasting. Several recent studies have looked at the effects of environmental regulations on employment. Several of these studies find no evidence that environmental regulations have decreased employment, suggesting that employment gains from emission controls offset employment losses from production.[35] However, other recent studies have found negative relations between environmental regulations and employment; these findings suggest that gains from emission controls are not sufficient to offset employment losses.[36] Taken as a whole, the available literature does not allow us to draw general conclusions about the relationship between environmental regulations and employment, suggesting that the nature of employment impacts might depend on the particular circumstances (e.g., the stringency of controls, industries affected, and regional scope) of the regulation.

Also, some elements of the SAMI strategies encourage the use of substitute goods that generate relatively low levels of emissions. While employment in these industries is likely to increase, some of the gains are likely to be realized outside the SAMI region depending on where the substitute goods and services are produced.[37]

We also note that employment impacts tend to be temporary. Over time the economy tends to absorb available labor resources to produce alternative goods and services. The rate at which unemployed individuals move back into the workforce depends, in part, on their mobility, the flexibility of their skills, and the general condition of the local and regional economies. Some workers, particularly those who are older, immobile, and lack flexible skills, may find it difficult to find alternative employment.

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[35] See Goodstein (1994), Repetto (1995), Berman and Bui (1997), Morgenstern, Pizer, and Shih (2000), and Renner (2000).

[36] See Duffy-Deno (1992), Pashigan (1994), and List and Kunce (2000).

[37] For example, employment in industries related to the natural gas industry is likely to increase because of fuel switching strategies, but some of these newly created jobs are likely to be outside the SAMI region.

Backward and Forward Linkages

Boxes (5) and (6) in Figure 4-1 describe, respectively, “forward” and “backward” linkages. One industry is linked forward with another industry if it sells inputs to that industry. An example of a forward linkage is the chemical industry selling inputs (e.g., raw chemicals) to another industry that produces household goods. If the chemical industry raises its prices, costs for producers of household goods likewise increase. Producers in the household industry will respond by attempting to raise their prices and/or reducing output and employment.

One industry is linked backward with another industry if it purchases inputs from that industry. For example, the chemical industry purchases electric power form the electric utility industry. Thus, electric power industry is linked backward with the chemical industry. If the chemical industry reduces its output as a result of emission control costs, it will reduce its demand for electric power. As a result, output and employment in the electric power industry are also likely to fall.

Intermediate Goods and Consumer Goods

Figure 4-1 distinguishes intermediate goods from consumer goods. An intermediate good is one that is not purchased directly by a consumer, but instead, is used as an input to produce other goods and services.

Consumers are not directly affected by prices in markets for intermediate goods, but ultimately their lifestyles are likely to be affected by price increases in these markets. For example, consumers rarely make direct purchases from the chemical industry. However, consumers do purchase many products that use chemicals as inputs. Because higher chemical prices increase the costs of producing consumer goods, prices of consumer goods are likely to increase as well. We show this "forward linkage" as the sequence of arrows flowing from Box (3) through Boxes (4), (5), and (7) in Figure 4-1.

Some industries produce both intermediate goods and consumer goods. For example, the electric power industry produces some electricity for residential consumption, and some for industrial and commercial consumption. In this case, the effect of higher electricity rates on lifestyles is twofold: (1) the direct effect on expenditures for residential electric power; and (2) the indirect effect on expenditures for goods and services that use electric power as an input.

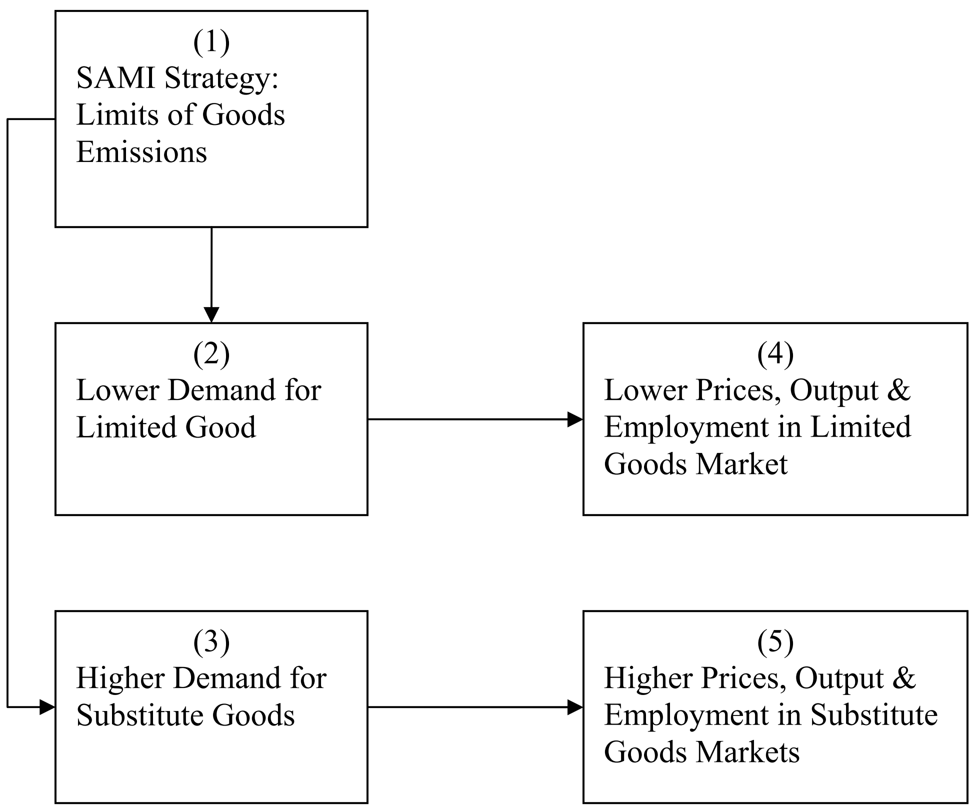
Indirect Lifestyle Impacts: Limits on Emissions Generating Goods

Some elements of the SAMI strategy are designed to limit the use of goods that generate emissions and encourage the use of substitute goods that generate fewer emissions. Fuel switching from coal to natural gas is one example. Encouraging substitution of natural gas burning stoves for wood burning stoves is a second example.

Figure 4-2 illustrates the likely indirect impacts of limits or bans on emissions generating goods. Limiting the use of an emission generating good has the effect of

Figure 4-2

Lifestyles Impacts of Limits on Emissions Generating Goods



reducing the demand for that good. As a result, we would expect the price of the limited good to fall, and output and employment in the industry to decline as well. The opposite is likely to occur in the market for the substitute good whose use is encouraged by the strategies. Demand for the substitute increases, and as a result, prices, output and employment in the substitute goods market also increase.

We have simplified Figure 4-2 and do not show the backward and forward linkages displayed earlier in Figure 4-1. However, these linkages are likely to occur here as well. For example, reduced output in the markets for limited goods is likely to create backward effects to firms that supply inputs, causing further output and employment reductions. Similarly, positive backward linkages are likely to occur in the substitute goods markets as their suppliers increase output and employment.

We also have not shown the distinction between intermediate and consumer goods in Figure 4-2. This distinction, however, is relevant here too. In particular, price increases in substitute goods markets are likely to be passed forward, at least partially, to markets for consumer goods. Similarly, consumers are likely to enjoy lower prices in consumer markets affected by prices in the market for limited goods.[38]

ASSESSMENT OF INDIRECT IMPACTS OF SAMI STRATEGIES

The following is a qualitative assessment of the indirect effects of the SAMI strategies on households' well-being. Immediately below, we identify ten "case study" industries that our the focus of our analysis. Next, we assess the potential for price increases resulting from the SAMI strategies. Finally, we look at exposure to potential unemployment in the SAMI region.

The Case Study Industries

The SAMI strategies are broad-based in that they call for emission reductions from sources in a large number of different industries. SAMI's Socioeconomic Work Group (SEWG) has compiled a list of ten "case study" industries. SEWG selected some

[38] The extent to which consumers enjoy lower prices in markets affected by emissions generating goods depends on the degree to which this goods are limited. For example, no benefits of lower prices will be enjoyed if use of the emission generating good is banned altogether.

of these industries because the SAMI strategies call on them for relatively large reductions in emissions. Others were selected by SEWG because of their special relationships with industries expected to be effected by the strategies.

The ten case study industries are:

- Textiles.
- Paper and paperboard.
- Chemicals.
- Primary metals.
- Natural gas transmission.
- Coal mining.
- Trucking.
- Railroads.
- Liquid fuel providers.
- Electricity generators.

Several of the industries—textiles, paper and paperboard, chemicals, primary metals, trucking, and electricity generators are expected to experience increased production costs as a result of the implementation of the SAMI strategies. While coal mining may incur some costs to control fugitive emissions[39], this industry is expected to be affected primarily by elements of the strategies that call for switching to low sulfur coal and other fuels. The demand for trucking services is also likely to fall because the SAMI strategies call for conversion of some trucking traffic to rail. While railroads may see increased traffic as a result of this conversion, they are likely to suffer a loss in traffic due to lower coal shipments. Finally, liquid fuel providers are likely to see a reduction in demand under the SAMI strategies because of the switch from conventional onroad vehicles to zero emission vehicles, and because of reductions in vehicle miles traveled.

[39] See Pechan (2001b).

Assessment of Potential Price Changes

Our analysis of potential price changes resulting from implementing the SAMI strategies proceeds as follows. First, we use the market analysis described earlier in this section to predict the likely direction of price changes for the ten case study industries. Next, we discuss the potential consequences of the SAMI strategies on electricity rates and service reliability.

Likely Price Changes in the Case Study Industries

Table 4-1 summarizes the likely effects of the SAMI strategies on prices changes in the ten case study industries. We use the following criteria to arrive at our conclusions: (1) Firms facing higher production costs will attempt to raise prices; (2) firms who experience increased demand for the goods and services they produce will tend to increase prices; (3) Firms that experience reduced demand for their products will tend to lower prices. We emphasize that these conclusions are subject to the caveats raised earlier. In particular, the ability to raise prices will depend on competition from substitute products and from producers outside the SAMI region, both domestic and international.

Table 4-1 indicates that price increases are likely in the first six industries listed—electricity generators, textiles, paper and paperboard, chemicals, primary metals, and natural gas transmission. Each of these industries is expected to experience increases in production costs as a result of the implementation of the SAMI strategies and are likely to attempt to pass through at least some of these costs to buyers by increasing costs.

Table 4-1 indicates that declining prices for the coal mining industry are likely. As we noted earlier, the coal mining industry is likely to experience a decrease in demand because the SAMI strategies call for reduced industrial and residential coal combustion. While the coal industry may incur some increases in production costs in order to control fugitive dust emissions, these costs appear to be relatively small[40] and the effects of reduced demand on prices is likely to out weigh the effects of increased production costs.

Table 4-1

LIKELY EFFECTS OF STRATEGIES ON CASE STUDY INDUSTRY PRICES

Industry	Direction of Price Change
Electricity Generators	Increase
Textiles	Increase
Paper & Paperboard	Increase
Chemicals	Increase
Primary Metals	Increase
Natural Gas Transmission	Increase
Coal Mining	Decrease
Liquid Fuel Providers	Uncertain
Trucking	Uncertain
Railroads	Uncertain

Table 4-1 indicates the effects of the SAMI strategies on prices in the liquid fuel provider, trucking, and railroad industries are uncertain. Liquid fuel providers are expected to experience reduced demand for their products under the strategies because of switching to zero emission vehicles (ZEVs) and reductions in the growth of vehicle miles traveled. The direct effect of reduced demand will be to lower market prices. However, implementing the SAMI strategies is likely to change the structure of this industry. As

[40] See Pechan (2001b).

demand for liquid fuel declines, the geographic density of retail gasoline outlets is likely to decline, thus reducing spatial competition. This is likely to be especially true for strategy B3 which calls for 100 percent market penetration of light duty ZEVs and 50 percent market penetration of heavy duty ZEVs by the year 2040. The B3 strategy also calls for 30 percent conversion of heavy duty traffic to rail by 2040.[41] These measures are likely to result in a substantial decline in the number of retail fuel outlets and, as a result, significantly reduce spatial competition in the market. The net impact of these two effects on market prices—reduced demand and changes in the market structure—is unclear.[42]

The effects of the SAMI strategies on rates charged in the trucking industry is also unclear. Converting truck traffic to rail is likely to reduce the demand for trucking services, thus depressing prices in the industry. At the same time, however, the SAMI strategies call for the trucking industry to meet more stringent emission standards. This element of the strategies increases costs in the industry, and absent other factors, would tend to cause rate hikes. Again, however, the combined net effect of reduced demand and higher costs on trucking rates is unclear.

As noted earlier, the SAMI strategies are likely to have a twofold effect on the demand for rail services. The call for converting truck traffic to rail will increase the demand for railroad services. On the other hand, reduced coal traffic will reduce the demand for rail services. The net impact on these two effects on the total demand for rail services is unclear.

Potential Effects of Energy Rate Hikes

We take a detailed look at the potential effects of electricity rate hikes on households in the SAMI region. First, the preceding analysis indicates that rate hikes in

[41] See Pechan (2001b).

[42] Changing the market structure of this industry may also affect the costs of delivering fuel to the market. For example, reducing the density of retail outlets may cause higher distribution costs.

this industry are likely.[43] Second, the available data show that households spend a significant portion of their income on electric power. For example, we estimate that in 1998, the median income household in the SAMI region spent about 6.65 percent of their income on electricity.[44] As a result, rate increases could potentially have a significant effect on consumer spending.[45]

The effect of electric rate hikes on lifestyles depends on how consumers respond to the rate hikes. A household may choose not to change electricity consumption. In this case, total expenditures for electricity increase with an increase in the unit price. This is an example of an inelastic demand for electricity and, with a fixed income, requires a reallocation of the budget, and reduced spending on other goods and services.

The demand for electricity is relatively inelastic because relatively few good substitutes are available for electric power. Natural gas is a substitute for some uses. However, as we explained earlier the SAMI strategies could potentially cause high prices for natural gas. The SAMI strategies also call for reduced use of other substitutes including residential wood and coal combustion.

Consumers may also attempt to mitigate the effects of electricity rate hikes by purchasing more energy efficient home appliances, including lighting, refrigeration units, and space heating and cooling units. The initial outlay cost associated with the use of more energy efficient lighting and refrigeration units is higher than continued use of

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[43] We acknowledge that rate hike for electricity are not a forgone conclusion. First, electric utilities must get approval for rate hikes from regulatory commissions. Second, long-run changes in the structure of the industry could increase competition form outside the SAMI region, thus reducing the ability of utilities to pass on costs to their customers.

[44] Computed from consumer expenditure data in the IMPLAN model for the median income household in the SAMI region. IMPLAN is a regional input-output model that includes expenditure data from the Consumer Expenditure Surveys.

[45] In addition to direct purchase from electric utilities, consumers also purchase electricity indirectly to the extent that electric power is used as an input to producing other goods and services that they purchase. These indirect purchases are not included in the estimated 6.65 percent referenced above.

conventional systems. Cost-savings are realized as energy cost reductions during use.[46] The relative life cycle costs will depend on a variety of factors including use patterns. In addition there may be non-cost performance issues (e.g., luminescence of energy efficient lighting) that a consumer will consider in an evaluation of the substitution potential of energy efficient alternatives.

Potential Effects on Energy Reliability

In addition to possible rate hikes, lifestyles will be impacted if the SAMI strategies affect the reliability of residential electric power supplies. During a series of interviews, representatives of electricity generators in the SAMI region were asked if the strategies would affect reliability.[47] Several of the representatives cited potential reliability problems. Specifically, they cited the following factors:

- Financing the acquisition costs of emission control equipment could divert scarce financial resources from construction projects to meet projected growth in demand and to repair and replace existing equipment.

- Retrofitting existing plants with emission controls requires downtime for installation and maintenance. Fitting repairs and maintenance within the schedule of planned downtime may be difficult.

Assessment of Potential Employment Effects

Table 4-2 summarizes our conclusions about the potential effects of the SAMI strategies on employment in the ten case study industries. The conclusions in this table are based on the following criteria: (1) Firms facing higher production costs will tend to reduce output and employment; (2) firms facing lower demand for their products will

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[46] See Pechan (2001b).

[47] Interviews with representatives from five electric utilities were completed during the fall of 2001. The interviews were conducted by BBC Research & Consulting.

tend to reduce output and employment; (3) firms enjoying increased demand for their products will increase output and employment.

We expect that employment will likely fall for electricity generators, textiles, paper and paperboard, chemicals, and primary metals. As noted earlier, each of these industries is likely to incur increased production costs from implementing the SAMI strategies. To the extent that firms attempt to raise prices in response to higher costs, the quantity demanded for their products will fall. As firms in these industries reduce output, employment will also decline. Employment will also decline if affected firms do not expect to be able to operate profitably close down operations.

Table 4-2

EFFECTS OF STRATEGIES ON CASE STUDY INDUSTRY EMPLOYMENT

Industry	Direction of Employment Change
Electricity Generators	Decrease
Textiles	Decrease
Paper & Paperboard	Decrease
Chemicals	Decrease
Primary Metals	Decrease
Natural Gas Transmission	Uncertain
Coal Mining	Decrease
Liquid Fuel Providers	Decrease
Trucking	Decrease
Railroads	Uncertain

Table 4-2 also indicates that employment is likely to fall coal mining, liquid fuel provider, and trucking industries. As noted earlier, the SAMI strategies are expected to result in decreased demand in these industries. To the extent that they reduce production in response to lower demand, employment will also fall.

The effects of the SAMI strategies on employment in natural gas and railroad industries is uncertain. Firms in the natural gas transmission industry are expected to experience higher costs to reduce emissions. Taken alone, higher costs would have a tendency to cause reduced employment. However, the strategy of switching from alternative fuels to natural gas will have the effects of increasing the demand for natural gas transmission services, thus increasing employment in the industry. Since we have not conducted a quantitative assessment of the net effects of higher costs and increased demand, we conclude the effects of the SAMI strategies on employment in this industry are uncertain.

Employment impacts in the railroad industry are also uncertain. As we noted earlier, this industry is likely to experience a decrease in demand because to reduced coal shipments, by higher demand because of conversion from trucking to rail. Again, the net effect of these two countervailing impacts is uncertain.

We emphasize that our assessments of potential employment impacts are limited to the ten case study industries. We have not included in our assessment potential increases in employment that might result indirectly from improvements in air quality (e.g., increased employment in the tourism industry). Also, we have not considered potential increases in employment resulting from manufacturing, installing, operating, and maintaining emission control equipment.

One way to assess the potential exposure of the SAMI region to employment impacts is to compare baseline projected employment in the ten case study industries with total employment across all industries. Tables 4-3 through 4-12 show the results of this comparison for the two benchmark years, 2010 and 2040.[48] We emphasize that the data presented in Tables 4-3 through 4-12 represent projected baseline employment that would occur in the absence of the SAMI strategies. To the extent that the strategies reduce employment in the case study industries, actual employment growth will be lower than the rates shown in these tables.

For example, Table 4-3 shows employment projections for the electric utility industry. Projected employment for all industries in the state of Alabama in the year 2010 is about 2,573.5 thousand. Projected employment for the same year for electricity generators is 15,758, about 0.61 percent of total projected employment in Alabama. The last row in Table 4-3 shows employment projections for the entire SAMI region. Region-wide employment for 2010 in the electricity generation industry is projected at 109,908, about 0.41 percent of total projected region-wide employment across all industries.

Projected employment for most of the case study industries is less than one percent of total employment, both for the SAMI region as a whole and for individual states. However, Table 4-11 shows that employment in the trucking industry is expected to account for about 2.83 percent of region-wide employment by 2040. Recall that employment in this industry could decline, both because of the effects of the compliance costs and because of converting truck traffic to rail.

While coal mining is expected to account for only about 0.28 percent of region-wide employment by 2040, employment in this industry is expected to be concentrated primarily in two states, Kentucky and, especially, West Virginia. As Table 4-7 indicates West Virginia employment in coal mining is expected to be 30,815, about 3.06 percent of state-wide employment in 2040. We expect more difficult economic transitions—longer spells of unemployment, larger spillover effects, and more serious impacts on localities—in cases where unemployment impacts are localized.

[48] Employment projections were made by applying projected state and industry employment growth rates by the Bureau of Economic Analysis (1995) to 1998 baseline employment levels in the SAMI region IMPLAN model. The employment projections were done by BBC Consulting & Research.

Table 4- 3

Projected Employment: Electricity Generators

State	Total Employment: All Industries (Thousands)		Employment: Electricity Generators			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	15,758	0.61%	20,842	0.70%
Georgia	5,051.8	6,168.4	17,637	0.35%	23,328	0.38%
Kentucky	2,380.8	2,678.3	10,792	0.45%	14,274	0.53%
North Carolina	5,188.1	6,120.1	19,353	0.37%	25,598	0.42%
South Carolina	2,456.1	2,864.1	12,651	0.52%	16,733	0.58%
Tennessee	3,682.0	4,260.0	14,412	0.39%	19,062	0.45%
Virginia	4,640.7	5,486.0	13,488	0.29%	17,840	0.33%
West Virginia	916.4	1,007.0	5,817	0.63%	7,694	0.76%
SAMI Region	26,889.4	31,568.1	109,908	0.41%	145,371	0.46%

Table 4- 4

Projected Employment: Textiles

State	Total Employment: All Industries (Thousands)		Employment: Textiles			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	3,373	0.13%	4,842	0.16%
Georgia	5,051.8	6,168.4	12,251	0.24%	17,642	0.29%
Kentucky	2,380.8	2,678.3	284	0.01%	409	0.02%
North Carolina	5,188.1	6,120.1	18,619	0.36%	25,431	0.42%
South Carolina	2,456.1	2,864.1	17,714	0.72%	23,379	0.82%
Tennessee	3,682.0	4,260.0	1,180	0.03%	1,578	0.04%
Virginia	4,640.7	5,486.0	5,507	0.12%	7,604	0.14%
West Virginia	916.4	1,007.0	0	0.00%	0	0.00%
SAMI Region	26,889.4	31,568.1	58,928	0.22%	80,885	0.26%

Table 4- 5

Projected Employment: Paper & Paperboard

State	Total Employment: All Industries (Thousands)		Employment: Paper & Paperboard			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	17,251	0.67%	26,889	0.90%
Georgia	5,051.8	6,168.4	14,312	0.28%	22,784	0.37%
Kentucky	2,380.8	2,678.3	2,433	0.10%	4,313	0.16%
North Carolina	5,188.1	6,120.1	10,059	0.19%	16,336	0.27%
South Carolina	2,456.1	2,864.1	8,964	0.37%	14,716	0.51%
Tennessee	3,682.0	4,260.0	9,327	0.25%	15,163	0.36%
Virginia	4,640.7	5,486.0	9,848	0.21%	14,953	0.27%
West Virginia	916.4	1,007.0	296	0.03%	421	0.04%
SAMI Region	26,889.4	31,568.1	72,490	0.27%	115,575	0.37%

Table 4- 6

Projected Employment: Chemicals

State	Total Employment: All Industries (Thousands)		Employment: Chemicals			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	5,433	0.21%	7,725	0.26%
Georgia	5,051.8	6,168.4	5,627	0.11%	8,516	0.14%
Kentucky	2,380.8	2,678.3	7,576	0.32%	10,908	0.41%
North Carolina	5,188.1	6,120.1	8,708	0.17%	13,604	0.22%
South Carolina	2,456.1	2,864.1	21,359	0.87%	32,488	1.13%
Tennessee	3,682.0	4,260.0	10,284	0.28%	14,617	0.34%
Virginia	4,640.7	5,486.0	2,170	0.05%	3,019	0.06%
West Virginia	916.4	1,007.0	8,505	0.92%	10,838	1.08%
SAMI Region	26,889.4	31,568.1	69,662	0.26%	101,715	0.32%

Table 4-7

Projected Employment: Primary Metals

State	Total Employment: All Industries (Thousands)		Employment: Primary Metals			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	10,035	0.39%	13,035	0.44%
Georgia	5,051.8	6,168.4	3,884	0.08%	4,803	0.08%
Kentucky	2,380.8	2,678.3	9,487	0.40%	12,703	0.47%
North Carolina	5,188.1	6,120.1	3,093	0.06%	4,260	0.07%
South Carolina	2,456.1	2,864.1	5,293	0.22%	7,420	0.26%
Tennessee	3,682.0	4,260.0	5,793	0.16%	7,810	0.18%
Virginia	4,640.7	5,486.0	4,133	0.09%	5,446	0.10%
West Virginia	916.4	1,007.0	10,311	1.13%	12,654	1.26%
SAMI Region	26,889.4	31,568.1	52,029	0.19%	68,131	0.22%

Table 4-8

Projected Employment: Natural Gas Transmission

State	Total Employment: All Industries (Thousands)		Employment: Natural Gas Transmission			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	2,769	0.11%	4,126	0.14%
Georgia	5,051.8	6,168.4	3,415	0.07%	5,476	0.09%
Kentucky	2,380.8	2,678.3	2,387	0.10%	3,355	0.13%
North Carolina	5,188.1	6,120.1	2,985	0.06%	4,504	0.07%
South Carolina	2,456.1	2,864.1	404	0.02%	595	0.02%
Tennessee	3,682.0	4,260.0	1,480	0.04%	2,301	0.05%
Virginia	4,640.7	5,486.0	3,050	0.07%	4,661	0.09%
West Virginia	916.4	1,007.0	3,841	0.42%	5,358	0.53%
SAMI Region	26,889.4	31,568.1	20,331	0.08%	30,376	0.10%

Table 4-9

Projected Employment: Coal Mining

State	Total Employment: All Industries (Thousands)		Employment: Coal Mining			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	8,140	0.32%	10,788	0.36%
Georgia	5,051.8	6,168.4	65	0.00%	77	0.00%
Kentucky	2,380.8	2,678.3	27,839	1.17%	35,184	1.31%
North Carolina	5,188.1	6,120.1	0	0.00%	0	0.00%
South Carolina	2,456.1	2,864.1	0	0.00%	0	0.00%
Tennessee	3,682.0	4,260.0	656	0.02%	561	0.01%
Virginia	4,640.7	5,486.0	9,256	0.20%	12,073	0.22%
West Virginia	916.4	1,007.0	25,158	2.75%	30,815	3.06%
SAMI Region	26,889.4	31,568.1	71,114	0.26%	89,498	0.28%

Table 4-10

Projected Employment: Liquid Fuels

State	Total Employment: All Industries (Thousands)		Employment: Liquid Fuels			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	22,600	0.88%	32,799	1.10%
Georgia	5,051.8	6,168.4	38,856	0.77%	58,768	0.95%
Kentucky	2,380.8	2,678.3	21,384	0.90%	31,213	1.17%
North Carolina	5,188.1	6,120.1	37,619	0.73%	55,828	0.91%
South Carolina	2,456.1	2,864.1	18,585	0.76%	27,347	0.95%
Tennessee	3,682.0	4,260.0	29,182	0.79%	43,757	1.03%
Virginia	4,640.7	5,486.0	35,630	0.77%	54,030	0.98%
West Virginia	916.4	1,007.0	9,039	0.99%	12,909	1.28%
SAMI Region	26,889.4	31,568.1	212,895	0.79%	316,651	1.00%

Table 4-11

Projected Employment: Trucking

State	Total Employment: All Industries (Thousands)		Employment: Trucking			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	62,527	2.43%	98,031	3.29%
Georgia	5,051.8	6,168.4	109,137	2.16%	176,292	2.86%
Kentucky	2,380.8	2,678.3	52,108	2.19%	80,658	3.01%
North Carolina	5,188.1	6,120.1	105,414	2.03%	158,318	2.59%
South Carolina	2,456.1	2,864.1	45,969	1.87%	72,405	2.53%
Tennessee	3,682.0	4,260.0	107,844	2.93%	165,189	3.88%
Virginia	4,640.7	5,486.0	72,738	1.57%	113,575	2.07%
West Virginia	916.4	1,007.0	19,642	2.14%	28,372	2.82%
SAMI Region	26,889.4	31,568.1	575,379	2.14%	892,840	2.83%

Table 4-12

Projected Employment: Railroads

State	Total Employment: All Industries (Thousands)		Employment: Railroads			
	2010	2040	2010		2040	
			Employment	% Total	Employment	% Total
Alabama	2,573.5	2,984.2	5,193	0.20%	7,902	0.26%
Georgia	5,051.8	6,168.4	9,483	0.19%	14,361	0.23%
Kentucky	2,380.8	2,678.3	6,005	0.25%	8,023	0.30%
North Carolina	5,188.1	6,120.1	3,531	0.07%	5,116	0.08%
South Carolina	2,456.1	2,864.1	2,563	0.10%	3,831	0.13%
Tennessee	3,682.0	4,260.0	6,283	0.17%	9,269	0.22%
Virginia	4,640.7	5,486.0	10,337	0.22%	16,152	0.29%
West Virginia	916.4	1,007.0	4,556	0.50%	6,596	0.66%
SAMI Region	26,889.4	31,568.1	47,951	0.18%	71,250	0.23%

INDIRECT EFFECTS: TEMPORAL ISSUES

Because SAMI is evaluating the effects of the strategies in two future benchmark years, 2010 and 2040, it is useful to summarize temporal issues related to our assessment of indirect impacts. We have discussed some of these issues earlier in this section.

Price impacts tend to be smaller in the long run. Over time, consumers have better opportunities to find substitutes for higher priced goods and services. Employment effects also tend to diminish over time. While durations of unemployment spells are likely to vary considerably depending on individuals' circumstances, the economy tends to absorb available labor resources. As we noted earlier, however, some of the replacement jobs, like some service sector positions, are likely to pay lower wages than the jobs lost.

The changes in the relative stringency of the strategies will also likely affect employment effects. Strategy B1 is expected to result in lower incremental costs for electricity generators and industrial point sources in 2040 than in 2010, relative to a baseline that includes on the way strategies planned by other agencies. As a result, the employment effects that can be attributed to strategy B1 might decrease over time. However, strategy B3 calls for progressively larger incremental emission control costs over time, suggesting larger indirect impacts on households.[49] Also, as we noted earlier, employment impacts may be exacerbated in the long run if producers outside the SAMI region, both domestic and abroad, increase capacity in industries affected by the strategies.

We also note that baseline SAMI-wide employment is projected to grow in each of the ten case study industries. This suggests that some of the employment impacts of the strategies will occur by eliminating future employment opportunities rather than by dislocating workers from jobs they hold. While both types of employment impacts will negatively affect households, they imply different types of distributional impacts on

[49] See Pechan (2001b).

households. Dislocating workers from jobs they actually hold is likely to generate dislocation costs such as moving expenses and job retraining expenses. Some of these costs are likely to be avoided if employment impacts occur by eliminating future employment opportunities.

Finally, we note the considerable uncertainty in assessing indirect impacts for the future. Uncertain technological advances could mitigate some of the impacts of the strategies by providing more efficient low-emission production technologies. The pace at which agencies outside the SAMI region adopt strategies for emissions generated by producers is also uncertain. As we noted earlier, the employment impacts of the SAMI strategies will be mitigated if producers outside the region face similar emission controls.

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APPENDIX

DEFINITIONS OF INDUSTRIES

The ten industries examined in this analysis and the industry components include:

1. Coal Mining (37, Coal Mining)*
2. Textiles (108, Broadwoven Fabric Mills and Finishing)
3. Paper and Paperboard (162, Paper Mills, Except Building Paper; 163, Paperboard Mills)
4. Chemicals (186, Alkalies & Chlorine; 187, Industrial Gases; 188, Inorganic Pigments; 189, Inorganic Chemicals Nec.; 190, Cyclic Crudes, Interm. & Indus. Organic Chem.; 201, Gum and Wood Chemicals)
5. Metals (254, Blast Furnaces and Steel Mills; 261, Primary Aluminum; 265, Aluminum Rolling and Drawing)
6. Electric (443, Electric Services; 511, State and Local Electric Utilities; 514, Federal Electric Utilities)
7. Natural Gas Transmission (444, Gas Production and Distribution)
8. Trucking (435, Motor Freight Transport and Warehousing)
9. Rail (433, Railroads and Related Services)
10. Liquid Fuels (451, Automotive Dealers & Service Stations; 210, Petroleum Refining)

*The numbers refer to the IMPLAN classification codes.