

Working Paper

Arizona State Freight Plan

(ADOT MPD 085-14)

Phase 3 Working Paper Energy Sector Profile and Transportation Performance Needs

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Working Paper

This working paper is one of 10 focusing on key Arizona economic sectors. Its purpose is to document the economic profile, outlook and transportation performance needs of Arizona's energy sector. This working paper will later inform system improvement needs to increase Arizona's economic competitiveness and growth. This working paper is provided for comment and discussion and should not be interpreted as final.

Acknowledgements

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Opinions

Unless otherwise indicated, the opinions herein are those of the author and do not necessarily reflect the views of ADOT or the State of Arizona.

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Executive Summary

Economic and Traffic Profile

Arizona's energy sector¹ contributed \$212 million to the State's gross domestic product (GDP) in 2012, representing .1 percent of the State's total economic output. Since 1997, GDP in the energy sector has grown at a rate of 17.1 percent per annum, well over performing compared to the overall state average of 4.9 percent GDP growth per annum. Oil and gas production in Arizona is considered to be minimal and concentrated in Apache County. The two major consumption activity clusters for oil, gas and solar power are located in Tucson and Phoenix.

	Measure	Energy	Arizona (statewide)
Economy	GDP (2012, \$ million)	\$212	\$271,503
	GDP Annualized Growth (1997-2012)	17.1%	4.9%
Jobs	Employment (2013)	322	2,619,055
	Compensation per Employee (2013)	\$84,413	\$57,393
Transportation	Total Commodity Flows (2012, Mt)	3.7	138.2
	Top Origin (2012, Mt)	New Mexico (1.5 Mt)	California (9.54 Mt)
	Top Domestic Destination (2012, Mt)	California (.1 Mt)	Mexico (5.6 Mt)
	Intrastate Flows (2012, Mt)	1.7	101.8
	% Truck (2012)	99.5%	87.2%
Source: CPCS analysis of data from Bureau of Economic Analysis and 2012 Commodity Flow Survey			

Supply to Arizona is essentially provided through refined products and natural gas interstate pipelines. In the case of refined oil products, it is estimated that about 260,000 to 270,000 barrels per day of products have to be delivered to Arizona in order to maintain stock levels (which satisfy approximately two to three days of demand). Natural gas deliveries to Arizona reached 355.6 billion cubic feet in 2013. Arizona benefits from significant solar power potential. Over the past 10 to 15 years, both utility scale and residential scale solar power capacity has been installed, notably to meet Arizona's Renewable Energy Standard.

Supply Chain Structure and Transportation Performance Needs

Petroleum product consumption in Arizona is supplied by two pipelines, both of which are owned and operated by Kinder Morgan and converge in Phoenix. Most natural gas consumption in Arizona relies on deliveries which are made via one of the ten interstate gas pipelines. Arizona hosts a diverse solar manufacturing base ranging from solar tempered glass production to energy storage technologies. Solar panel manufacturing supply chains have a global nature and some major manufacturers and suppliers are located in Arizona.

¹ In this section, the energy sector is limited to energy production. Analysis in this section excludes retail components such as GDP related to gas stations. This activity is captured in the working paper on "Warehousing and Retailers".

In the future, the increased share of gas and renewables in Arizona's energy mix, the increased cost to build pipelines, and the surge of demand for gas in Mexico will be the three major trends that will impact the energy sector.

Notable Barriers and Related Priority Improvements to Enhance Competitiveness and Growth

In recent years, the refined products pipeline network of Arizona has been improved to increase capacity and reliability. In the case of natural gas, many stakeholders note that the State requires gas storage capacity to meet peak demand and increase the reliability of supply chains. However, gas pipeline operators are continuously monitoring demand and capacity with clients.

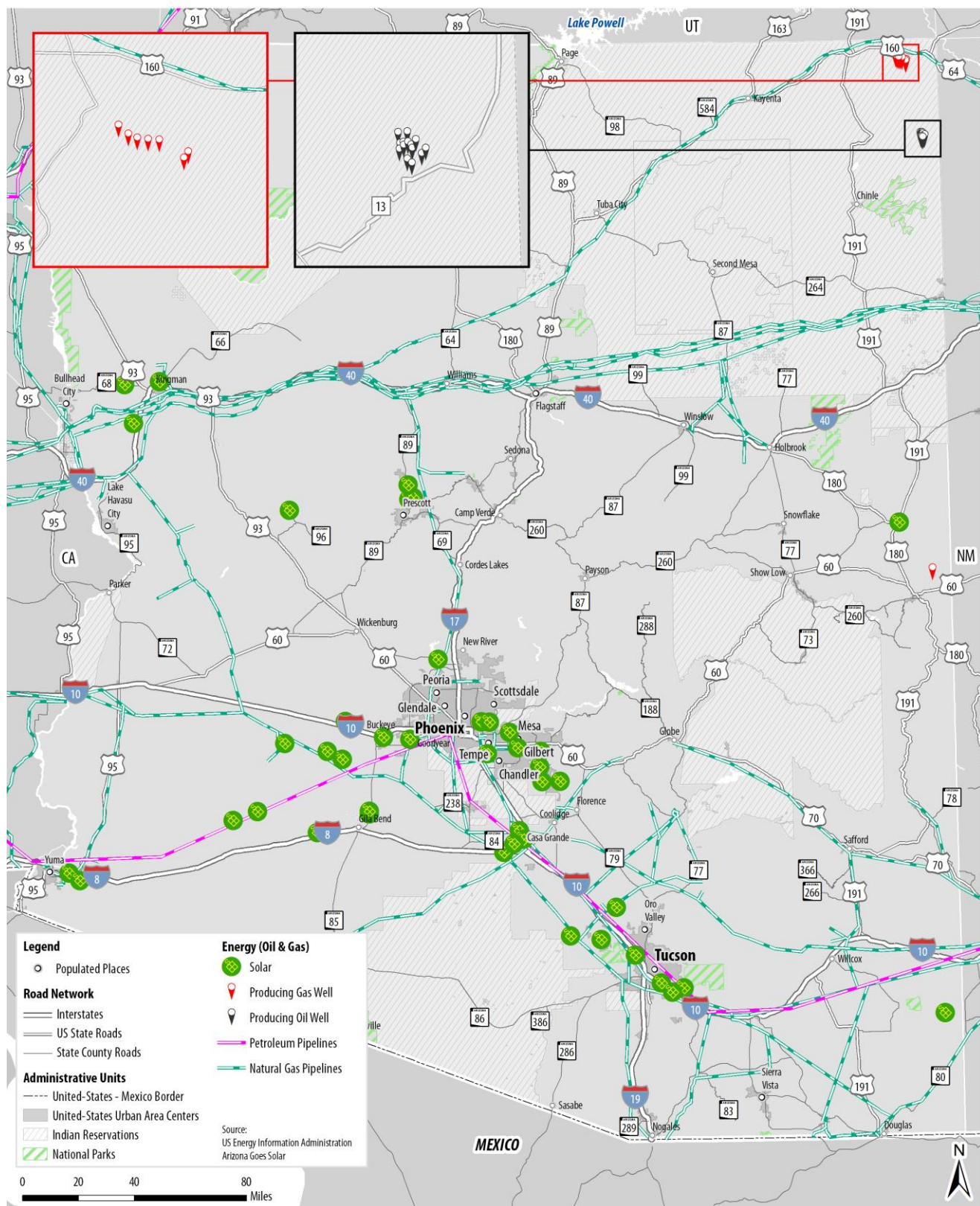
In the case of solar power, the global nature of the industry, the limited share of transportation in total costs and significant variability in supply chain structures of the various solar panel components makes it difficult to prioritize specific improvements in Arizona's transportation system. For example, some major solar panel suppliers such as Kyocera Solar or First Solar are headquartered in Arizona, but they do not necessarily manufacture or have logistics facilities in Arizona.

This is a key attribute of the industry. Efficient solar energy equipment requires high value research and development, and the physical equipment is comprised of heavy materials and lighter high tech instruments. However, while Arizona is a suitable place to install the equipment, there is great competition regarding where the research and advanced manufacturing will occur. In the recent past both U.S. government subsidies combined with local economic development incentives drove select areas of investment. Broader market forces have moderated this progress. Even uncertainty related to the future price of oil will impact shorter term growth opportunities in the sector. This makes it difficult to identify a specific transportation strategy that can be tied to this industry.

Figure ES-1-1: Major Oil, Gas and Solar Infrastructure in Arizona

CPCS Solutions for
growing economies

Arizona Major Solar, Gas and Petroleum Infrastructure
Energy (Oil & Gas)



Acronyms and Abbreviations

ACA	ARIZONA COMMERCE AUTHORITY
ADOT	ARIZONA DEPARTMENT OF TRANSPORTATION
APS	ARIZONA PUBLIC SERVICE
CFS	COMMODITY FLOW SURVEY
CSP	CONCENTRATED SOLAR POWER
EIA	U.S. ENERGY INFORMATION ADMINISTRATION
GDP	GROSS DOMESTIC PRODUCT
IRP	INTEGRATED RESOURCE PLANS
mcf	MILLION CUBIC FEET
MPD	MULTIMODAL PLANNING DIVISION
Mt	MILLION TONS
MW	MEGAWATT
NAICS	NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM
PHMSA	PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION
US	UNITED STATES

1

Introduction

Key Messages

The Arizona Department of Transportation, Multimodal Planning Division, retained a team led by CPCS Transcom, Inc. to assist in the development of Arizona's State Freight Plan.

The aim of this working paper is to establish the freight transportation performance needs, outlooks, and economic contribution of Arizona's energy sector (defined here as NAICS Codes 211 and 324). This will later inform the analysis of broader transportation system based needs and priorities.

This working paper was developed in large part through stakeholder consultations and analysis of energy sector data.

1.1 Introduction: Why an Arizona State Freight Plan?

Arizona's economic potential is supported by the state's transportation infrastructure, which connects sources of production to markets.

When transportation infrastructure and related services are efficiently designed and competitively positioned, businesses benefit from lower transportation costs, faster and better transportation services, and increased reliability, which in turn contribute to their own competitiveness and growth, and that of the broader region.

Jurisdictions with access to competitive transportation infrastructure and services are at a competitive advantage in attracting investment, creating jobs and realizing economic growth. Arizona's State Freight Plan can help enable this outcome.

To this end, the ADOT's Multimodal Planning Division (MPD), is developing Arizona's State Freight Plan which will provide strategic guidance to enhance Arizona's economic competitiveness and facilitate economic growth.

1.2 Project Objectives

The State Freight Plan will define immediate and long-range investment priorities and policies that will generate the greatest return for Arizona's economy, while also advancing other key transportation system goals, including national goals outlined in MAP-21. It will identify freight transportation facilities in Arizona that are critical to the State's economic growth and give appropriate priority to investments in such facilities.

The State Freight Plan will ultimately provide Arizona with a guide for assessing and making sound investment and policy decisions that will yield outcomes consistent with the state's visions, goals, and objectives, and notably, promote regional competitiveness and economic growth.

1.3 Purpose of this Working Paper

Since it is economic activity – particularly from goods movement sectors – that drives demand for freight transportation infrastructure and services, optimization of the state's freight transportation system, and related strategies, goals and investments, must start by addressing the transportation performance needs of the sectors moving freight. Yet, the transportation

performance needs of freight can differ by sector and commodity group, locations and even company.

For this reason, the team identified 10 key freight sectors in Arizona for specific focus: wholesalers and retailers, food and beverage, high-tech manufacturing, general manufacturing, transportation equipment manufacturing, transportation and logistics, mining (except oil and gas), energy (oil and gas), agriculture, and forestry.

The purpose of this working paper is to provide a focused assessment of the transportation performance needs, outlook and economic contribution of the energy sector (defined here as NAICS Codes 211 and 324).

Specifically, it addresses the following key questions:

- At a high level, what is the profile and economic contribution of the energy sector to Arizona's economy?
- How do the supply chains of Arizona's energy sector utilize the transportation system and what are the major origins, destinations, intermediate points, and final products of these chains?
- How are energy sector supply chains structured, managed, and what are the primary drivers of transportation decisions and related performance needs?
- What are the key trends in the energy sector, how are these influencing freight flows, and what are the implications, opportunities and challenges for the competitiveness of Arizona's freight system going forward?

1.4 Methodology

This working paper is informed by a combination of literature review, data collection and analysis, and consultation with energy sector stakeholders. Documents reviewed are footnoted throughout the working paper, as appropriate. A list of individuals consulted is provided in Appendix A (unless the stakeholder has specifically requested non attribution).

1.5 Limitations

This working paper is in many cases informed by data and input provided by third parties. CPCS has verified this information to the extent possible through analysis and cross-checking with other sources but cannot guarantee the accuracy of data received from third parties.

2 Energy Sector Profile

Key Messages

This working paper concentrates on the oil, natural gas and solar power sectors. Oil and gas production in Arizona is considered to be minimal and concentrated in Apache County. Supply to Arizona is essentially provided through refined products and natural gas interstate pipelines.

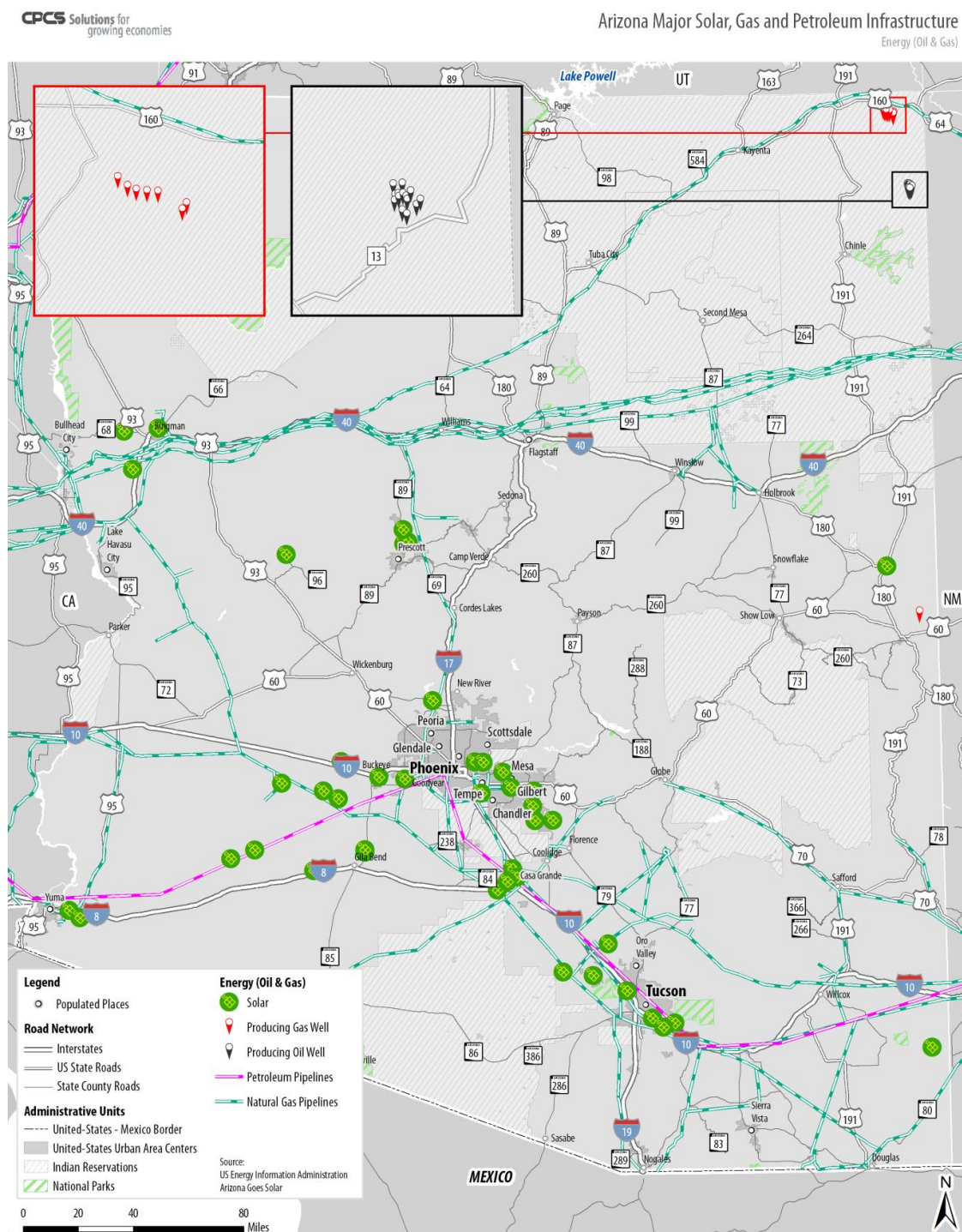
Arizona benefits from significant solar power potential. Over the past 10 to 15 years, both utility-scale and residential scale solar power capacity has been installed.

The two major activity clusters for oil and gas consumption and solar power are located in Tucson and Phoenix.

2.1 Overview of Energy Sector

The energy sector in Arizona includes many players and resources ranging from coal and uranium to solar and wind. This working paper concentrates on three of them: oil, natural gas and solar. The figure below illustrates Arizona's major oil, gas and solar infrastructure.

Figure 2-1: Major Oil, Gas and Solar Infrastructure in Arizona



Oil production in Arizona is minimal compared to other U.S. states such as New Mexico, California and Texas. Current production occurs in Apache County and is conducted by Nacogdoches Oil and Gas Inc. and the Navajo Nation Oil & Gas Co. Petroleum products consumption in Arizona relies extensively on shipments made through Kinder Morgan's pipeline network which notably supplies Phoenix and Tucson with refined products. In 2013, the Energy Information Administration (EIA) estimated that over 87 percent of petroleum products consumed in the State were delivered to the transportation sector. The industrial sector reportedly consumed a supplementary 10 percent, followed by the commercial (1.6 percent) and residential (1.1 percent) sectors.

Natural gas production is also minimal and most of demand is supplied through the interstate pipeline network operated by El Paso Natural Gas (Kinder Morgan), Transwestern Pipeline Company and Questar's Southern Trails pipeline. While the electric power generation sector makes limited use of oil, about two-thirds of natural gas consumption in Arizona is used for power generation. Major players in the electric power generation sector in Arizona include Arizona Public Service, Arizona Electric Power Cooperative and Tucson Electric Power. Residential and commercial sectors consume much of the remaining share. There is no natural gas storage capacity in Arizona.

Arizona has excellent solar energy potential. The development of this potential focuses on the implementation of utility-scale infrastructure and facilities which supply the electric power generation sector as well as distributed solar power which can broadly be illustrated by rooftop solar panel installations of variable capacity. Arizona's Renewable Energy Standard aims to have 15 percent of electricity sales be generated by renewable sources by 2025. According to the EIA, 30 percent of this energy must be provided by non-utility distributed generation. As of 2014, there were about 50 manufacturers associated with the solar power industry in Arizona.²

2.2 Economic Profile and Importance to Arizona's Economy

2.2.1 GDP and Trade

The energy sector³ in Arizona contributed \$212 million to the State's gross domestic product (GDP) in 2012, representing .1 percent of the State's total economic output. Since 1997, GDP in the energy sector has grown at a rate of 17.1 percent per annum, well over performing compared to the overall state average of 4.9 percent GDP growth per annum.⁴

² *Op. cit.* 20.

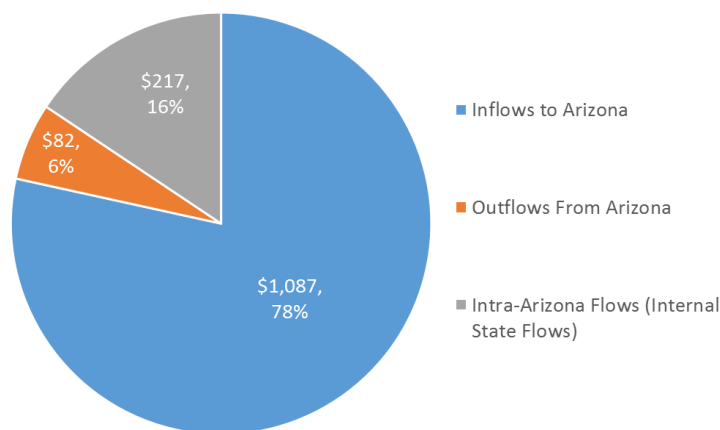
³ In this section, the energy sector is limited to production including oil and gas extraction and petroleum and coal products manufacturing. Analysis in this section excludes retail components such as GDP related to gas stations. This activity is captured in the working paper on "Warehousing and Retailers".

⁴ Bureau of Economic Analysis Regional Economic Accounts, GDP by State. GDP in current dollars.

2.2.2 Domestic Commodity Flows

Overall, \$1.4 billion of goods in the energy sector travelled into, out of, or within the State of Arizona in the year 2012. Of this, \$1.1 billion of goods originated in other states and were destined to Arizona, \$82 million originated in Arizona and were destined for other states, and \$217 million in goods travelled within the state of Arizona.

Figure 2-2: Value of Flows Into, out of, and Within Arizona in 2012 (\$millions)

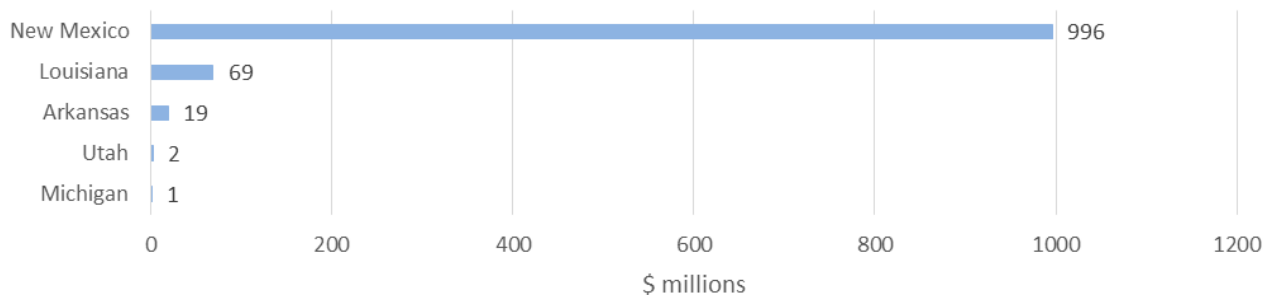


Source: CPCS analysis of Commodity Flow Survey, 2012.

Origins of Domestic Inflows to Arizona

The figure below summarizes the origins of energy products that were shipped to Arizona from other states. New Mexico was the largest origin of energy products destined for Arizona with \$996 million in products shipped to Arizona, followed by Louisiana and Arkansas at \$69 million and \$19 million respectively.

Figure 2-3: Value of Domestic Energy Inflows to Arizona by State or Origin (2012)



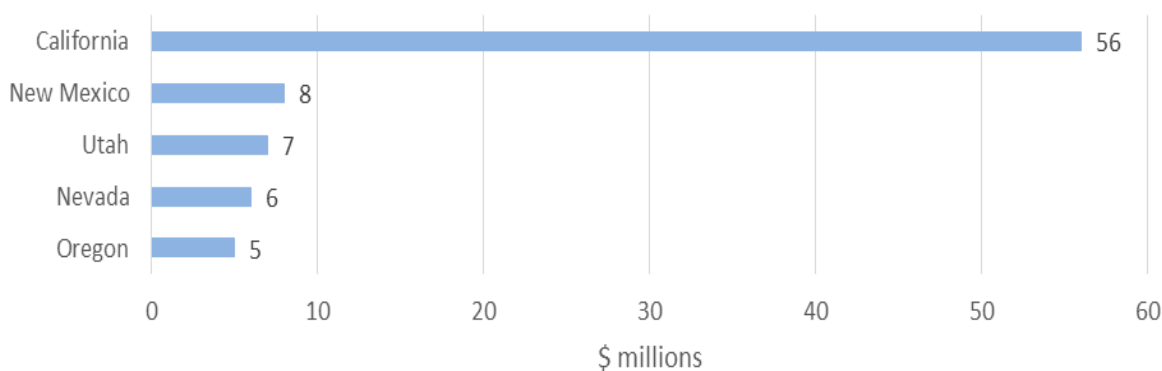
Source: CPCS analysis of Commodity Flow Survey, 2012.

Destinations of Domestic Outflows From Arizona to Other States

The figure below summarizes the destination of energy products originating in Arizona. California was the largest destination of Arizonan energy products, where \$56 million worth of products originating in Arizona were destined. Some of these flows to California may have been subsequently destined for international destinations through ports located in California.

Section 2.2.3 provides an overview of international trade flows to and from Arizona for the energy sector.

Figure 2-4: Value of Domestic Energy Outflows from Arizona by State of Destination (2012)

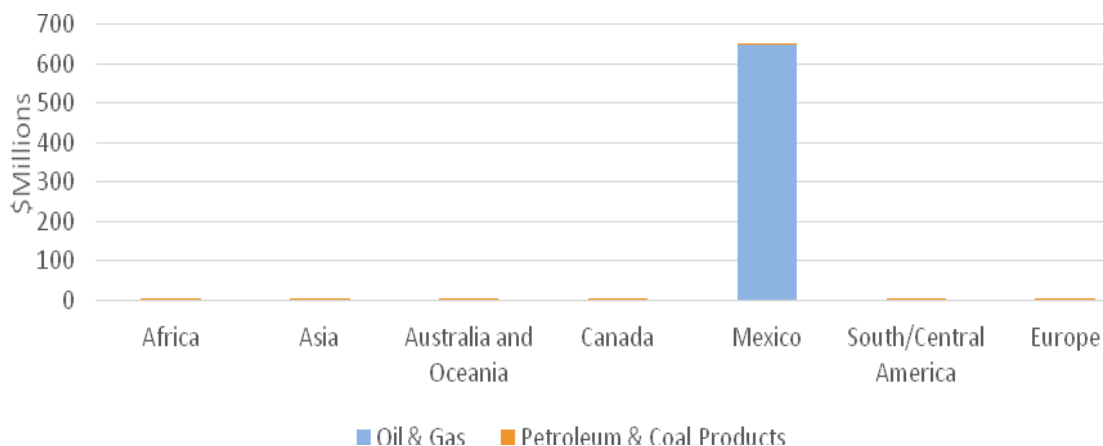


Source: CPCS analysis of Commodity Flow Survey, 2012

2.2.3 International Trade

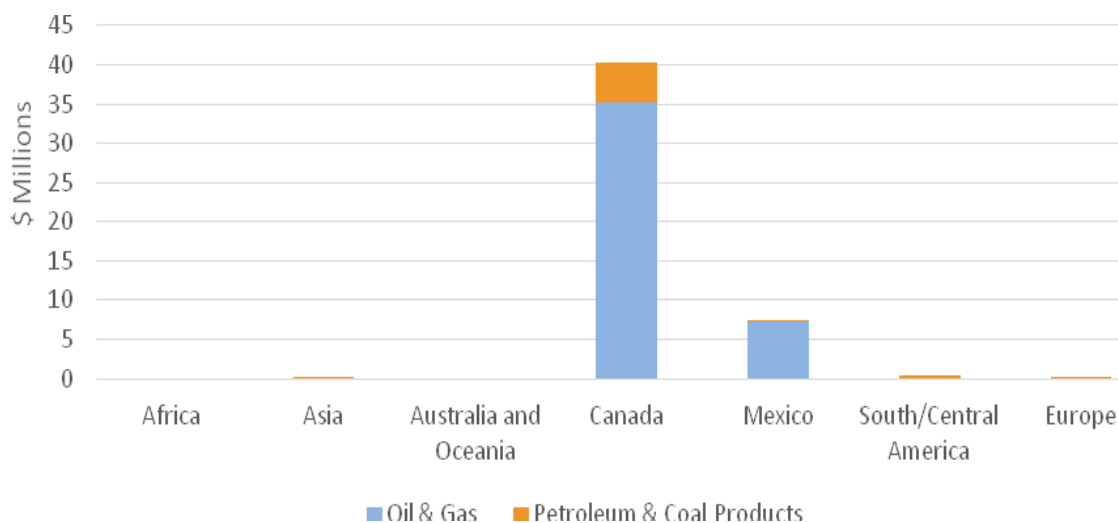
Exports from Arizona in the energy sector totalled \$661 million in 2014 while the state imported \$48 million of goods from the same sector. Exports of energy products are destined almost exclusively for Mexico.

Figure 2-5: Destinations of Arizonan International Energy Exports (2014)



Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

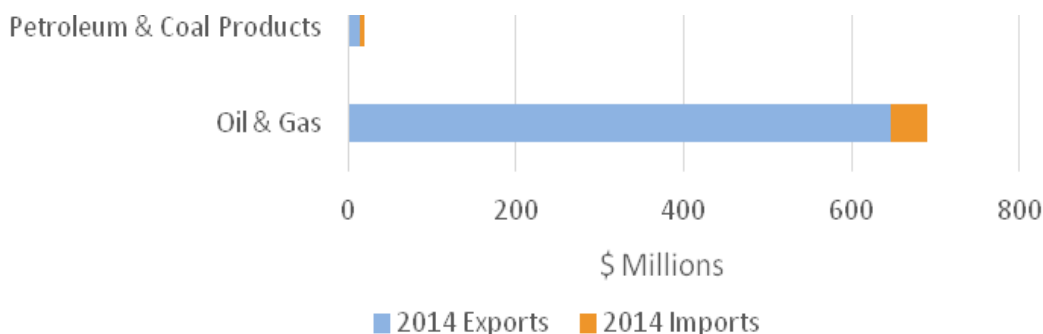
Figure 2-6: Origins of Arizonan International Energy Imports (2014)



Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

Almost all international trade for the energy sector relates to oil and gas, the vast majority of which is exports.

Figure 2-7: Top Traded Products in the Energy Sector (2014)



Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

2.2.4 Employment and Wages

The energy extraction and manufacturing sector is not a significant contributor to employment in the State. In 2013 the sector employed 322 people.^{5 6} The total wages and salaries paid to employees in 2013 was \$18 million dollars, making the average annual earnings per employee in 2013 approximately \$49,800 for the sector.

⁵ Excludes self-employment.

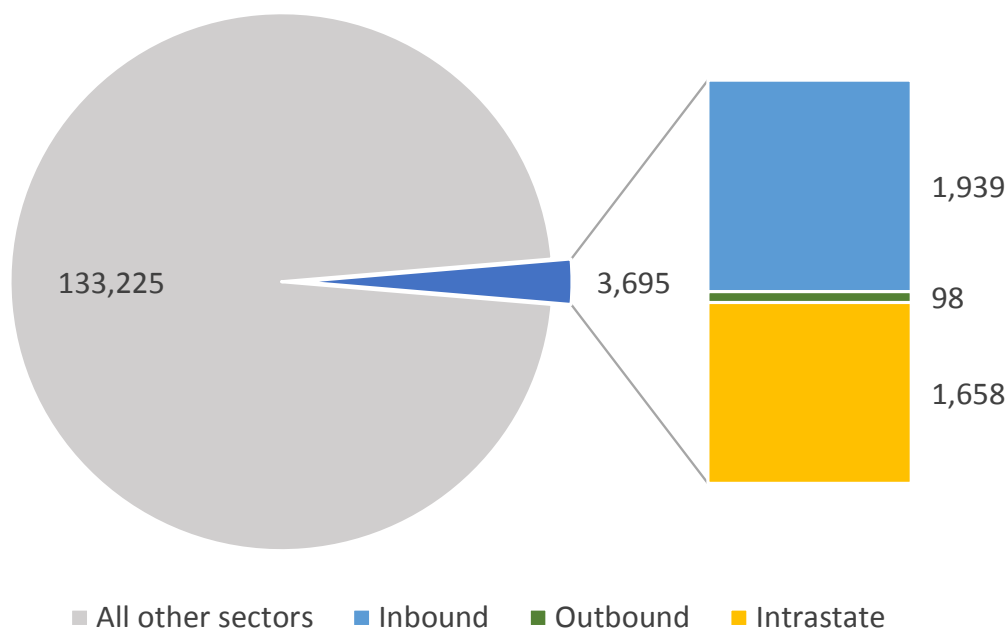
⁶ Bureau of Economic Analysis Regional Economic Accounts, Personal Income and Employment by State. SA7N Wages and Salaries by NAICS Industry

2.3 Locations and Traffic Profile

Arizona generates over 3.5 million tons (Mt) of freight traffic that are related to the energy sector. This is around 3 percent of the total freight generated by all the sectors in Arizona (Figure 2-8). The majority of the flows are either inbound (1.9 Mt or 52 percent) or intrastate (1.6 Mt or 45 percent) and a tiny proportion (3 percent) are outbound shipments.

The numbers presented here are obtained from Commodity Flow Survey (CFS), 2012. CFS accounts for only domestic movements. These include domestic shipments as well as the domestic components of international supply chains⁷. Please note that these volumes exclude the wholesale and retail shipments which is analyzed in a separate working paper on the wholesale and retail sector.

Figure 2-8: Arizona Energy Sector Volume ('000 Tons)



Source: CPCS analysis of Commodity Flow Survey, 2012.

2.3.1 Activity Clusters

The activity clusters were identified by the geographic distribution of employment in the energy sector (Figure 2-10)⁸. The largest concentration of oil and gas extraction activities are

⁷ In CFS, the sum of individual state volumes is slightly lower than the national volume which is due to data suppression and rounding in individual state-to-state movements. For consistency across all the graphics (maps and charts), this paper presents the total of state level volumes.

⁸ Sector-specific employment was estimated at the zip-code level from County Business Pattern Data, 2013 by U.S. Census Bureau, by multiplying the mid-point of employment range and the number of establishments.

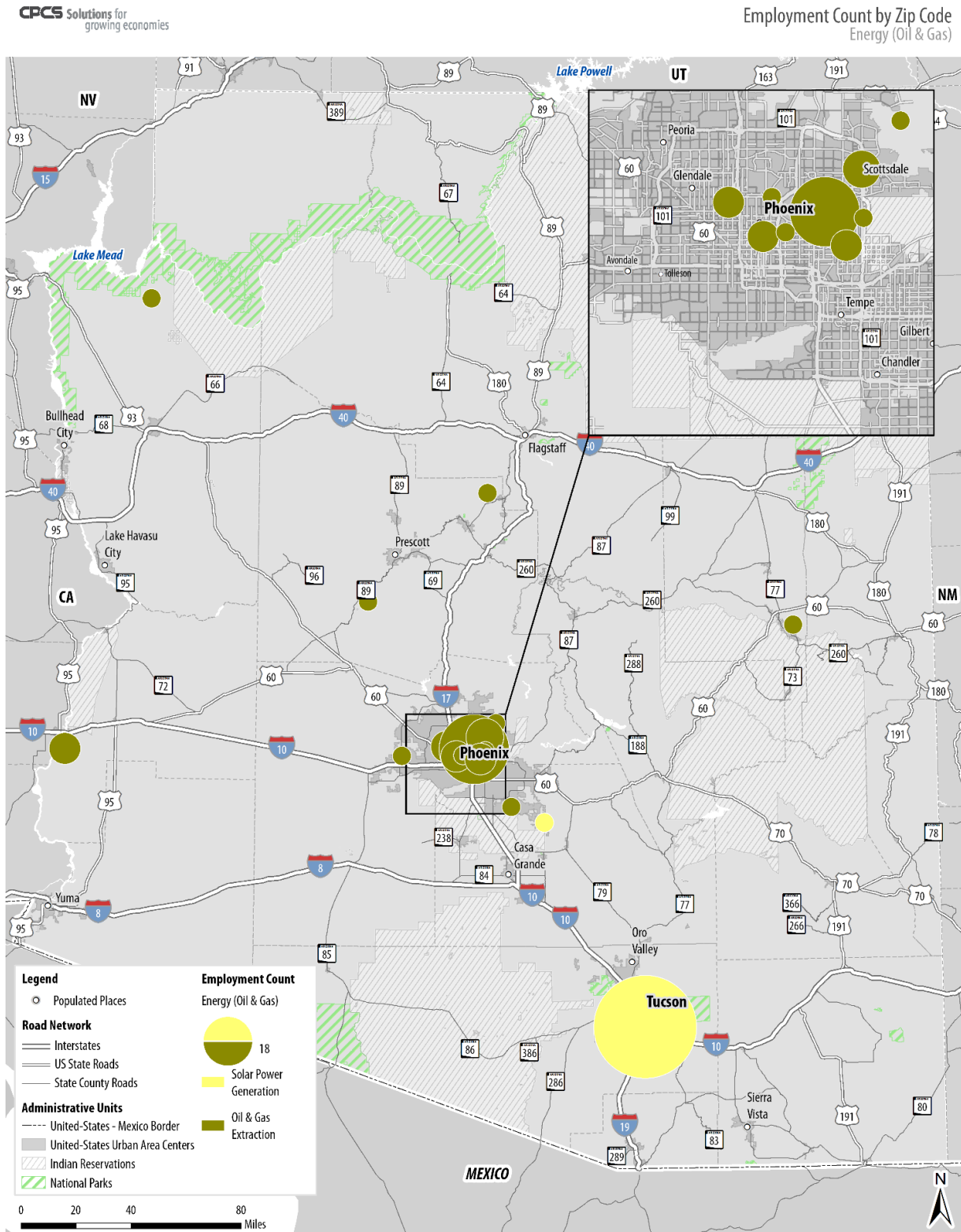
located in and around Phoenix. There is a major solar power generation hub in Tucson and to a smaller extent, in southeast of Phoenix. There are no oil refineries in Arizona.

Figure 2-9: Phoenix Petroleum Products Terminal



Source: CPCS

Figure 2-10: Arizona Energy Sector Employment Clusters

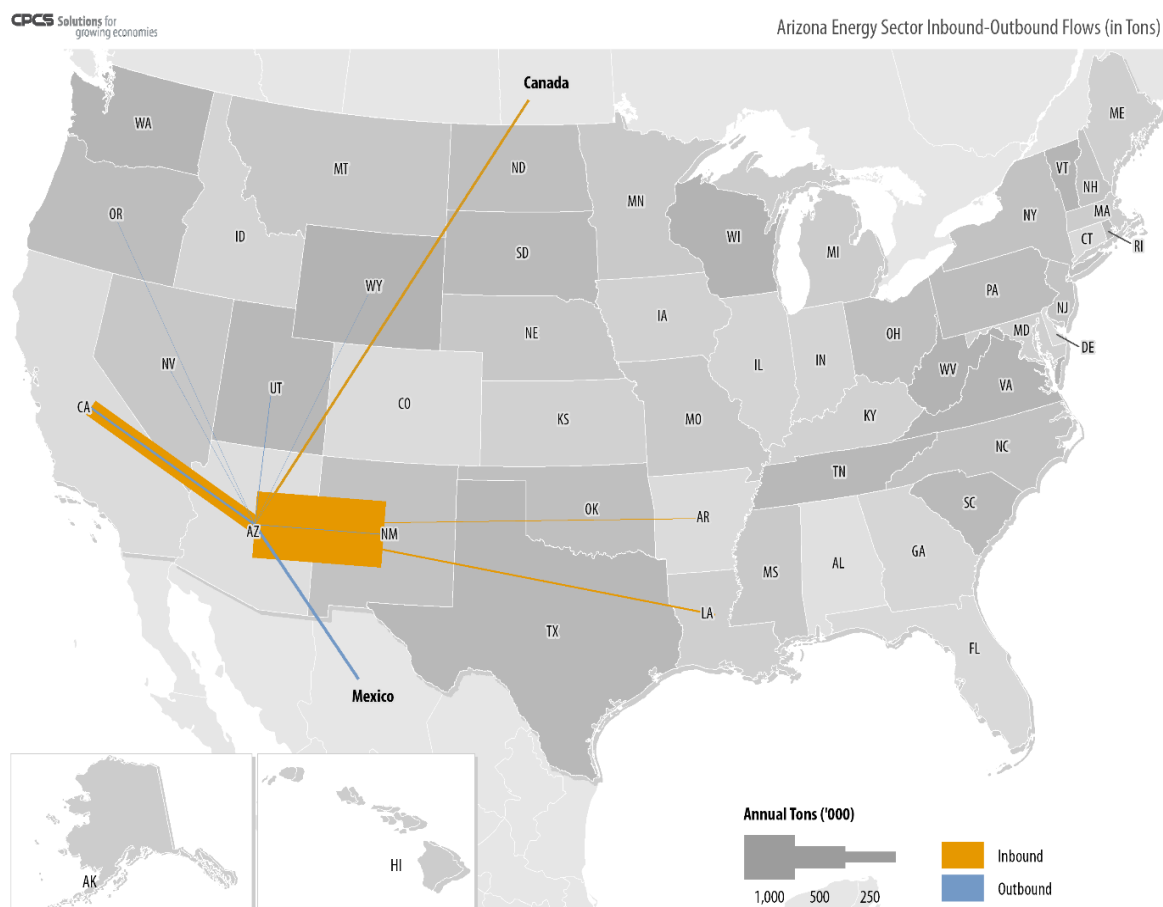


Source: CPCS analysis of County Business Pattern Data, 2013 by U.S. Census Bureau.

2.3.2 Major Origins and Destinations

Arizona's total inbound energy sector freight flows (2.0 Mt) originate overwhelmingly from New Mexico (natural gas and refined products) and California (refined products and some natural gas). Outbound traffic is much less significant (.2 Mt) and is destined to Mexico, California and a number of northwestern States.

Figure 2-11: Arizona Energy Sector Inbound-Outbound Tonnages



Source: CPCS analysis of Commodity Flow Survey, 2012. The import/export figures were obtained from Freight Analysis Framework 3 estimates for 2012.

2.3.3 Modal Breakdown

The U.S. Energy Information Administration indicates that most of the oil and gas supplied to Arizona is carried by the pipeline system. In the case of refined oil products, it is estimated that about 260,000 to 270,000 barrels per day of products have to be delivered to Arizona in order to maintain stock levels.⁹ Natural gas deliveries to Arizona reached 355.6 billion cubic feet in 2013.¹⁰

⁹ Based on annual consumption estimates and average sales.

¹⁰ Energy, Information administration, Report 176 – Natural Gas Deliveries, page consulted on 2015-06-24.

3 Supply Chain Structure and Transportation Performance Parameters

Key Messages

Petroleum product consumption in Arizona is supplied by two pipelines, both of which are owned and operated by Kinder Morgan and converge in Phoenix. Most of natural gas consumption in Arizona relies on deliveries which are made via one of the ten interstate gas pipelines. Arizona hosts a diverse solar manufacturing base ranging from solar tempered glass production to energy storage technologies. Solar panel manufacturing supply chains have a global nature and some major manufacturers and suppliers are located in Arizona.

Pipeline transportation performance is largely determined by costs and reliability to meet demand variability. Stakeholders believe that developing gas storage capacity in Arizona could improve the energy sector's supply chain performance.

In the future, the increased share of gas and renewables in Arizona's energy mix, the increased cost to build pipelines as well as the surge of demand for gas in Mexico will be the three major trends that will impact the energy sector.

3.1 Supply Chain Structure

3.1.1 Petroleum Products

Petroleum product flows in Arizona are composed of crude oil shipped outside of the State for refining and of refined products shipped to Arizona by pipeline for consumption.

In 2014, there were 19 oil-producing wells in Arizona. Total production reached 56,239 barrels. During drilling operations, muriate of potash may be used to prepare brines for drill-in, completion, and workover fluids. Nacogdoches Oil and Gas Inc. and the Navajo Nation Oil & Gas Co. were the two major well operators. Production occurred in three distinct fields (Dineh-bi-Keyah, Dry Mesa and Black Rock) located in Apache County. According to the Energy Information Administration, Arizona ranks 30th in terms of oil production by State and as such, it depends on supply from other States to meet internal demand.

There are no oil refineries in Arizona. The closest refinery is located in Gallup, New Mexico. In this context, oil production is trucked outside of the state.

Petroleum product consumption in Arizona is supplied by two pipelines, both of which are owned and operated by Kinder Morgan and converge in Phoenix (see Figure 2-1). From Wilmington, California, the 20-inch “West Line” enters Arizona in the Yuma area and then flows towards Phoenix where products are stored before distribution and consumption. It has a capacity of 204,000 barrels per day.¹¹ The “East Line” which is composed of two parallel pipelines (16-inch and 12-inch) that originate in El Paso, Texas. It enters Arizona in the San Simon area and heads to Tucson before turning north-west to reach Phoenix and has a capacity of over 200,000 barrels per day.¹² The Phoenix terminal can also be supplied by a rail offloading facility. About 260,000 to 270,000 barrels per day have to be delivered to Arizona to maintain stock levels.¹³

¹¹ PRNewswire, 2006, Kinder Morgan's \$210 Million East Line Expansion Complete and in Service - More Fuel for Arizona, page consulted on 2015-06-24.

¹² Kinder Morgan, Products Pipelines – East Line, page consulted on 2015-06-24.

¹³ Based on estimated annual consumption and average monthly sales by year.

Figure 3-1: Phoenix Petroleum Products Terminal



Source: CPCS

It was estimated in 2011 that the two petroleum products terminals of Arizona can hold about three to five average days of demand.¹⁴ Petroleum products supply chains of Arizona were therefore operating largely on just-in-time basis where any disruption of supply can have significant impacts on consumption. According to EIA data, average stocks of gasoline in Arizona's bulk terminals were about two million barrels in 2013 and 2014. This value was of about 957,000 barrels for distillate fuels.¹⁵ Considering an estimated consumption of 97.2 million barrels of petroleum products in 2013¹⁶, average stocks of petroleum products in Arizona were capable of covering about 11 days of average consumption.

While petroleum products are generally distributed by trucks to retailers, the Luke and Davis-Monthan Air Force bases in Phoenix and Tucson are linked to Kinder Morgan's terminal facilities by six-inch pipelines.

3.1.2 Natural Gas

The Energy Information Administration (EIA) reports that there were five gas wells in operation in Arizona in 2013. Production which averaged nearly 450 million cubic feet (mcf) between 2000 and 2009 decreased significantly in 2010 to about 183 mcf¹⁷. The decline continued in following years to reach 12.4 mcf in 2014¹⁸. It is not expected that production will increase in the short to medium terms because most wells are reaching the end of their productive life. This production also occurs in Apache County but it is essentially concentrated in the Dry Mesa and Black Rock fields. Once extracted, the gas is recovered and fed into the pipeline system.

¹⁴ Source: Arizona State University, 2011, *Arizona's Energy Future*, Arizona Town Hall, 163 pages. This evaluation did not provide precisions on the type of demand (i.e.: wholesale, retail, industrial, etc.)

¹⁵ Energy Information Administration, *Refinery, Bulk Terminal, and Natural Gas Plant Stocks by State*, page consulted on 2015-06-24.

¹⁶ Energy Information Administration, *Arizona Profile Data – Consumption and Expenditures*, page consulted on 2015-06-24.

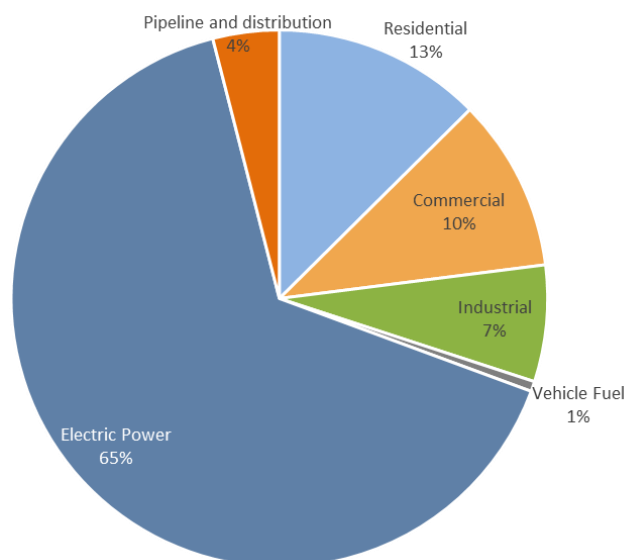
¹⁷ Energy Information Administration, *Arizona Natural Gas Marketed Production*, page consulted on 2015-06-24.

¹⁸ Source: Arizona Geological Survey, *Oil, Gas, Helium Production Report – December 2014*, 5 pages.

Most of the gas consumed in Arizona thus relies on deliveries which are made via one of the ten interstate gas pipelines. According to the EIA, net receipts of natural gas were of 333,353 mcf in 2013. These volumes essentially flowed from the Permian Basin (Texas and New Mexico). Total volumes carried in Arizona's gas pipeline network are actually much higher, notably because over 900,000 mcf of gas transits from New Mexico and Texas to California.

Unless it is liquefied, natural gas is difficult to store efficiently and there are no underground gas storage facilities in Arizona. Gas is thus supplied directly to consumers through distribution pipelines. In 2013, the EIA reported that 65 percent of gas consumption in Arizona was used to produce electricity. Residential and commercial consumers followed behind at 13 percent and 10 percent, respectively.

Figure 3-2: Natural Gas Consumption By User in Arizona



Source: CPCS from EIA data

3.1.3 Solar Power

Solar power supply chains differ depending on technologies used. Concentrated solar power (CSP) technologies produce power by concentrating sunlight with mirrors or lenses into a solar power tower which converts sunlight into heat and then electricity. The technologies associated with CSP are essentially used for utility-scale projects. As of February 2015, there is one 280 megawatts (MW) CSP in operation in Gila Bend, three projects totalling 690 MW under development and one smaller five MW project is under construction in the area of Tucson.¹⁹ It is unlikely that there will be more engagements by utilities in major solar power

¹⁹ Solar Energy Industries Association, 2015, *Major Solar Projects in the United States*, 50 pages.

producing capacity because they are already close to meeting their renewable energy standard targets.²⁰

The other predominant technologies rely on photovoltaic cells to produce energy. The most common are crystalline silicon cells which occupy about 93 percent of the market while thin-film cells occupy 7 percent. Both these technologies are used to manufacture solar panels. Solar cells and panel framing sourcing is essentially cost-driven while glass, bus wiring and junction require some level of qualification and quality.²¹

The most recent EIA data on solar thermal power collector production in the U.S. indicates that 164 thousand square feet of panels were shipped from Arizona in 2009. This represented about 1 percent of total U.S. shipments. The EIA also indicates that solar panel manufacturing in Arizona essentially consisted of crystalline silicon and thin-film modules²² but the State hosts diverse solar manufacturer ranging from solar tempered glass production to energy storage technologies. Arizona ranked third in terms of destination of solar panels, receiving 745 thousand square feet of panels, or 5 percent of total shipments made to the U.S. As of 2014, there were about 50 manufacturers associated with the solar power industry in Arizona.²³

3.2 Transportation Performance Parameters

The performance of oil and gas transportation in Arizona relates to pipeline reliability and costs. With limited oil/refined products storage capacity and no gas storage capacity, pipeline reliability is crucial for electricity production as well as domestic and transportation uses. In the case of costs, consultations revealed that construction costs for pipelines have been increasing. This impacts the capital costs of infrastructure and then ultimately the price of flowing gas to utilities and consumers.

Transportation performance can have an impact on solar power supply chains. However, transportation costs are typically a fraction of manufacturing and this has led to diverse supply chain structures that can support global sourcing strategies.²⁴ In such a context, many manufacturers have specialised in specific solar panel components which have very different transportation performance parameters ranging from cost for lower value inputs such as polysilicon ingots to product integrity preservation for glass, electrical systems and modules.

²⁰ Evans, A. and Gamez, M., 2014, *Arizona's Solar Logistics Chain: Part 2 Solar Manufacturing Case Studies*, L. William Seidman Research Institute, 34 pages.

²¹ Chen, J., 2011, *Renewable Energy Supply Chains – A Guide for Economic Developers*, International Economic Development Council, 55 pages.

²² EIA, 2013, *Solar Photovoltaic Cell/Module Shipments Report 2012*, 31 pages.

²³ *Op. cit.* 20.

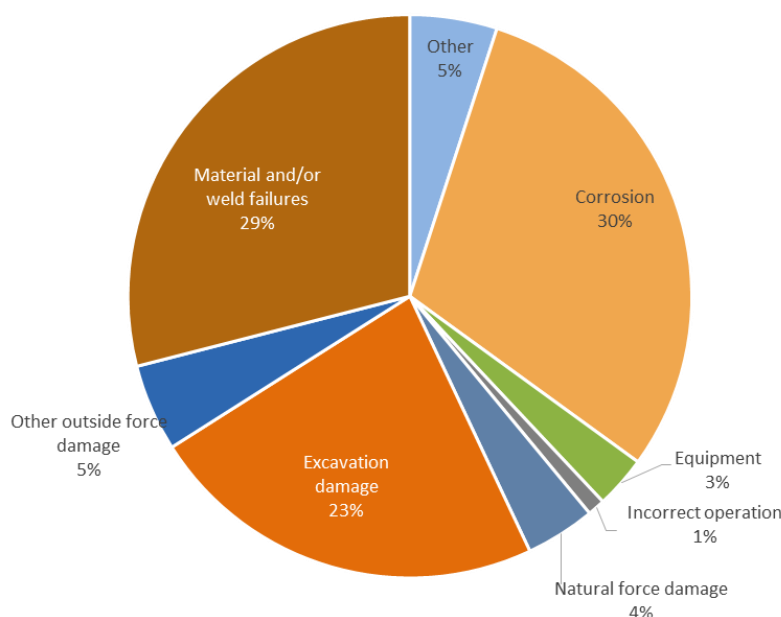
²⁴ Deutch, J. and Steinfeld, E., 2013, *A Duel in the Sun – The Solar Photovoltaics Technology Conflict between China and the United States*, MIT, 27 pages.

3.3 Barriers to Transportation Performance

In Arizona, the absence of gas storage facilities is often cited as one of the major barriers to the energy sector's supply chain performance and this has been confirmed through consultations. Although plans to build large-scale gas storage capacity exist, market conditions apparently do not justify such investments. For example, the Picacho Peak Gas Storage project was originally expected to begin construction in 2011. In the absence of sufficient customer commitments, this project is currently on hold.²⁵

Transmission pipeline incidents and accidents may have various causes.²⁶ Between 2005 and 2009, the causes of significant onshore hazardous liquid pipeline incidents were mostly (59 percent) associated to corrosion and material and/or weld failures. Excavation damage followed at 23 percent while outside force damage and natural force damage respectively caused 5 percent and 4 percent of incidents (Figure 3-3). Similar values can be observed for significant incidents on gas transmission pipelines.

Figure 3-3: Causes of Significant Onshore Hazardous Liquid Pipeline Incidents
(Right-of-Way Line Pipe Only – 2005-2009)



Source: CPCS from PHMSA data

²⁵ Source: Picacho Peaks, page consulted on 2015-06-30.

²⁶ PHMSA, 2010, *Building Safe Communities: Pipeline Risk and its Application to Local Development Decisions*.

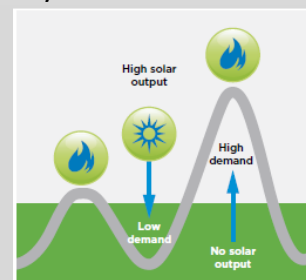
3.4 Trends and Implications

In the context of population and economic growth which significantly influence energy demand, Arizona's utility companies are currently changing their energy portfolios to increase the use of renewable energies such as solar and wind. Due to the variable nature of solar and wind power, increased capacity in natural gas generation is also sought. Collectively, the four major electricity utilities of Arizona are expected to add over 6,000 MW of natural gas power as well as 944 MW of renewable power between 2014 and 2028.²⁷

Arizona Public Service 2014 Integrated Resource Plan²⁸

The Arizona Corporation Commission's Resource Planning and Procurement rules require large utilities to file a report on their statewide integrated resource plans (IRP) every two years.

In 2014, the energy mix Arizona Public Service (APS) relies extensively on coal and nuclear power which respectively represent 35 percent and 28 percent of the company's energy mix. By 2029, the share of natural gas in this mix is expected to reach 28 percent and become APS's most important source of power. In the case of renewables (including distributed energy), its contribution to APS's energy mix is expected to increase by 118 percent between 2014 and 2029. It is considered that the selected scenario for APS's most recent resource plan, "... provides the most reasonable combination of overall economic performance, and flexibility in the generation fleet to support grid reliability, integrate renewable energy and manage uncertainties." In the short- to medium-term, APS plans to:



Flexible generation assets help balance the grid by bridging the gap between traditional and renewable resources

- Transition resource portfolio while ensuring an adequate supply of resources
- Update conventional generation resources
- Continue expansion of renewable generation
- Add transmission resources
- Evaluate and decide on remaining coal fleet
- Continue implementation of customer resources
- Invest in advanced grid technologies

²⁷ Global Energy and & Water Consulting and Evans Power Consulting, 2014, *Assessment of the 2014 Integrated Resource Plans of the Arizona Electric Utilities*, 115 pages.

²⁸ APS, 2014, *2014 Integrated Resource Plan*, 446 pages.

Another trend mentioned during consultations consists of a surge of growth opportunities for the delivery of gas to Mexico. For example, U.S. exports of natural gas south of the border grew from about 333 billion cubic feet in 2010 to nearly 770 billion cubic feet in 2014.²⁹ The fact that natural gas will increasingly be used in Arizona's energy mix as well as increased market opportunities in Mexico will certainly translate into more pipeline capacity. This is constantly monitored and evaluated by pipeline operators and their clients. While cost is a determining factor for pipeline operators to competitively deliver gas to their clients, reliability is also critical.

Pipeline and Hazardous Materials Safety Administration (PHMSA) data do not report any hazardous liquid pipeline incidents or accidents in Arizona between 2010 and 2014. The most recent incident on an interstate hazardous liquid pipeline dates back to May 2009 when a hydraulic ram shaft failed and caused a three and a half hour shutdown of Kinder Morgan's West Line south of Phoenix. In 2003, stress corrosion cracking resulted in the shutdown of Kinder Morgan's East Line in Tucson. This shutdown lasted a little over two days but it is reported that up to 2.3 million gallons per day of gasoline were not delivered to Phoenix.³⁰ Incidents on natural gas transmission pipelines have occurred in Arizona in recent years. PHMSA data reports four incidents on this network since January 2010. These incidents caused shutdowns of one to two days.

Provided that Arizona is essentially supplied in petroleum products and gas through interstate pipeline networks, incidents and accidents occurring outside of the state can impact the reliability of supply to Arizona. At the national level, the PHMSA reports a downward trend in the annual number of significant hazardous liquid pipeline incidents while there has been an increasing trend in the annual number of natural gas transmission pipeline significant incidents.

Such statistics indicate that pipeline integrity management is a key element in mitigating the barriers to pipeline performance. In a context where excavation damages are responsible for over 20 percent of significant incidents, prevention programs are also considered to be decisive elements in mitigating the barriers to pipeline performance.

The rapid expansion of photovoltaic panel production worldwide led to overproduction and by 2008, prices for solar panel modules started to decrease significantly. The U.S. Department of Energy notably reports that modeled system prices for photovoltaic systems in the residential sector decreased from \$6.91/Watt in the fourth quarter of 2009 to \$3.29/Watt at the end of 2013.³¹ Similar reductions were observed in the commercial and utility sectors. Even if transportation costs are a fraction of manufacturing, the reduction in prices has

²⁹ Energy Information Administration, U.S. Natural Gas Exports and Re-Exports by Country, page consulted on 2015-06-26.

³⁰ *Op. Cit.* 14.

³¹ Feldman *et al.*, 2014, Photovoltaic System Pricing Trend – Historical, Recent and Near-Term Projections – 2014 Edition, SunShot – U.S. Department of Energy, 31 pages.

strongly impacted profit margins in the industry and manufacturers of solar modules are actively working on strategies to improve logistical efficiencies, notably in transportation.

The Governor's Office of Energy Policy reported at the end of 2014 that decreasing demand for solar power portends negatively for Arizona solar component manufacturers.³² This situation stems from the fact that electricity utilities consider being ahead of their renewable energy goals. In this context, it is not assumed that the solar energy sector will generate significant pressure on Arizona's transportation network, at least in the short and medium terms. Arizona's solar industry could however witness growth in coming years as technologies mature and improve in performance.³³

³² Governor's Office of Energy Policy, 2014, *emPOWER Arizona*, 116 pages.

³³ *Ibid.*

4

Sector Priorities for Transportation System Performance Improvement

Key Messages

In recent years, the refined products pipeline network of Arizona has been improved to increase capacity and reliability. In the case of natural gas, many stakeholders note that the State requires gas storage capacity to meet peak demand and increase the reliability of supply chains. However, gas pipeline operators are continuously monitoring demand and capacity with clients. This enables them to pinpoint priority improvement needs and to develop required capacity as needed.

In the case of solar power, the global nature of the industry, the limited share of transportation in total costs and significant variability in supply chain structures of the various solar panel components makes it difficult to prioritize specific improvements in Arizona's transportation system. For example, though some major solar panel suppliers such as Kyocera Solar or First Solar are headquartered in Arizona, they do not necessarily manufacture or have logistical facilities in Arizona.

4.1 Priority Improvements Needs

4.1.1 Petroleum Products

In 2006, Kinder Morgan indicated that it replaced more than 230 miles of eight-inch diameter pipeline between El Paso and Phoenix with new 16-inch and 12-inch diameter pipe. This was followed in 2007 by the modernization of the East Line which involved the replacement of about 130 miles of eight-inch diameter pipeline between El Paso and Tucson with a new 16-inch diameter pipe. This increased the capacity on the East Line to over 200,000 barrels per day. Such modernization efforts considerably improved the reliability of petroleum products supply chains in Arizona.

4.1.2 Natural Gas

Many stakeholders note that the State requires gas storage capacity to meet peak demand and increase the reliability of supply chains. According to the EIA, past efforts to build storage which would mitigate supply disruptions have encountered financial and environmental constraints.³⁴ Major pipeline operators in the state such as Kinder Morgan³⁵ and Transwestern Pipeline Co.³⁶, as well as utilities like Arizona Public Service³⁷, Arizona's G&T Cooperatives³⁸, Salt River Project³⁹ and Tucson Electric Power⁴⁰ however believe that gas supply is reliable and sufficient to meet short term demand. In its 2015 summer preparedness presentation to the Arizona Corporation Commission, Kinder Morgan nevertheless notes that it pursues the objective of implementing gas storage capacity.⁴¹ This would enable the company to provide no-notice service and hourly delivery variability; enhance flow capacity and overall system reliability.

In the case of pipelines, operators are continuously monitoring demand and capacity with clients. This enables them to pinpoint priority improvement needs and to develop required capacity as needed. However, the costs of infrastructure projects tend to increase and this impacts the delivery costs of gas.

³⁴ Energy Information Administration, 2015.

³⁵ Kinder Morgan, 2015, *El Paso Natural Gas Pipeline – Summer 2015 Energy Preparedness*, Presentation to the ACC.

³⁶ Transwestern Pipeline Company, 2015, *Summer Preparedness Update*, Presentation to the Arizona Corporation Commission.

³⁷ APS, 2015, Arizona Public Service Company 2015 Summer Readiness, Presentation to the Arizona Corporation Commission.

³⁸ Arizona's G&T Cooperatives, 2015, *Arizona's Cooperatives Summer Preparedness Report to ACC*. 2015

³⁹ Salt River Project, 2015, *SRP Summer Preparedness 2015*, 4/15/2015 ACC Hearing.

⁴⁰ Tucson Electric Power and UNS Electric, 2015, *2015 Summer Preparedness*, Presentation to the Arizona Corporation Commission.

⁴¹ *Op. cit.*: 35.

4.1.3 Solar Power

The solar panel industry in Arizona has benefited from its proximity to California (a major market for solar power in the U.S.), the low cost of doing business and governmental initiatives.⁴² The global nature of the industry, the limited share of transportation in total costs and significant variability in supply chain structures of the various solar panel components make it difficult to prioritize specific improvements in Arizona's transportation system. However, assuming shipments of solar panels to Arizona were of 745,000 square feet in 2009 and that shipments from the state reached 164,000 square feet, the solar energy industry is not considered to generate significant pressure on Arizona's transportation system. For example, at 2.5 pounds per square foot⁴³ and a conservative payload of 30,000 pounds per truck, the total amount of trucks loaded with solar panels shipped to Arizona in 2009 would have been 62. Furthermore, as noted above, although some major solar panel suppliers such as Kyocera Solar or First Solar are headquartered in Arizona, they do not necessarily manufacture or have logistics facilities in Arizona. For example, First Solar's manufacturing facilities in the US are located in Ohio while Kyocera's distribution facility is in California.

⁴² *Op cit.*: 20

⁴³ Value estimated from technical parameters for a solar panel on Alibaba.com. About 12 kg/m², page consulted on 2015-06-01.

Appendix A: List of Stakeholders Consulted

Name	Title	Organization
Steven L. Rauzi	Oil and Gas Administrator	Arizona Geological Survey
Tom Dobson	Business Development	El Paso Natural Gas
Melissa Ruiz	Manager, Corporate Communications and Public Affairs	Kinder Morgan
Melissa Chavez	Inside Sales Representative	Kyocera Solar
CJ Woody	HSE Manager	Navajo Nation Oil & Gas