Netherlands Business Support Office
Texas

2016-2017

Renewable energy potential in Texas and business opportunities for the Netherlands

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September 2016 – February 2017

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1. Introduction

Texas has great potential in the energy sector. Advantages such as an independent energy grid make development in the energy industry quite attractive. Together with its long leadership in the oil and gas industry, Texas has developed the skills and the potential to stand out in the renewable energy industry next to States as California, Washington or Oregon (TexasWideOpenForBusiness 2014). The resources and opportunities serve not only to attract American businesses but could allow Dutch businesses to profit from Texas' advantage in the renewable energy industry sector, too.

Dutch businesses, however, need support in getting familiar with the way of doing business in Texas. The Netherlands Business Support Office in Texas (NBSO Texas) belongs to the Dutch economic network in the United States and provides support to businesses seeking to start up or to trade in the U.S. They are a valuable source for connecting Dutch businesses and their trade activities to Texas' potential of (renewable) energies. But are there sufficient opportunities and competitive advantages for Dutch businesses and their trade activities in the field of renewable energies? Is there a benefit related to these trade activities? What are market threats and how can they be prevented? Which stakeholders are necessary to involve those Dutch businesses into the trade with Texas and into a profitable way of connecting to the renewable energy sector? Commissioned by the NBSO, these questions will be answered in this advisory report.

1.1. Research Question

According to this introduction, the following research question is formulated:

To what extent can there be potential for trade promoting activities on the field of renewable energies in Texas for Dutch businesses?

The report will answer this question by zooming in on these sub questions:

- What is the potential of renewable energy in Texas?
- Can this potential be translated into business opportunities for Dutch businesses?

1.2. Method

The first question will look at the economic and geographical and geological potential for every renewable energy resource. The potential is dependent on questions such as locations, energy storage, supply to the customer (transmission), reliability and economic incentives in Texas. The second question addresses challenges Dutch businesses could have when entering the Texan (renewable) energy market and comparative advantages they could make use of.

Questions will be answered based on what is found in the literature and in the Texan renewable energy market environment. Websites of businesses and organizations and newspaper articles are added to the academic literature. Apart from that, interviews and personal communication with relevant parties in the renewable energy sector in Texas and the Netherlands will give a more detailed insight into what matters for the stakeholders in this sector. The interviews are semi-structured by making use of a rough guideline of questions, but also following the flow of the conversation.

1.3. Definition of renewable energy

Before enhancing the possibilities and potentials of renewable energy in Texas, a clear definition of renewable energies has to be given. This research uses the definition of the Texas Renewable Energy Industry Alliance (TREIA), which is found back in academic literature (e.g. Ellabban et al. 2014) as well:

"Any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources" (TREIA 2016).

Renewable energy falls under the term of sustainable energy, which means:

"*The provision of energy such that it meets the needs of the future without compromising the ability of future generations to meet their own needs. (See Sustainable Development). Sustainable Energy has two key components; renewable energy and energy efficiency" (Renewable Energy & Energy Efficiency Partnership 2010).*

So sustainable energy is a broader term because it includes renewable energy *and* energy efficiency and it includes the ability of energy to not be exhausted in the far future. With regard to time and detail, this paper will focus mainly on renewable energy. Renewable energy consists of flow renewables, which come from a continuous flow of energy. Stock renewables differ from flow renewables since using stock renewables today has an impact on using them tomorrow, whereas flow renewables can be used consequently without their use today influencing their use tomorrow. Stock renewables include for example agricultural land or forests and flow renewables include solar, wind or tidal energy (Perman et al., 2011). Here, stock renewables such as biomass will be taken into account, too.

Nuclear energy is subject to discussion whether it is renewable or not. It certainly does not pollute the atmosphere with CO2, SO2 or NOx. However, to generate heat from fission of atoms it requires uranium, a finite resource on Earth. According to Bernhard L. Cohen, "if the Uranium deposit could be proved to last as long as the relationship between the Earth and Sun is supposed to last (5 billion years) then nuclear energy should be included in the renewable energy portfolio" (Stanford University 2012). In this way, it is still debatable whether to include nuclear energy in renewable energy generation. This report will shortly assess the potential of nuclear energy in Texas.

1.4. Units

As a main use of renewable energy is the production of electricity it is useful to know the following measurement units:

Power is described in watts and the rate per unit of time at which electric energy is transferred by an electric circuit.

Energy is the total amount of electricity consumed over a period of time and often measured in megawatt-hours (MWh) or British Thermal Units (BTU). One MWh equals 3.4 million BTU. In this report, MWh are used. One MW of electricity is enough to power approximately 300 homes (Texas Wide Open For Business 2014).

Unit	Abbreviation	Decimals
Milliwatt	mW	0,001 W
Watt	W	1 W
Kilowatt	kW	1000 W
Megawatt	MW	1000 000 W
Gigawatt	GW	1000 000 000 W
Tetawatt	TW	1000 000 000 000 W
Petawatt	PW	1000 000 000 000 000 W

Smaller units than milliwatt do of course exist but are not used in this report.

2. The current market situation for energy in Texas

Being the second largest state of the United States after Alaska, with the second largest population number after California, Texas accounts for more than one eighth of the nation's energy consumption. Most of this consumption is accounted for by industries such as petroleum refining, chemical manufacturing and transportation (U.S. Energy Information Administration 2016). Since 1901 Texas has been known as a foremost producer of energy in the nation and with the discovery of new oil fields through the decades, the oil sector has influenced Texas' economy like no other sector. The production of crude oil and electricity in Texas are on first place as well as natural gas which accounted for 29% of U.S. marketed gas production in 2014. Production of coal ranks seventh place in the U.S.

2.1. An independent electricity grid

Energy generation, transmission and frequency regulation services are being ensured by the Electric Reliability Council of Texas (ERCOT), which separates Texas' electric grid from the nations' other electricity grids and makes it independent from federal regulation (Texas Wide Open For Business 2014). Covering 75% of the state's landmass and representing 90% of the state's electric load, ERCOT works as a membership-based, non-profit corporation and is supervised by the Public Utility Commission of Texas (PUC) and the Texas Legislature (ERCOT 2016). The latter one introduced the free choice of the Retail Electricity Provider (REP) for consumers in 1999. This was enforced in 2002. The utilities of the competitive whole sale electricity market offer their energy to REPs who then sell it to consumers. Generators are registered under ERCOT as Resource Entities and retailers are referred to as Load Serving Entities (ERCOT 2016).

ERCOT serves as an exchange market in which they dispatch the generation to meet the load. In ERCOT's day-ahead market, generators give bids to offer and REPs give bids to buy MWs for every hour. Qualified Scheduling Entities can submit bids and offers on behalf of generators and retailers. ERCOT clears the market by determining which quantity has to be generated for which price. The load will always be met, if REPs were not able to buy the full quantity of MWs from the generator, they will have to buy the difference on the real time market for any price (thus being price takers) (Hailu 2016). Large MW quantities for a relatively small price give a price signal to investors. The current production levels thus do also give an indication about which fuel type is relatively cheap. Since 2011, ERCOT opened the nodal market, which addresses congestion problems by pricing on a local level instead of dispatching electricity on a zonal level. Load is still charged a load weighted averaged zonal price, but generators are paid a price for every MWh they injects into the grid at a local price. This is called the nodal price and it is created every five minutes in the real time market (Hailu 2016). The zonal price is calculated every 15 minutes (ERCOT 2016).

2.2. The main fuel types supplied

Figure 1 below gives an oversight of the main fuels produced under ERCOT in 2015. Natural gas accounts for 43,7% of all fuel generation, followed by coal, which underwent significant decrease in 40% in 2010 to 28,8% in 2016. One fuel type which may not be the most straightforward to think of is wind energy, which holds 15,1% of the fuel generation in 2016, which is 2,9% more than nuclear power. Other generation includes solar, hydro, petroleum coke, biomass or landfill gas) (U.S. EIA 2016). According to the U.S. Energy Information Administration (U.S. EIA), Texas households consume an average of 22,56 MWh per year which puts them 14% below the U.S. average. Electricity consumption is 26% higher in Texas compared to the other states. Total energy consumption per capita in Texas ranks sixth compared to the other states, with natural gas being the main energy product consumed. Electricity use peaks in summer, when the heat requires more air conditioning (U.S. EIA 2016). There was a 2.4% increase in ERCOT load (equal to an average increase of 866 MW per hour) from 2014 to 2015, which underlies the hotter temperatures. This could be particularly experienced in larger cities such as Houston and Dallas (Potomac Economics 2016). Generally, load increases year by year (ERCOT 2016).

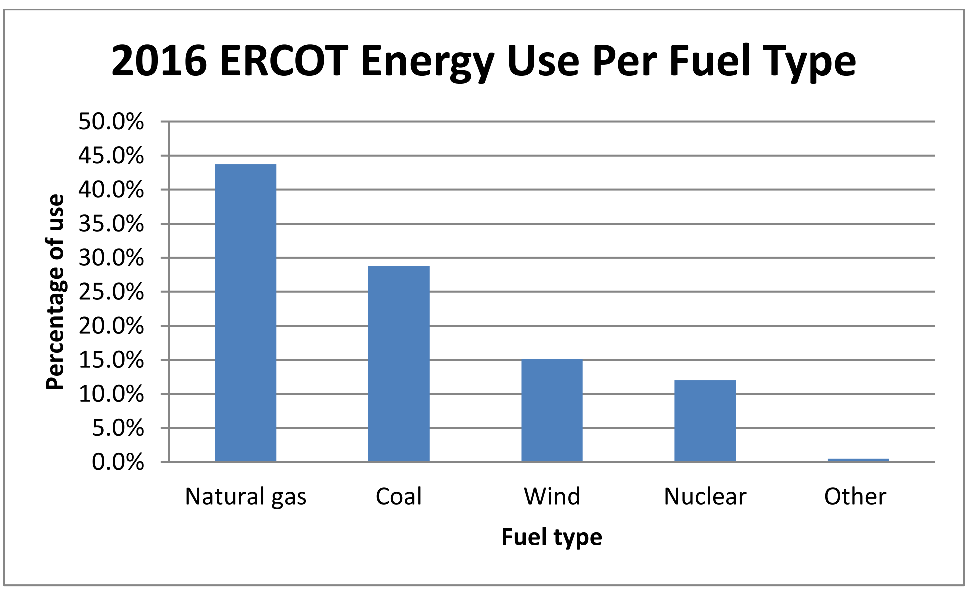


Figure 1. 2016 ERCOT Energy Use Per Fuel Type. U.S. EIA 2016.

In 2015, 4.8 GW of new generation resources came online, only providing 1.7 GW of net effective capacity. 3.7GW of this new generation comes from wind resources, which only effectively provides approximately

600MW of wind capacity. Of the remaining 1.1 GW, 100 MW are contributed to newly installed solar resources, while 1 GW of this consists of new natural gas combined cycle units (Potomac Economics 2016).

In ERCOT, energy prices are generally low. Natural gas prices contributed to the 34% lower load weighted average real time energy price in 2015 as compared to 2014. In 2015, this average real time energy price was $26.77 per MWh. The experienced growth in natural gas underlies the development of new technologies such as hydraulic fracturing, also known under the name “fracking”. Also, natural gas has become more an investment opportunity and is traded as a commodity. This comes from the interaction of the physical market, in which the energy has to be physically delivered and of the financial market, in which investments and various exchanges occur, which do not have to be presented physically (FERC 2015). The low production costs, environmental benefits compared to oil and coal and the pipeline expansions make the demand for natural gas rise in the coming years (FERC 2015). Even so, low oil prices and competition from other energy sources propose new challenges for producers while partly representing benefits for consumers (Hartmann and Sam 2016), (Tsai 2016). Under current trends, ERCOT expects natural gas generation to grow from 39.4% in 2017 to 43.6% by 2031 (ERCOT 2016). Furthermore, ERCOT expects most of the coal units to retire in future scenarios, affected by cheap gas prices and the Regional Haze rule in Texas. The Regional Haze Rule is proposed by the Environmental Protection Agency (EPA) to improve air quality (EPA 2016). Another interesting development is the growth of solar energy. While coal capacity is expected to be reduced by approximately 9% under current trends, solar power is predicted to increase from nearly 2% capacity in 2017 to 17% by 2031. This would lead to more than 20 000 MW cumulative capacity additions by 2031 (ERCOT 2016). Big companies like Shell, BP, Samsung, E.ON, EDF, Alstom Wind or Duke Energy are already leading in renewable energy operations (Texas Wide Open For Business 2014). Having a considerable amount of cash on their balance sheet, they can afford installation costs and invest in renewable energy projects to fulfill their corporate social responsibility goals (Shalabi 2016).

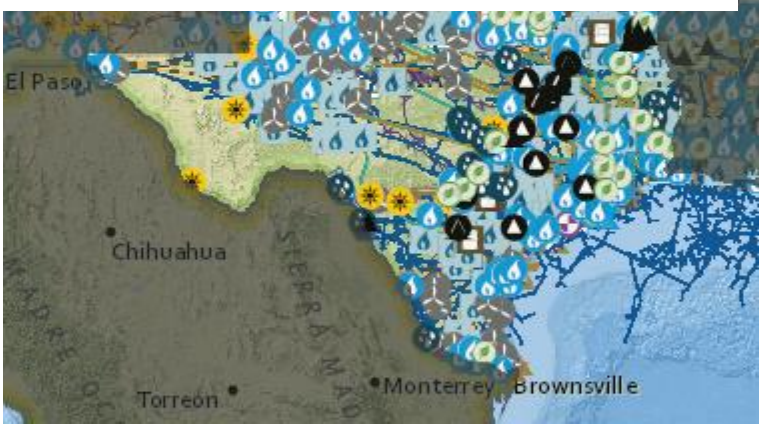
3. Renewable energy in Texas

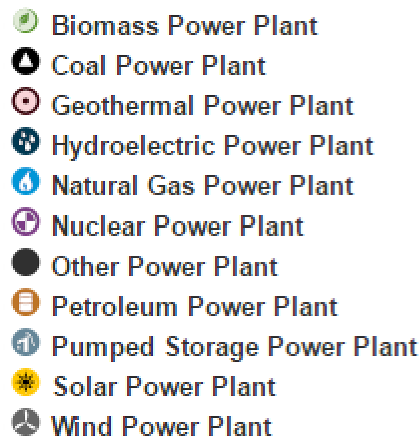
In the U.S, companies and government institutions recognize the economic benefits of saving energy in energy intensive operations. These energy intensive operations are found in the manufacturing, petrochemical, and IT industries. Especially large datacenters engage in purchasing renewable energy; Amazon holds a current goal of running 25% of its operations on renewable energy, going to 50% in 2017 (Beceiro 2016). Apart from that the military, the largest governmental energy consumer, requisitioned the deployment of 3GW of renewable energy by 2025, thus targeting their goal to run 25% of their facilities on renewable energy (Department of Defense 2015). But not only larger entities purpose goals in sustainability; also customers are driven by energy independence and conscience. The demand for renewable energy is generally increasing. As Texas has plenty of fossil fuel resources, their need for renewable energy might not come into mind. Still, the recent downturn in oil and gas prices forces Texan based companies to look at alternative sources as well and diversify their products and services. Moreover, good economic and outstanding geographical conditions foster the use of renewable energy in Texas.

3.1. Location of renewable energy resources in Texas

Texas' geography and climate allows for capturing various sources of energy, to which renewable energy certainly belongs. Warm, moist air from the Gulf of Mexico sweeps westward across Texas enhancing precipitation. Whereas the climate is humid and subtropical along the coast, it is semi-arid on the high plains and arid in the mountainous west (U.S. E IA 2016). According to these differences in climate, the map of the U.S. EIA below shows the plants and infrastructure in Texas that contribute to the energy sector. Although the website provides more detailed indications of transport, storage, pipelines and transmissions, here the light is shed upon the various power plants in Texas.

Figure 2. Power Plants in Texas. U.S. EIA 2016.





As stated in the section about the general energy market, natural gas power plants are very dominant. Wind power plants find themselves mostly in the spatial north-west (the Great Plains) and also at the Gulf Coast, where there is sufficient wind to generate power. The west shows also some solar power plants, as do locations near Austin and San Antonio. Potential for biomass can be found in East Texas, where the waste of the timber industry is recycled and also in the South of Texas, where rice hulls and crop residues serve as an input from agricultural waste. Even the High Plains in the north provide biomass material by feedlot manure and cotton gin trash (SECO 2008). Biodiesel and ethanol are part of this production. Texas has no geothermal power plant but the U.S Department of Energy is carrying out research about the potential of geothermal power, which takes a very new perspective when thinking of the heat in the oil and gas wells that can sometimes be above boiling point. Instead of relying on rare natural occurrences such as Geysers in northern California or Island, East and South Texas could make way for coproduction of geothermal energy in form of hot water/pressure as a coproduct in oil and gas wells (Airhart 2011). Although the North of Texas is dry and provides rather unstable sources of water, there are some hydroelectric power plants near Austin and San Antonio, making use of the Colorado River basins. At the border of Mexico, there exist hydroelectric power plants, too.

The chapters to come will elaborate more on the geological conditions for each resource, which form the basis to generate energy with these sources in the first place.

3.2. Governmental measures for renewable energy in Texas

Together with the recognized potential of renewable energy sources in Texas, state and federal policies delivered important support to the renewable energy sector.

In 1999, Texas was one of the first states in the U.S to adopt a Renewable Portfolio Standard (RPS) which requires electricity suppliers to source a minimum percentage of their electricity needs from eligible renewable resources. Flexibility and cost reduction of this system are added by tradable renewable energy certificates (REC) to prove compliance. For each MWh of eligible renewable generation located within or delivered to the Texas grid, one REC is issued (Langniss and Wiser 2003). Once the REC has been issued it can be sold to the open market, and after that it cannot be used any more. The purchaser of the REC has used its benefits and "retired" the REC, so it cannot be double counted. Long term contracting within the RPS ensures certainty for renewable energy developers in their revenues and also certainty against construction lags and operational problems. In addition to that, contract terms provide little incentive for developers to propose projects which are unlikely to be completed (Langniss and Wiser 2003). The RPS is applicable to investor-owned utilities and retail suppliers. Currently, the state demands a cumulative net capacity of 5800 MW to be installed by 2015 and a target of 10 000 MW by 2025, which has already been achieved in 2010. 500 MW of non-wind power should be reached by 2015 (DSIRE 2016).

Next to this state initiative, adopted by the PUC, the state has invested over $4.7 million in renewable energy-related projects and their related technologies in 2013 through the Texas Enterprise Fund (TEF) (Texas Wide Open For Business 2014).

Another favorable condition is the renewables franchise tax deduction, which excludes any installed property of a company that is producing wind or solar energy from property taxes. Other businesses with installed solar and wind devices can make use of a franchise tax deduction of 10% of the system's costs. Further, any residential, commercial and industrial renewable energy installation are exempt from property tax under Texas law (Texas Wide Open For Business 2014).

Apart from these state policies, there is the overall federal production tax credit (PTC), which is worth $0.023 for every kilowatt hour of electricity generated for the power grid. In December 2015, the bill to extend the tax credit for five years was approved. This is valid for wind facilities; other technologies commencing construction after the 31rst of December 2016 are not eligible anymore. Once obtained, the credit applies for ten years (DSIRE 2017). According to the AWEA, this fosters investments into the economy and improvement of wind technology (AWEA 2016).The PTC decreases by 20% for every year for new wind projects until 2019. Instead of the PTC, developers can also choose the investment tax credit (ITC), which gives a rebate for a certain percentage of the capital expense used to build the project (Renewable Energy World 2010). The amount received by the ITC and the expiration date vary per technology (DSIRE 2017).

3.3. Dealing with energy storage and grid reliability

Wind energy supply is subject to high variability and wind blows more at night, when demand for electricity is lower. Also, solar panels are only penetrated by the sun on the day. On the other hand there may be times of excess supply. Energy storage is therefore a way to balance the variability in demand and supply of renewable energy generation. Different methods of energy storage exist.

The energy stored in a natural gas pipeline can make up for the variability of wind energy by regulating up and down and adjusting the output of energy according to the supply and demand. The extent to which you can regulate up or down gas to make up for excess or shortages in wind and solar, depends on the technology of the power plants. Simple cycle plants can regulate up and down rather quickly, but they only have 30% conversion efficiency, whereas the newest turbines of combined cycle plants have 70% conversion efficiency. However, regulating up and down is more difficult for these plants (Shalabi 2016). According to AWEA, for now it may be more cost-effective to integrate wind energy to already existing flexible generators (simple/combined cycle gas turbine), and make use of their flexibility instead of relying on energy storage in form of batteries, wind curtailment or traditional storage (AWEA 2016). Gas and renewables can be complementary from an economic perspective, depending on the technology and the capital costs (Shalabi 2016).

Back up by natural gas is one of the ancillary services in the ERCOT market. These services provide back-up power and co-optimize the market (Farley 2017). Another ancillary service which is often being addressed is battery storage. One advantage is, that they can be built in small buildings and that they are very locational. The demand for ancillary services can also be served by them and represents a possible revenue stream. Texas has the largest utility scale battery, the Notrees Battery Storage Project operated by Duke Energy at Goldsmith, Texas (Lexology 2017). Batteries, however, are often more suited for small scale storage. NMC, LFB and LCO batteries are applied for energy and power cells or electric vehicles (Verma 2016). Possible shortages in supply of lithium, which is a common component in most batteries lead to some discussion. However, lithium resources are sufficient for now but they also do depend on the growth of electric vehicles and grid storage demand in the future. Limited production facilities could represent a problem (Verma 2016). Over the last year, battery costs have declined by 70% and big companies such as Tesla, LG Chem, Panasonic, Samsung or Stem are advancing in battery development.

A possibility for energy storage for the larger grid in Texas is compressed air energy storage. During times of excess supply, electricity is taken from the grid and captured in air. It is then cooled down to be compressed and stored underground. When there is need for more load, the air is heated and expanded to be converted into electrical power again. Excess wind supply is therefore efficiently utilized and curtailment (reduction in wind production) is prevented (Farley 2017). Compressed air energy storage finds its market in the ancillary services as well. Prices of ancillary services are high, whenever there is much wind and the price of electricity is too cheap for thermal units (oil and gas) to recoup their variable operating costs. Demand of ancillary services is high, when thermal units decide to go offline due to low prices of electricity (Farley 2017). With expanding wind installations in Texas, there is potential for compressed air energy storage facilities to sell power in long term contracts to utilities or help wind generators to use their energy efficiently. Currently, there is one project to be built in North Texas and completed by 2020 by Apex. While there is one supplier, Siemens, for the Apex Bethel Energy Center, there are business opportunities for utilities and wind generators to engage in energy storage with them (Farley 2017). Another existing project is Texas Dispatchable Wind 1 LLC, located in Seminole and funded by the Texas Commission on Environmental Quality (TCEQ). Further, Chamisa Energy partnered with Dresser-Rand to compress air in salt caverns and come online by 2018 (Lexology 2017).

In addition to the upper named technologies, thermal storage is another option. It has many forms, and one mentioned is chilled water and ice thermal technology. Here, cheap electricity (during the night) is used to freeze water and to use it later in the day for cooling applications. With 90MW the largest project of its kind is from Brazos Electric Cooperation in Jacksboro, Texas (Lexology 2017). Another technology is the flywheel, which provides energy storage by inertia. There a currently three flywheel projects in Texas, one by Austin Energy, by the Texas Scottish Rice Hospital for Children in Dallas and one by the JV Industrial Data Center (Lexology 2017).

While reliability of wind and solar and curtailment and its associated loss of sustainable energy is one weakness, opportunities by inventive ways of energy storage are provided. The market for energy storage is present in the demand of ancillary services, which are necessary to maintain reliability in ERCOT. Currently, the ERCOT market can rely on the low price of natural gas resources to cover reliability maintenance but the increasing need of energy demand in the future, will definitely represent market potential for energy storage as well (Farley 2017), (Bradley 2017).

3.4. Transmission challenges

Wind and solar farms are built in West Texas, where land is abundant but also remote from places receiving the load. In order to address the challenge of connecting resource nodes in West Texas, the Competitive Renewable Energy Zone (CREZ) was completed in 2013, initiated by the PUC. The CREZ project constructed transmission lines connecting the Panhandle and West Dallas with major cities, including Dallas in the East together with the Central and West Central, down to San Antonio. The project costed $6.9 billion and transmits 18.5 MW of wind power across ERCOT (Texas Wide Open For Business 2014). However, there is discussion about a second phase of CREZ: With the growing production in wind farms such as in the area McCamey for instance or the growing solar sector, transmission congestion can be experienced at times, which calls for an expansion of transmission lines to deliver power to the electric grid (Staine 2014). Moreover, growing solar capacity further in the West of Texas could require more transmission lines (ERCOT 2017). As the transmission project is only subject to ERCOT and not to federal oversight, the costs of the CREZ project were spread over rate payers. Moreover, natural gas prices were higher, so investing in renewable energy was easier at that time (Rhodes and Upshaw 2016). It initiated debate, for example by the Texas Comptroller of Public Accounts. Funds have to be found to invest in transmission while proving the needs for funds at the same time. These needs arise from building wind farms. But wind farms cannot be built without transmission lines. This gives rise to the “chicken-egg” problem (Staine 2014). The question whether a second CREZ project is possible is dependent on ways of balancing the generation with the load as efficiently as possible as well. Wind blows mostly at night and in spring and fall, so transmission lines are not filled up by wind on the day. While they may be full at night, there could be space for solar and other resources on the day (Rhodes and Upshaw 2016).

It can be said, however, that CREZ I contributed heavily to the generation and commercialization of renewable energy. The infrastructure Texas has by these transmission lines represents a 'subsidy' for the renewable energy sector by itself (Beceiro 2016), (Tulloh 2016).

3.5. Smart grid

To better manage the flow of electricity across the state in real time and maximize the potential of wind generation capacity in the state, smart grid technology is a grid management tool enabling communication between far facilities on the grid (Texas Wide Open For Business 2014). Smart grid includes smart meters, smart appliances, renewable energy resources and energy efficiency resources (FERC 2008). Smart grid makes use of computer based remote control and automation. Computer based control enhances two-way digital communication and data gathering for devices on the grid. Automation technology lets the utility adjust and control each individual device or millions of devices from a central location (U.S. Department of Energy 2016). This can play a role in energy storage. By gathering insights into the supply and the demand of electricity and adjusting it appropriately, energy can be used more efficiently. Moreover, smart grid includes distributed energy resources (DER), which refer to smaller scaled utilities, for instance on a residential level, generating energy to the grid.

With the increasing importance of ensuring electricity delivery and energy reliability as indicated in 3.3., smart grid can contribute to more efficient means of balancing energy needs. For instance, there is a scenario where DER could provide ancillary services once ERCOT has more visibility on them; ERCOT mainly regulates the transmission system at higher voltages (Hailu 2016). A possible scenario could entail that smaller scaled utilities' inverters are grouped together and receive signals which indicate an upward or a downward regulation in electricity (Rhodes and Upshaw 2016), (Wiese 2016). Municipality owned utilities such as Austin Energy or CPS Energy in San Antonio deploy a capital incentive for customers to invest in DER and let them sell to the grid as well. This falls also under the term of net metering. Another term, known as smart metering belongs to the same concept and is more accurate in communicates power usage from the customer in near real time to the utility, also showing when electricity was consumed. Another aspect of energy efficiency is the demand response management, in which participating consumers agree to adjust their electricity use when the grid's capacity is stressed (Texas Wide Open For Business 2014). With Texas being a deregulated state, there is no net metering law or policy. However, together with California, Texas is ranked first place when it comes to smart meter deployment (Texas Wide Open For Business 2014). Several electric transmission and distribution (T&D) utilities are part of a consortium called Smart Meter Texas to give customers more control over their electricity use. The team consists of AEP Texas North and Central Company, CenterPoint Energy Houston Electric LLC, Oncor Electric Delivery Company LLC in Dallas and Texas-New Mexico Power Company. The consortium was endorsed by the PUC (Smart Meter Texas 2016).

Currently, smart metering is seen as a useful business initiative, revealing more about electricity demand and thus the value of electricity and if the costs of the REP are recovered by their charges (Magee 2016). Moreover, growing energy demand and individual environmental concerns underscore the importance of DER and smart grid solutions.

4. The wind energy sector

After obtaining a general impression of Texas' energy situation, how its geography and climate relate to that and which government measures have been taken to enhance Texas' potential, it is time to get a more detailed look on specific sectors of the renewable energy sector in Texas. This chapter will start to elaborate on the strengths and weaknesses of the most expanded renewable energy sector in Texas: wind power.

4.1. Wind power resources and capacity

As has already become clear previously, wind power accounts for most of the renewable energy in Texas as it was produced more than one fifth of the U.S. total in 2014 (U.S. EIA 2016). If Texas were a country, it would rank sixth place globally for installed wind energy capacity and it does also rank first place for wind-energy related manufacturing (Texas Wide Open For Business 2014). With 16.9 GW of installed wind capacity in 2016, Texas leads the nation (U.S. EIA 2016), (ERCOT 2016). In 2012, the National Renewable Energy Laboratory concluded that Texas' annual technical wind potential accounts for 17% of the entire nation (NREL 2012).

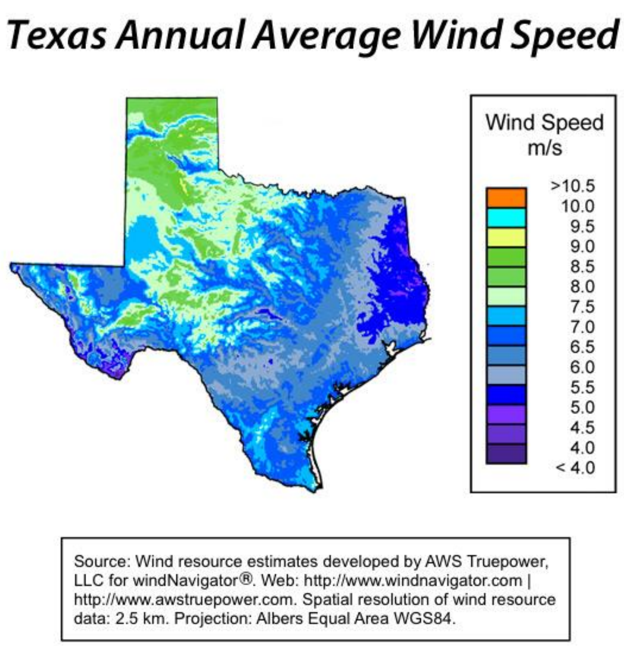


Figure 3. Texas Annual Average Wind Speed. AWS Truepower LLC 2016.

Wind turbines convert the wind's kinetical energy into mechanical power. The generator in the wind turbine converts this power into electricity. As shown in Figure 2 earlier, North and West Texas show suitable places to develop wind power. Areas with 6.5 meters per second are considered a resource for wind development. Figure 3 shows that North and West Texas can hold on well to this criterion. Currently, 74% of the wind resources are located in West Texas (Potomacs Economics 2016). Next to the wind speed, the capacity factor plays a role, representing actual power produced over time relative to the power that would be produced by the same wind turbine operating at its maximum (Texas Comptroller of Public Accounts 2008). For wind power in Texas, this has been 32,5% in 2015, with the prior years showing similar percentages. Once again, this is higher than in other states of the U.S (U.S. EIA 2016). Furthermore, the availability factor, the percentage of the year the power plant produces electricity is for most of today's machines around 98% (Texas Comptroller of Public Accounts 2008).

4.2. Current state of wind development

Given the tax credits and tax deductions and exemptions mentioned in 3.2., the policy incentives have created a very friendly situation for the wind market. Long term contracting in Purchase Power Agreements (PPAs) and extended subsidies such as the ITC and the PTC ensure that growth of renewables such as wind energy continues (Tsai 2016), (Rhodes and Upshaw 2016), (Shalabi 2016), (Bradley 2017). For wind facilities to start construction prior to 2017, the amount of the PTC was \$0.023 per kWh. With this amount decreasing by 20% every year to come after that, the current PTC for projects beginning construction in 2017 is \$0.0184 per kWh. Once obtained, this amount will be given in the following ten years. For large wind facilities the ITC is decreasing until 2019 as well, with a value of 24% of the capital expenditures starting in 2017. Small wind turbines starting construction before 2017 were eligible for a credit of 30% (DSIRE 2017).

With the abundance of private land in West Texas, it is quite attractive to invest in wind power. Landowners leasing the land to wind developers gain. In West Texas, landowners have formed "steering committees" to hire attorneys in order to contact wind developers and negotiate wind leases (Texas Comptroller of Public Accounts 2008). Due to their experience with the oil and gas industry, "landmen" in Texas have the knowledge about permitting for wind farms as well. Landowners selling the surface rights and therefore, also the wind rights to a wind developer can even ask themselves whether to not severe the rights and retain the wind rights, as wind development is so attractive in Texas. This is an issue to be careful about, as there is no guidance under Texas law whether this is valid or not (Thomas 2017).

There are no fuel costs or variable costs in general for wind power and compared to conventional power plants, capital costs are lower, too. With the newly constructed transmission lines, there is less congestion to transfer power from remote locations to cities. Potential for wind development has increased greatly after the building of the transmission lines (with 8.3 GW from 2013 to 2016) (Farley 2017). On the other hand, wind blows mostly off-peak at night, so peak demand during the day is hard to meet by only wind and there may be an oversupply in the night. At times, generators may pay ERCOT to buy wind at negative prices since they can still profit with the RECs received for every KWh of wind generated. Also, oversupply of wind leads to curtailment. All this depresses the marginal price (Shalabi 2016). At the same time, it hurts conventional industries such as coal and nuclear, although wind generates relatively less capacity and needs other resources to back up its unreliability. Expecting more growth in the wind sector, ERCOT sets importance on more efficient energy pricing during peak demand conditions and system stress (Potomacs Economics 2016), (ERCOT 2016). Figure 4 shows existing wind capacity plus wind projects proposed to ERCOT's interconnection queue in GW. Also, one can see that at windy days, an astonishing 48,28% of load is served by wind (ERCOT 2016). Wind is still expected to dominate the renewable energy market in the coming years (ERCOT 2016), (Bradley 2017).

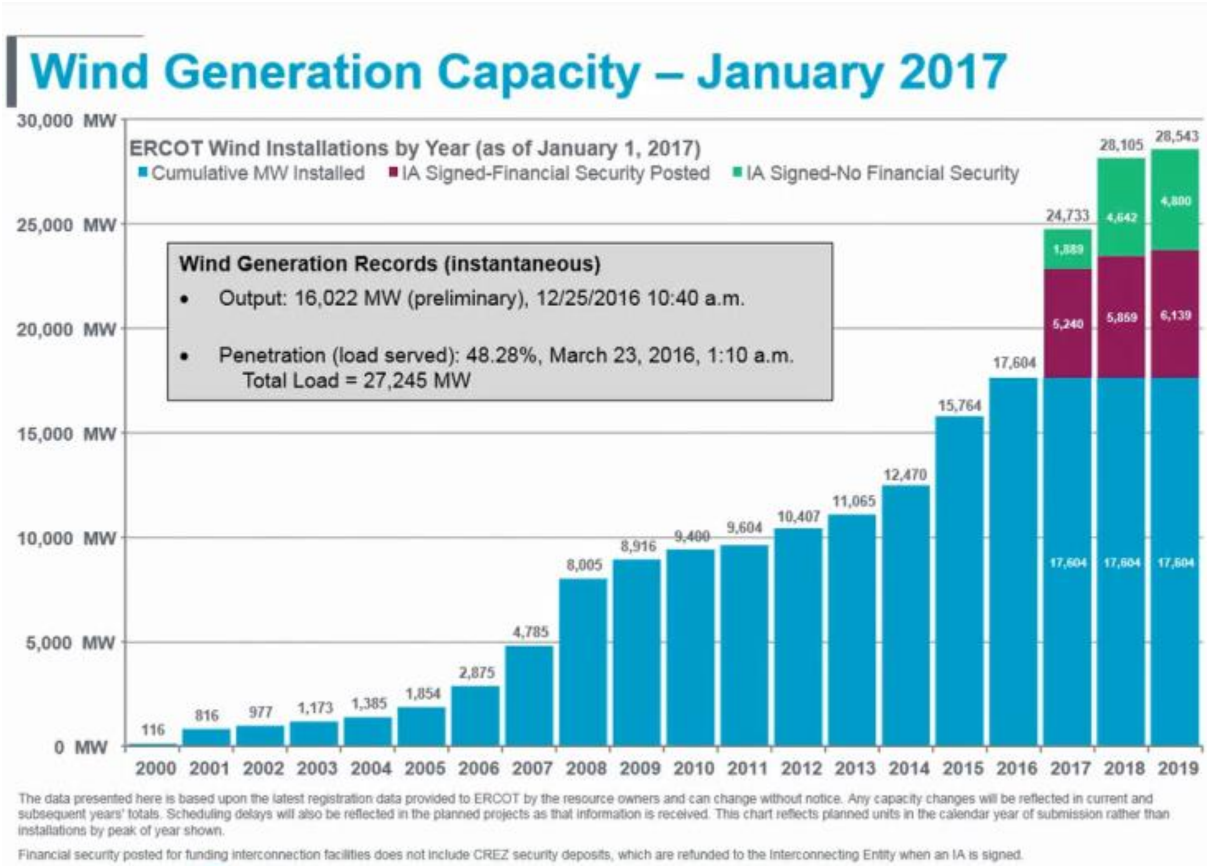


Figure 4. Wind Generation Capacity-January 2017. ERCOT 2016.

4.3. Business opportunities in wind

Regarding the large development in the wind sector, there has been a shift to larger businesses taking over the wind energy market. Big high technology companies such as Google and Microsoft purchase output of several farms in Texas to send the power to data centers or to the wholesale market. Amazon, Target, Adidas, Lockheed Martin, McDonalds and Unilever are other examples. As corporate businesses they also purchase wind power to showcase their sustainability goals (REBA 2016), (Beceiro 2016).

Developing wind projects is costly and time consuming and therefore an interesting investment opportunity for businesses with sufficient capital. Assessment and construction phases cost two to five years alone. The operational phase lasts for about 25 years. The average term of a wind energy lease can range from 30 to 50 years, but typically is about 35 years. Wind turbines have a life span of more than 20 years (Airtricity Inc 2007). Taking this into consideration, it can be expected that demand for maintenance and new development increases, once the current wind farms depreciate (Rhodes and Upshaw 2016). As the figure of ERCOT's interconnection queue shows, there is a 78% increase in new wind projects expected by 2019 (Farley 2017). Business opportunities are also found in the market for financial hedging and banks (Bradley 2017). With the ITC and the PTC reaching until 2019, there is still a chance to benefit from these subsidies until then.

Texas ranks first place nationally in wind industry employment, covering jobs along the entire supply chain. Texas itself is a leader in steel fabrication and transportation for wind energy. Advanced materials such as carbon fiber are exported from Texas to the world market (Texas Wide Open For Business 2014). Apart from this, Texas has ongoing research and development studies in the field of wind power, including the West Texas A&M University Alternative Energy Institute, the National Institute for Renewable Energy or the Texas Tech's National Wind Institute (Texas Wide Open For Business 2014). For smaller businesses it may be harder to enter the market regarding competition from large, settled companies. However, they can also find their niche in the energy storage market and related wind technologies.

4.4. Off-shore wind

Facing the sheer abundance of land and wind in West Texas, it is hard to imagine wind being profitable somewhere else. Currently, there are no operating off-shore wind projects in Texas. Nevertheless, off-shore wind has the advantage of being stronger and also blowing during the day (Shalabi 2016), (Rhodes and Upshaw 2016). Thus, it could make up for the capacity needed to meet net load and ensure reliability. Building wind farms near the coast often raises issues with migratory birds (Rhodes and Upshaw 2016), (Tulloh 2016). Threats of hurricanes are present, too. However, there is potential for off-shore wind ten miles from the coast, where there are only gas and oil pipelines, which could even lead to symbiotic development, since they are experienced in subsea design (Rhodes and Upshaw 2016). Another problem of siting new windfarms is the interference with military operations (Tulloh 2016). Still, the capital costs are more expensive and with the current low energy prices on the market, off-shore is not the first option to invest in. Currently there are very few off-shore wind projects in Texas. One would have to wait until costs decline to invest in this sector.

4.5. Conclusion

This chapter elaborated on the wind industry in Texas. Wind was able to grow due to favoring policies such as the RPS and is expected to grow due to the expansion of the PTC and the ITC. What is more, land is very cheap and easy to acquire. The natural circumstances in West Texas offer good opportunities for wind development. One struggle is the unreliability of wind and the fact that it blows mostly during night, pushing down the marginal price. Due to low prices, non-wind resources such as coal and nuclear cannot keep up to back capacity when wind is unreliable. Currently, natural gas can back up this intermittent supply. The future is also directed by the provision of ancillary services and the importance of efficient pricing mechanisms. Smart grid technologies and integration of distributed energy resources but also large scale energy storage as ancillary services can play a meaningful role for the future. Value adding technologies promise profit for small and big businesses alike, while larger businesses with sufficient capital are fitter to invest in the development of large wind farms and purchase PPAs. Off-shore wind development can definitely be a valuable resource in the future, when land is scarcer and wind and solar have taken up much capacity.

5. Solar Energy

Solar energy may not be as prominent as wind energy in Texas, having an installed capacity of 589 MW which puts Texas on tenth rank nationally. This can power 63 000 homes. Nevertheless, growth of solar capacity was 65% in 2015 with a 48% increase of investment over that year. Installed solar PV system prices dropped to 12% since 2015 and 66% since 2010 (SEIA 2016). In its Long Term System Assessment Update for 2016, ERCOT expects solar energy to grow from approximately 2% in 2017 to 17% in 2031 (ERCOT 2016).

5.1. Solar resources and capacity

Looking at Figure 5 and Figure 6 gives a confirmation of the amount of solar resources in Texas. Figure 5 shows the energy each renewable energy resource can deliver. The accessible resource is the amount of the total resource that is technically feasible to extract with existing or near-term technology. Energy density compares the relative concentration of the resources at a prime Texas location for each. The measurement unit, a quad per year, is enough to serve all annual energy needs for about 3 000 000 people (SECO 2008). The fact that there is enough solar power to provide energy needs of 12,9 milliard people per year in Texas highlights the potential of solar energy.

Resource	Total physical resource (quads/yr)	Accessible resource (quads/yr)	Energy density: Good Texas site (MJ/m2/yr)	Primary energy uses *				Non-energy uses
				elec	heat	mech	trans	
Solar	4,300	250	8,000	y	y			
Wind	12	4	15,000	y				
Biomass	13	3	45	y	y	y		Food feed fiber
Water	3	1	10	y	y		y	Water supply; flood control
Geothermal	1 (2,300,000 quads)	1	3	y	y	y		
Building climatology	0.6	0.26	430	y	y			

* where *elec* is electricity, *mech* is mechanical, *trans* is transportation, and *y* is yes

Figure 5. Quantification of Texas renewable energy resource base and identification of primary uses. SECO 2008.

Basically, there are two main ways to gain energy from solar radiation. The first one is the direct conversion of solar radiation into energy by photovoltaics (PV) , which therefore only operate when the sun is shining. The other one, solar thermal energy uses mirrors to concentrate sunlight. The thereby obtained thermal energy generates steam to operate a conventional turbine that produces electricity. The latter method is implemented on the large scale in remote areas (Abengoa 2016), (SECO 2008). As shown by Figure 2, most large-scale solar utilities can be found in West Texas, which has 75% more radiation than in East Texas. This is also confirmed by Figure 6, which shows the solar radiation in Texas. In West Texas this radiation is strongest with 6 to 6.8 kW per square meter per day. Moreover, the abundance of cheap private land sets good conditions for developing large scaled solar thermal projects. In general, Texas had 20% of U.S.'s annual technical potential for concentrating solar power in 2012 (NREL 2012). Further, the U.S. Renewable Energy Technical Potential report from the National Renewable Energy Laboratory (NREL) states that Texas holds the largest national potential in urban and rural utility scale PV.

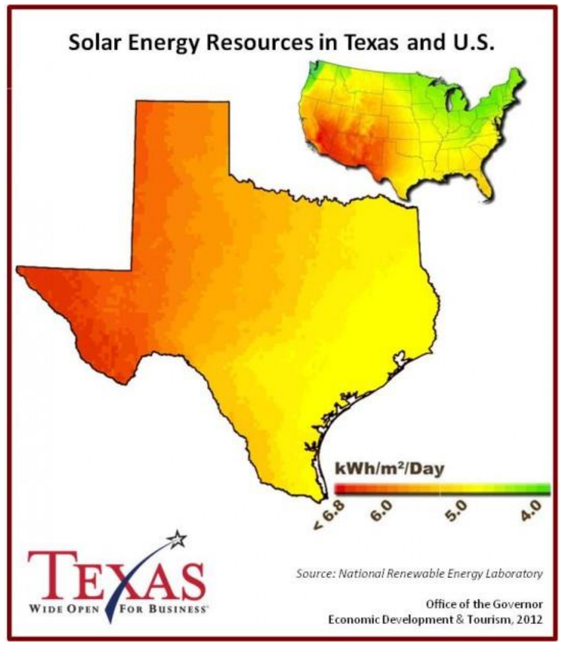


Figure 6. Solar Energy Resources in Texas and U.S. Texas Wide Open For Business 2014.

5.2. Current state of solar development

Although Texas clearly does not lack the geographical and geological factors which contribute to potential for solar energy, it is not performing as well as California, North Carolina, Arizona or New Jersey concerning installed solar capacity. However, it is an upcoming state in growing solar potential. Currently ranking eighth on cumulated installed solar capacity nationally, Texas moved to the third rank for the third quarter of 2016. Texas is thus just in the beginning phase of adapting solar, but the market is taking up the potential quickly, even though policies to promote it are less 'aggressive' (Hemmeline 2016), (GTM Research 2016). For example, Texas does not have solar performance payments or sales tax exemptions for solar. Sales taxes often range from 6.25% to 8.25% and thus make a difference to large purchases in solar panels (Solar Power Rocks 2016). An advantage of Texas is the absence of income taxes. Furthermore, the federal ITC entails a 30% tax credit which will not expire for PV, solar water heating, solar space heating/cooling or solar process heat. Only hybrid solar lighting systems, which use solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight, expired at the end of 2016. Yet another favorable condition is the solar property tax exemption, which waives solar properties 100% from the property tax (Texas Wide Open For Business 2014).

While the RPS has already reached their goal of 10 000 MW for 2025, this comes mainly from wind power. The 500 MW that has to be achieved by non-wind resources does not include a solar carve out, which regulates utilities to generate a certain amount of MW by solar power. Since there is no solar carve out, there is not SREC (solar renewable energy credit) market either, although ERCOT still maintains the REC market (Solar Power Rocks 2016). Main reasons for Texas running behind other states in solar can thus be traced back to early developments in the different states' RPSs. While incentives for wind were plenty in Texas' RPS, California's RPS focused on solar. Apart from that, other states did not experience as low electricity prices as Texas did, which made it harder for solar to compete (Hoffner 2016), (Wiese 2016).

However, solar technology is developing in the world and its declining capital costs make solar less dependent on government incentives.

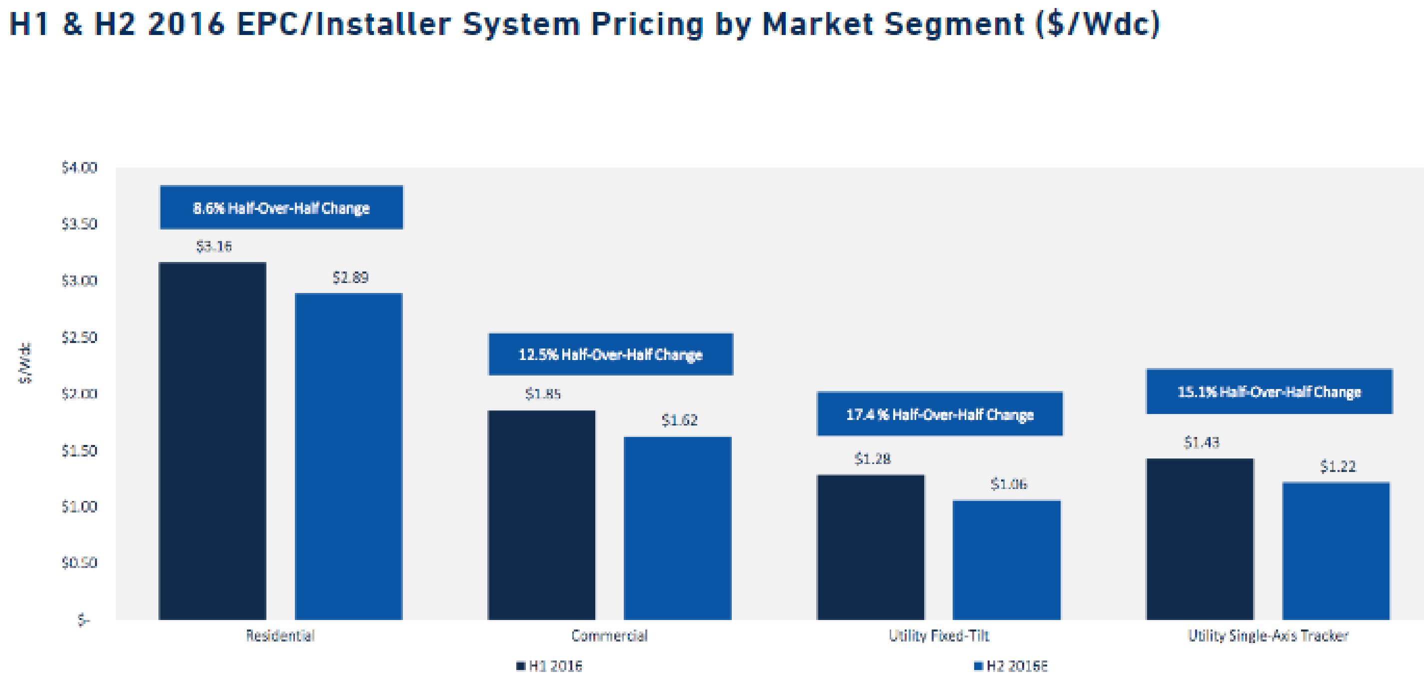


Figure 7. Drop in EPC/Installer System Pricing by Market Segment. GTM Research 2016.

Figure 7 above gives a clear impression on the dramatic cost decline in engineering, procurement and construction/ installer system pricing in 2016. The dark blue bars indicate the first half, the lighter blue bars the second half of the year. Cost are given in $ per Watt in direct current. Note that the price here is the final price the installer ascribes to the system owner (Gallagher 2016). Just within one year, utility scale capital costs have decreased significantly, as can be seen for the fixed tilt and tracker equipment (17.4% and 15.1% respectively). Also, inverter and racking markets are declining in prices. Residential and commercial scale experienced cost declines to fewer extents as well (Gallagher 2016). Cheap and abundant land makes the development of utility scale prominent in Texas; nearly 80% of installed solar capacity in Texas is utility scale (SEIA 2016).

A drive from the customer side for independent energy generation and sustainability promote the growth of residential solar. Businesses see potential in applying smart meters on residential level to get more insights in household energy demand, their value of electricity and to see if the costs of the retailer are recovered by the charges (Magee 2016). Net metering programs, a decline in residential solar costs and battery development contribute to DER together with the need of energy reliability, which plays an increasing role in ERCOT.

5.3. Business opportunities in solar

With a deregulated energy market, there is no net metering policy and solar rebates and incentives vary per company. Companies decide themselves whether to invest in solar developments, incentives and rebates.

For instance, CPS Energy in San Antonio holds Texas' largest solar farm. With its 95MW, the Alamo Solar Farm is part of a 400MW project (Texas Wide Open For Business 2014). CPS Energy, which is the nation's largest municipally owned utility, has a contract to purchase the power of the farm OCI Solar Power, a subsidiary of South Korea's OCI. KACO new energy, a Germany-based PV inverter opened a manufacturing plant in San Antonio. Another example is the Spain-based ERCAM Trackers opening a manufacturing facility producing dual-axis trackers in San Antonio (Texas Wide Open For Business 2014). The contracts between these international companies and CPS Energy are part of their New Energy Economy initiative, started in 2011 in which they agree to buy the products of the company in order for them to settle in San Antonio and add to the economic development in the region (Caceres and Jungman 2016). Apart from San Antonio, Austin Energy has attractive capital incentives for commercial and residential solar investors (Shalabi 2016). Their "Value of Solar" program allows customers to sell generated energy back to the grid and therefore promotes DER and energy efficiency.

Furthermore, Oncor, a T&D service provider in Dallas used a portion of its investments in energy efficiency for solar incentives when they were bought out by another company in 2008. When the investor's money was spent up they found solar still to be a cost-efficient measure and held on to these incentives in their standard offer program. Generally, other municipal cities in Texas such as Denton or San Marco offer rebates, too (Solar Power Rocks 2016).

In general, big vertically integrated companies such as CPS Energy or Austin Energy can provide opportunities in partnering up with generators or providers of different (technology) services. Apart from that, solar is relatively new in Texas, so technologies adding to the value of the sector have a chance of creating business as well. With the expansion of DER, installers and smaller enterprises in general may find a way to enter the Texan solar market, too. As not every consumer in Texas may have the right conditions for installing solar panels on their roofs, another opportunity is community solar, in which participants lease or own a fraction of a large shared solar system and benefit from the energy it produces. MP2 Energy, Austin Energy, El Paso Electric CPS Energy and Pedernales Electric Cooperative are examples of utilities applying community solar (Go Solar Texas 2016).

5.4. Conclusion

By these examples and the sheer abundance of solar resources in Texas, there are plenty of business opportunities for distributors, product manufacturers, designers, developers in the solar industry. Net metering and interconnection policies may be relatively weak in Texas compared to other states. It is however the question to which extent policies and regulations are required if the market already takes up the potential and the business opportunities in the solar industry at a fast growing pace. Texas is a deregulated market with prices signaling investment decisions. Solar is competitive and strongly growing.

Still, it always has to compete with cheaper electricity such as natural gas and wind. Therefore, the RPS, incentives and cost reductions drive its development significantly. Large scale solar thermal plants are attractive in Texas because of the cheap vast land and the strong radiation in the West. DER by solar is applied in various cities and there is room for employment opportunities and more research and development, since DER can play a role in ensuring further electricity reliability in the future. This can be combined with collaboration and sharing of resources and projects with the municipal or private utilities in Texas, which have already seen the benefits of going solar.

6. Biomass

Biomass includes many production possibilities and depends largely on agriculture, forests and the cattle industries- of which there are plenty in Texas. Utility scale biomass electricity generation accounted for 2.7% of renewable energy production in Texas in 2014. Apart from that, ethanol production held 2.3% of total renewable energy production in Texas in 2014, while ethanol consumption ranked second place in the U.S. (U.S. EIA 2016). In 2014, less than 1% of state's electricity was generated from biomass. There are four ethanol plants in the northwest of Texas (U.S. EIA 2016). Utility-scale biomass net electricity generation was 131 MWh in October 2016 (U.S. EIA 2016).

6.1. Biomass resources and capacity

Biomass consists of waste products of agriculture, forestry and post-consumer waste. These products do include sugar, starch or lignocellulosic material. Biomass is feedstock for a biorefinery which can convert these inputs into either fuel for energy, fibers and molecules for chemicals and materials, food products or pharmaceutical products. So there are many ways to take in business with biomass, depending on the conversion processes of biomass and the desired end product. One common production good is ethanol, which is produced from biomass materials such as corn, grain sorghum, barley and sugarcane which are then subject to a fermentation and distillation process, converting starch to sugar and then to alcohol (ethanol). Ethanol can be blended with gasoline to create a fuels such as E85 or E15; the number indicating the percentage of ethanol mixed with the regular fuel (SECO 2008).

According to Figure 8, Texas provides many feedstocks for biorefinery. East Texas agricultural income depends 35% on timber. The waste (sawdust, bark, wood chips) from timber serves as an input for forest mills to generate steam and electricity for local use. In this way, forest mills represent the largest biomass energy users in the U.S. and fulfill half of their energy requirements by using biomass in efficient co-generation processes (SECO 2008). The presence of biomass power plants and the biomass potential in the East of Texas are confirmed when looking at Figure 2.

Waste from agriculture provides potential in the North West of Texas, which has also four bioethanol plants. Moreover, biomass potential is not only found in rural areas. The urban variant of biomass production is found back in waste of big cities. In the case of landfill gas utilization, the gathering of methane gas occurs through wells placed vertically or horizontally in the waste mass. Before it would be flared, the gas is diverted from the flare and is treated and can be used to generate electricity, fuel or other products (Bean 2016).

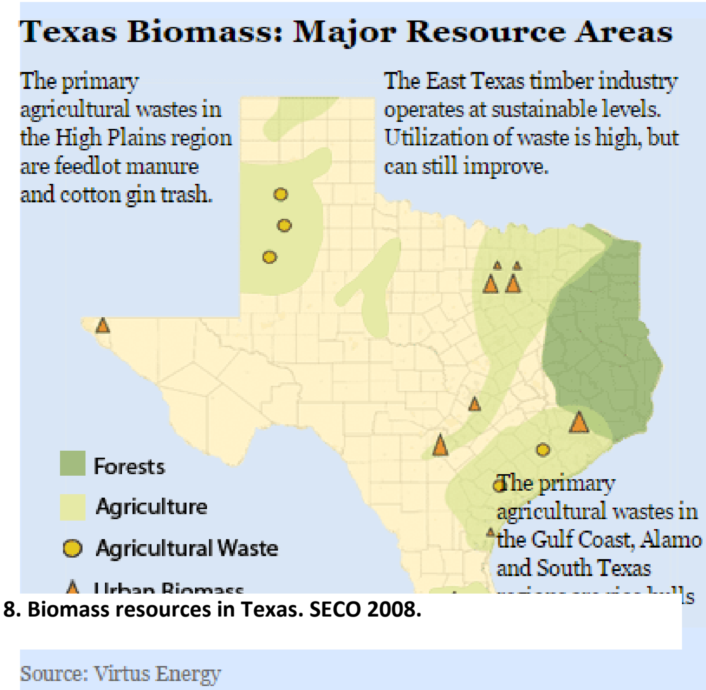


Figure 8. Biomass resources in Texas. SECO 2008.

6.2. Current state of biomass development

Biomass production requires the power plant to be close to the feedstock resource, since transportation of the material by diesel-fueled trucks is expensive. Moreover, biomass should not get wet, which limits means of transportation even more. Therefore, most bioethanol plants in the U.S are in the "Midwest corn belt" including the states Illinois, Iowa, Nebraska, Minnesota and Indiana, where production is close to the resource. Initially a project from White Energy, the Hereford Plant makes use of market proximity to the town Hereford and has now been taken over by Green Plains (Green Plains 2017). Bio ethanol plants in the Panhandle now mostly employ starch and sugar as feedstock. In general, biomass is very capital intensive, which makes it hard to compete against solar or wind. Austin Energy owns a biomass plant in Nacogdoches, North East Texas, which generates 100MW of renewable energy but will not be invested in after the contract ends in 2032 due to high expenses (Shalabi 2016). This project is another example of community driven investments by larger firms.

With regard to landfill gas utilization, it is hard to compete with natural gas power plants and thus find an economic case in the production of electricity (Bean 2016), (Hallenbeck 2017). The potential of landfill gas lies in renewable natural gas for use in vehicles or for use in industries, which would like to lower their carbon foot print. This can be particularly observed for newer landfill projects that are being build, since the existing ones were built under the prospect of high electricity prices (Hallenbeck 2017). For the use in fuels, there would not be a problem of less effective mile coverage as with E 85, as the gas is identical to regular gas used for fueling a car. The main costs lie in extracting the gas from the landfill, cleaning it up from other components and the cost of compression to put it in the pipeline (Bean 2016). Currently, there is demand for efficient technologies in separating gas from non-methane organic compounds, such as CO_2, CO, N or smaller constituents such as sulfur (Hallenbeck 2017).

It would not be possible to cover these costs without a premium, which is a certificate, called Renewable Identification Number (RIN), under the federal Renewable Fuel Standard Program. The certificate has a market value for utilizing renewable fuel or blending it with regular fuel for vehicles (Bean 2016). Whereas many biomass subsidies expired in 2013, there is a Texas Tax Code, offering a biofuel tax exemption which waives blended taxable diesel from the diesel fuel tax. There is no Low Carbon Fuel Standard (LCFS) which favors biodiesel as in California (Beunis 2017).

Still, the Texas Emerging Technology Fund (TETF) did also invest nearly $11.7 million in emerging biofuels and biomass technology (Texas Wide Open For Business 2014). In 2007, current Secretary of Energy and prior Texas Governor Rick Perry awarded Texas A&M a $5 million grant to pursue the Texas Bioenergy Strategy by researching biofuel advancements. Texas A&M University and the Chevron Corroboration have partnered to research ways to increase cellulose crop production to boost biofuel production in the years after that (State Impact NPR 2011).

6.3. Business opportunities in biomass

Regarding the vast land of Texas and the transportation difficulties for biomass production there, it can make sense to focus production of biomass somewhere else. The company Zilkha Biomass Selma, headquartered in Houston gets their feedstock from sawmills in Alabama and transports their product to Europe (France), as biomass demand there is higher than currently in Texas. Moreover, with water resistant wooden pellets from these sawmills, the pellets can more easily be transported and shipped to supply the biomass energy market in Europe (Zilkha 2017). Thus business opportunities entail trade of feedstock or in this case a creative product with parts of the world where biomass demand is higher.

Landfill gas utilization provides an opportunity in the vicinity of cities in order to use their waste. Further, power plants are built relatively cheap in Texas and pipeline regulations are somewhat looser than in California for instance. With the nation's largest fuel refining and chemicals workforce there are easily sufficient skilled workers which are active in the biofuel sector or could translate their skills from the fossil-fuel based industries to this sector (Texas Wide Open For Business 2014).

With regard to competition and subsidies, business opportunities can be more attractive for biofuel than biomass electricity production. When the long-term contracts of existing power plants expire or whenever electricity prices are especially low, it is worth to look at biofuel production. The RINs are a big value driver for renewable gas. As the RIN is already taken up in legislation, projects can still be started and make use of their value. In the case of biofuel, there is still demand for clean-up technologies to meet the gas specifications (Hallenbeck 2017), (Bean 2016). Companies such as the nation-wide Waste Management or Toro Energy in Texas are serving biogas generation and show interest in European companies who work with efficient clean-up technologies (Hallenbeck 2017), (Bean 2016). Apart from biogas, Waste Management is dedicated to pre-processing waste and ensuring the logistics of waste. Most of their technologies regarding that matter come from Europe, so they are very open towards efficient, successful products from European businesses. The potential of purchasing engineered clean-up equipment from international companies holds the condition that these technologies have already been implemented and work properly (Hallenbeck 2017).

6.4. Conclusion

Relative to other states, Texas is not the foremost biomass producer, due to competition of low energy prices from other commodities. However, it can be said that as a rich agricultural state, livestock, grains and wood allow for successful biomass production if the resource is close to the plant. With regard to the various production possibilities in biomass and the given Renewable Fuel Standard Program, it is relatively easier to concentrate on biofuel or heat production. Landfill gas utilization is one example for this. Business opportunities are provided by the demand for efficient clean-up technologies.

7. Water energy

Water energy cannot be summarized by one technology; hydropower, salient gradient, thermal ocean power or tidal power allow for different generation possibilities. Texas is generating less than 1% of hydropower. With that they can produce 1 million MWh of electricity annually directly from water resources via 675 MW of hydroelectric power capacity (SECO 2008). Generally, water reservoirs are intended to store water or to use water for electricity generation. Something worth mentioning is that 95 % of the withdrawn water is continually cycled between the power plant facility and adjacent cooling ponds and lakes without loss (SECO 2008). The direct use of water for mere energy production itself is not as common in Texas; water is primarily used for storage (EIA 2016), (SECO 2008).

7.1. Conventional hydropower and pumped storage

Accounting for 45% of renewable energy production and 6.1% of total U.S. electricity in 2015, hydropower is the most common and a very efficient renewable energy resource in the U.S. It is also one of the oldest energy resources in the U.S (U.S.EIA 2015). The cost of the infrastructure and power production are relatively low for hydropower, as the facilities already exist, for Texas once used to produce most hydropower in the 1930s. With the little 1% of hydropower production today, one can see that other energy sources have taken over. Texas has not a lot of rainfall and there are not many elevation differences close to the water (Rhodes and Upshaw 2016). River basins with operating hydropower and potential are for example the Colorado, Brazos or Guadalupe in the Central West or Trinity, Neches, Cypress and Sulphur in the Central/East of Texas. The Lower Colorado River Basin operates six dams. A hydropower assessment completed in 2006 (Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants) estimates the total resource potential including low power hydro plants and yet undeveloped plants. Although this study shows that there is quite some capacity, existing plants would require re-permitting and retrofitting. Undeveloped sites may not be built at all. A reason is environmental and economic constraints (SECO 2008). Even so, the more efficient pumped storage plants have the same potential as the hydropower plants, but are not operated as such because they would impede fisheries and ecosystem management. Since pumped storage plants are able to release the water during peak demand, they form an electricity source which can serve as an ancillary service and offset more unreliable resources.

For a system, commencing construction prior to January 2017, the PTC was still in place with $0.012 per kWh. Thus, new hydropower facilities received approximately 1 cent per kWh for ten years after the installation is completed compared to a wind farm receiving approximately 2 cent per kWh (SECO 2008). Currently, Texas is not focused on more hydropower development.

7.2. Ocean Power

Wave power is not as strong in Texas as in other places. Good power densities should lie between 20 kW/m and 40 kW/m; Texas' wave power is below 10 kW/m. Wave height is relatively low at the Gulf Coast, for it is shallow and thus dissipates waves (SECO 2008). This does matter, as waves would have to be harnessed many miles off-shore for them to provide valuable energy generation, which makes such projects rather costly (SECO 2008). Nevertheless, Atmocean, a US-based wave energy technology developer is testing its third wave tank trial at Texas A&M University (Tidal Energy Today 2016). Another company, Neptune Wave Power, is headquartered in Dallas and deploys its specific technology in locations outside of Texas, for instance New Hampshire (Neptune Wave Power 2017).

Going on from the fact that the coast of Texas is rather shallow, there is not much potential for generating energy by ocean thermal energy conversion either. This technology makes use of the difference of temperatures between the warm surface and the cold depth of the ocean. With the lack of depth in the Gulf of Mexico, exploitation of temperature differences due to depth gets difficult (SECO 2008). The temperature difference that exists is quite marginal; there are better places to conduct ocean thermal energy conversion. Further, temperature differences are easily predictable in normal seasons but hard to predict in seasons of hurricanes. Even at more favorable locations in California, Florida or Hawaii the technology and the infrastructure is still in development (SECO 2008).

Tides in Texas are quite small. Therefore, a tidal facility would need to be large in length to capture more of the tidal range and thus generate more power. The Texas Coastal Ocean Observation Network (TCOON) has the responsibility to measure these tidal ranges for boundary delineations. Projects of such size do certainly entail high costs and would interfere with touristic and recreational areas (SECO 2008). Tidal and wave power are better suited for other locations, yet this does not necessarily hold for research on the subject.

7.3. Salinity gradient power

Yet another renewable energy resource is found by looking at salient gradient power. One method is employing the difference of osmotic pressure and chemical potential between fresh and salt water. The other one makes use of a salt-brine in which fresh water is injected and a salinity gradient suppresses convection, while the bottom of the reservoir is preferentially heated by solar input (SECO 2008). Texas holds opportunities for the latter approach, as the University of Texas in El Paso has undertaken research in this field for two decades. The advantage is reliability on demand. Another advantage is its deployment of a waste product. One test project did not turn out to be as successful since the temperature difference between the top and bottom of the reservoir was quite low which in turn led to low efficiency in gaining electricity (SECO 2008). Infrastructure for this technology would be relatively little.

The method of osmotic pressure is still in development, since osmotic pressure difference requires membranes, which are still quite costly (SECO 2008). Here, research is also ongoing, and not only in Texas. The technique of osmotic pressure would require a pipeline bringing fresh water from the river mouth to the salty ocean water. Building this infrastructure could run into difficulties by environmentally sensitive areas (SECO 2008). However, the demand of fresh-water might also promote production of semi-permeable membranes, which could eventually support the purpose of generating electricity by osmotic pressure. Whereas the prior information is based on an older assessment from the State Energy Conservation Office and underlines the difficulties of the technology during that time, the company Thermal Energy Partners is planning a desalination project using membranes from a Dutch company to produce fresh water. The desalination project would be powered by geothermal energy (Jackson 2017). Using the expertise of other countries on these technologies and combining it with their own strengths, water energy production can be successful in Texas.

7.4. Conclusion

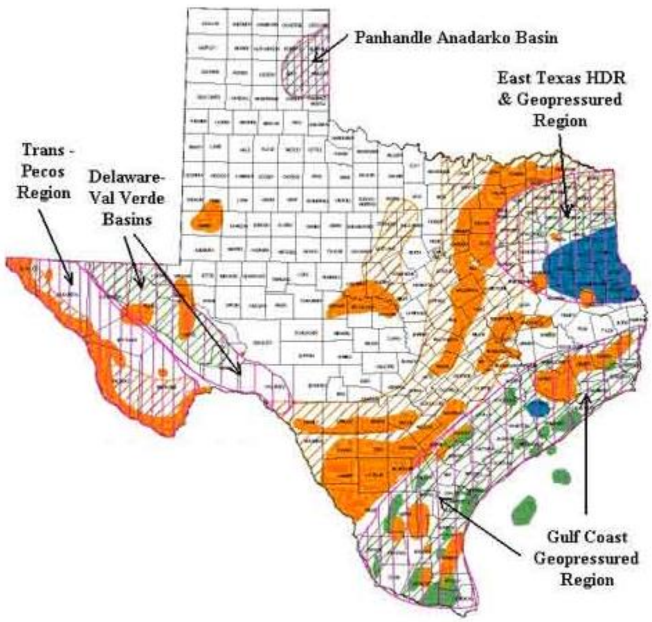
Whereas hydropower once used to be a major source of employment and energy in the 1930s, other energy resources have taken over the market and hydropower represents less than 1% of the energy production in Texas. Nevertheless, this report does not exclude slight possibilities of research and development projects in the field of water power. The SECO Assessment has been carried out in 2008 and technologies and conditions might have changed. Still, ocean power and salient gradient are not only subject to research in Texas and thus the question how promising these technologies are, depends on overall international research in this field. Texas can rely on existing expertise or collaborate in current research. But given the resource potential, Texas is not the first place when considering business opportunities in ocean power. Hydropower, on the other hand, is a common resource but does not occur much in Texas anymore due to already existing facilities and due to gas and oil having taken over. Salient gradient holds some opportunity in Texas, due to the research in El Paso and possibly economic conditions for salient gradient in solar ponds- but still there is always competition from the current successes of the renewable energy market. As the example from Thermal Energy Partners and El Paso shows, salient gradient power can be combined with other renewable technologies. Given the reliability and efficiency of water energy, research and planning projects will go on. For a better assessment of specific characteristics of water energy technologies here, a deeper research is required.

8. Geothermal energy

Next to hydropower and biomass, geothermal energy is the largest renewable energy resource in the U.S. Harvesting geothermal energy distinguishes between energy gained from two or three km deep under the ground and from energy gained from approximately 100 m under the ground. The deeper the exploration takes place, the higher the temperature. The United States have the most geothermal power of the world. Texas has the potential to contribute 10% to the United States' geothermal energy potential. Currently, geothermal energy production in Texas is less than 1% (Jackson 2017).

8.1. Geothermal resources and capacity

Potential for geothermal energy in deeper earth finds itself in various ways. There is space for hydrothermal resources, as indicated by the orange areas in Figure 9. These are found in fractured and porous rocks in form of hot water or steam. Geo-pressured resources are represented by the green spots on the map below. They consist of hot brine with methane and are found in deep aquifers where water is trapped under high pressure due to burial processes (SECO 2008). Also, the heated geological formation of hot dry rock is present in the East of Texas, providing possibilities for heating and electricity. In addition to that, the areas designated by the lines in the map show large geothermal potential, for the existence of oil and gas wells proved to hold temperatures above 212 degree Fahrenheit (100 degree Celsius) in these regions, some above 300 degree Fahrenheit (150 degree Celsius) (Airhart 2011), (SECO 2008).



Source: Virtus Energy Research Associated, adapted by author

Figure 9. Geothermal potential in Texas. SECO 2008.

Since Texas has the experience of locating oil and gas resources and thus the skills for subsurface analyses of heat-resources, reservoirs and deep-water availability, they have an advantage in locating and drilling for geothermal resources as well. Another potential lies in the co-production with oil and gas wells, which produce hot fluids as a waste product representing an opportunity for geothermal energy production and a cost reduction for oil and gas producers in disposing of this co-product (SECO 2008), (Airhart 2011), (U.S. EIA 2015).

Depending on the temperature and the depth of geothermal resources, there are basically three kinds of production possibilities: Heat pumps, direct use and geothermal power plants (SECO 2008). Geothermal heat pumps or heat exchange systems employ geothermal energy from shallower grounds with temperatures of 10-30 Celsius. These technologies make use of a loop system in 60-80m deep ground where temperatures remain constant. Warmer water underground is pumped to heat houses and buildings during winter time under higher compression of the pump. During summer time underground temperatures are colder than the air above. Therefore, the fluid from underground is now transported to the pump and circulated to supply the building with cooler air. There is environmental and economic efficiency involved, as one unit of electricity is needed by the heat pump to generate four to five units of heat. A gas furnace can only produce one unit of heat for one unit of electricity (CBS 2015).The U.S Department of Energy emphasizes that every state in the U.S. has the potential to deploy geothermal heat pumps as the ground has the same shallow ground temperatures (Department of Energy 2017).

Direct use of geothermal energy entails the tapping of hot water for industrial processing needs, such as fisheries, food, pasteurizing milk and residential and commercial buildings. This requires deeper drilling and hotter temperatures. It is less developed and only employed at a few locations in Central Texas (SECO 2008).

The last method, geothermal power plant, is also still under development but is already subject of planned implementation in various areas. Heat and steam of geothermal resources drive turbine driven generators to produce electricity. This can be done by dry steam, flash steam or binary cycles, the latter one having the greatest potential due to greater efficiency and zero air emissions (SECO 2008). The Gulf Coast region of Texas shows very high temperatures which play a major role in geothermal electricity development (Jackson 2017), (Hanegraaf 2017).

8.2. The current state of geothermal development

It is the untapped potential for well co-production that has driven research for opportunities in deep geothermal energy generation. The Geothermal Laboratory of the Southern Methodist University has published a study in 2007 in which they assess the best locations to acquire heat energy (SECO 2008). These locations were found in West Texas, where depleted oil and gas wells could be converted to geothermal wells to generate renewable energy. Another study in 2008 focused on the use of hot fluids wasted from hydrocarbon wells.

As stated by SECO, by contracting with the Southern Methodist University and collaborating with the U.S. Department of Energy GeoPowering West Program, they hope to move Texas to a state with more geothermal energy knowledge and consumption (SECO 2008). Costs of drilling wells have reduced, which is attributed to the improvements in drilling technology and horizontal drilling, which also allows for more efficient drilling in different directions. Next to that, hydraulic fracturing increased the permeability of the shale formations. Technology advancements in binary cycle heat exchange systems allow for efficient economic power creation with lower boiling points (Airhart 2011). For geothermal development to be more dominant, it requires the knowledge about available resources. This knowledge has been developed by the National Geothermal Data System, a website providing data for all states about criteria for geothermal development (Airhart 2011).

On the other hand, geothermal exchange systems that cool in summer and heat in winter are already well developed. With a rising need for smart energy storage systems, geothermal energy provides a very cost-effective solution for further investments.

For geothermal energy in general, an ITC of 10% applies and includes heat pumps and equipment for producing and distributing renewable energy. In case of gaining electricity by geothermal energy, transmission is excluded from the credit. The credit is extended for all geothermal electricity investments in the future years, except for geothermal heat pumps, which was only valid for projects beginning construction until the end of 2016 (DSIRE 2017).

8.3. Business opportunities in geothermal

Despite the many opportunities, the potential in deep geothermal exploration has not yet found its way to the market completely. One company exploiting this potential is Universal Geopower, based in Houston and operating geothermal plants by co-production of oil and gas wells (Airhart 2011). The company Thermal Energy Partners, located in Austin, plans and implements geothermal power plant projects on a worldwide scale. Currently, they are looking into a geothermal power plant on the Dutch Caribbean Island Nevis and how to connect its power to the adjacent island Saba by an undersea cable (Jackson 2017). Opportunities to partner up with institutes and companies to bundle skills and knowledge are always available given Texas' strong energy research and experience. Moreover, a study from the Department of Energy calculated geothermal energy costs at $10 cents per kWh. The fact that co-production opportunities in oil and gas wells leaves out the cost for drilling production and injection wells favors this relatively cheap cost (Airhart 2011), (Hanegraaf 2017). This is also attractive for oil and gas producers who could refer from more payments to clean up waste products of their wells. In general, the potential is attractive; it just needs more successful examples of implemented geothermal energy projects.

In 2015 there has been an initiative by Whisper Valley in Texas to help the City of Austin reach its CO_2 reduction goals by including 7500 net-zero solar and geothermal power equipped homes (Rehau 2015), (Rhodes and Upshaw 2016). This technology makes use of a heat pump geo-exchange system, where hot fluid in shallow-built pipes is carrying heat into the building in colder seasons and out of the building in warmer seasons by moving heat from and to the earth (SECO 2008), (Rhodes and Upshaw 2016). In addition to this partnership, there are several other private businesses that discovered the potential of geothermal heating for houses and buildings. For example Stan's Heating&Cooling, Efficient Air Conditioning & Electric in the Austin area, Apex Home Energy Savings in San Antonio, Sims Air Conditioning & Heating Inc, Decatur Heat & Air Inc or Airtron Inc in Dallas. Advanced Mechanical Systems in Austin or Southwest Mechanical in San Antonio are drillers who install geothermal heatpumps. Consumer benefits entail lower energy bills and better efficiency.

8.4. Conclusion

From the resources and the research which has been done, it can be resumed that Texas definitely has what it takes to develop renewable energy production from geothermal resources. Apart from the resources estimated in Figure 9, the advantageous point lies in the existence of oil and gas wells, which provide hot fluids to be disposed, which could then be used for the generation of geothermal energy. Another point is that Texas has the know-how and the skills concerning well exploration and location of subsurface resources. A project such as in Whisper Valley, a community of Austin, proves that geothermal electricity provision can be possible. Yet, there are more challenges to overcome with regard to the strong competition by cheaper prices of other (renewable) energy industry segments.

9. Nuclear energy

Ever since the disaster in Fukushima in 2011, people have a rather critical opinion about the implementation of nuclear energy. Still, it is a clean energy resource with relatively low emissions and an indefinite future. As stated in 1.3., where renewable energy is defined, one could argue that it can be renewable. Apart from its risks it has the potential of being a clean energy resource which is necessary to meet the world's electricity demand. Texas ranks seventh in the nation that is world's largest producer of nuclear power with 30% of entire nuclear generation (Nuclear Energy Institute 2015), (World Nuclear Association 2017).

9.1. Nuclear resources and capacity

With only 5% of its energy portfolio dedicated towards nuclear energy, Texas still gains 10% of its electricity from nuclear (State Impact 2016). National averages state that each reactor employs 400 to 700 workers and contributes about $470 million to the economy (Nuclear Energy Institute 2016).

Texas has four nuclear power plants, two of them owned by Luminant (a subsidiary of Dallas-based Future Holdings) Power in Glen Rose, 60 miles southwest of Fort Worth, and the other two by South Texas Project

Nuclear (STP) in Bay City. Their added capacity is 4960 MW. Further, Austin has a small nuclear reactor at the J.J Pickle Research Campus. The University of Austin uses it for its Engineering Teaching Lab and is running a nuclear and radiation engineering program. Research institutes and universities such as Texas A&M University or the Southern Methodist University focus on nuclear energy potential as well.

9.2. Current state of nuclear development

The question of the nuclear development in the future is concerning the entire United States. 20% of U.S' electricity is supplied by nuclear running on 90% capacity factor and contributing to most of the free-emission generation (Bureau of Economic Geology 2017). Most plants are older than 40 years, while they are licensed to operate until 60 years. A second license renewal from the U.S Nuclear Regulatory Commission (NRC) would let them run to 80 years (Nuclear Energy Institute 2016). The problem however presents itself in the difficulty of obtaining new licenses under current market conditions. Safe operation and protection must be proven and with costs of $20 million for preparation and reviews, the reviews and inspections take about two years (Nuclear Energy Institute 2016). The decision to renew is based on the economic situation of the plant including its location and the regional electricity demands. At the end of a 40 year's license capital costs will be fully recovered and decommissioning costs will have been fully funded. A renewal of the license presents the cheapest option for nuclear facilities for future generation (Nuclear Energy Institute 2016). Even so, some operators decide to retire plants earlier because of the low electricity prices (Bureau of Economic Geology 2017).

The Comanche Power Plant units from Luminant are relatively young, one 27 and the other one being 23 years old (Luminant 2017). It is planning to renew its license, in order to run unit 1 until 2050 and unit 2 until 2053 (Nuclear Energy Institute 2016). The STP Nuclear Power Plants have been commercialized in 1988 and operate 29 years ever since. Already having applied for renewal, NRC's approval would let unit 1 be operated until 2047 and unit 2 be run until 2048 (Nuclear Energy Institute 2015). The total operation of these plants contributes approximately $2.9 billion to the economy of Texas. Nearly 2800 people are employed at the nuclear power plants of Texas. Operating these plants involves a high level of community involvement and environmental stewardship as well. For instance, employers cover positions as voluntary scout leaders or emergency medical technicians and are present on community or on school boards. Safety is another point that is underlined severely (Nuclear Energy Institute 2015).

9.3. Business opportunities in nuclear

According to the Texas PUC, the four nuclear plants in Texas are economically stable. Otherwise, it is often the case that nuclear energy is dependent on subsidies (San Antonio Express News 2016). The STP Nuclear plants in Bay City are operated by Austin Energy, NRG Energy and CPS Energy (State Impact 2016). The collaboration and the size of these companies show that nuclear energy projects require a large amount of capital. For instance, Exelon Generation proposed a $16billion nuclear power plant in 2011 in Victoria, Texas, but later cancelled the plans due to less favorable economic conditions such as low natural gas prices (Nuclear Engineering International 2012). According to the World Nuclear Association, developing nuclear power in deregulated markets is more difficult than in regulated markets, where there is less competition (World Nuclear Association 2017). In addition to that, nuclear power projects will be under discussion by certain parties such as the Texans for Sound Energy Policy. In contrast to the big costs, uncertainty and competition for future projects stand the benefits that can boost the economics in form of taxes and employment of the particular region significantly (CNN 2011), (Nuclear Energy Institute 2015). Moreover, there have been technology advancements with regard to safety, which make nuclear power projects worth considering, given the sufficient amount of capital.

9.4. Conclusion

Nuclear power projects undergo the same uncertainty in Texas as they undergo anywhere in the United States. Since the accident in Fukushima, people's preference for nuclear power shifted dramatically, although there have been technology improvements ever since. Since Texas demand for reliable electricity is growing as well, nuclear energy is worth considering for companies or a cluster of companies, which have the sufficient capital. Universities and research institutes promote exploration of safe and efficient nuclear energy technologies. The competitiveness in a deregulated energy market such as Texas stands in contrast to the business friendly attitude and the economic benefits nuclear energy would bring, which can be found in Texas as well.

10. The Dutch energy market

The last chapters have broadly elaborated on the potential of renewable energies in Texas. In the following, the link to the Dutch energy sector will be made so that the renewable energy potential in Texas can be translated to the Dutch business sector in particular.

10.1. A liberalized energy market

The Dutch energy market is different than the energy market in Texas, due to various authorities, deviations in competitiveness and sheer scale. Therefore, the way business is done in this sector is different as well. Just like in the United States, the Dutch electricity market was once fully regulated. In 1996, the liberalization of the Dutch energy market was announced by the Dutch government. When the Electricity Act entered into force in 1998, monopolies were abandoned, foreign takeovers were enabled, domestic mergers and trade were supported (Dutilh 2000).

Currently, there are generators on the one hand and competing electricity providers on the other hand. Apart from that, the T&D utility is responsible for delivering the electricity to the customer and they are the monopolist in their particular region. The eight regional T&D utilities are referred to as Distribution System Operators (DSO) (Deloitte 2012). Higher voltage is managed by TenneT, the Transmission System Operator (TSO) of the Netherlands and of Germany. Apart from that TenneT has international connections, which enhance among others market coupling with Belgium and France and Scandinavia and intraday trading with Norway.

TenneT operates in a zonal market, because it is the most intuitive and straightforward approach: Border interconnections between European Member States have historically been equipped weaker, so drawing the borders between the European countries as the borders of the zone was the most intuitive step. Congestion is managed by holding electricity exchange to some extent in the designated bidding zones. Whenever there is grid congestions, costs will be socialized by the grid charges instead of being addressed to the specific congestion point (TenneT 2017).

In order to prevent discrimination by the system operators' monopolies, the Autoriteit Consument en Markt (ACM) is an entity which sets the maximum price a T&D utility can ask for transporting electricity. T&D utilities that are performing very well in their tasks are allowed to demand higher prices (ACM 2016). Differences between the produced amount of electricity and the demanded quantity are communicated by TenneT to a certain 'PV party' (programma verantwoordelijke partij), who will calculate the final price in order to balance supply and demand. This party is responsible for purchasing electricity to meet the demand. That can occur on a spot market (the Amsterdam Power Exchange: APX), through long term contracting, bilateral trade or from abroad (Belgium, Germany, Norway, the UK). APX was integrated in 2015 with Central Western Europe and the UK and thus became the European Power Exchange (EPEX). As a wholesale electricity market, a day-ahead market and an intraday market exist. Generation is dominated by some main market players: Nuon (Vattenfall), Essent (RWE), E.ON, Eneco and Delta. Liberalization made national generation and distribution companies being taken over by large European vertically integrated companies (Vattenfall and RWE). Therefore, the Dutch energy market can be described as moderately concentrated (Deloitte 2012).

10.2. The current renewable energy situation in the Netherlands

In 2015, 21% of the renewable energy in the Netherlands was generated by wind, 17.9% of this on- and the remaining 3.1% offshore. Solar energy holds a smaller portion of 4.3%, geothermal holds still 5.1% and water energy only holds 0.3%. The by far largest portion of renewable energy generation is occupied by biomass with nearly 70%. While biomass energy generation grew with only 1.8%, solar experienced a growth rate of 30% and wind 19%. 40.1% of all renewables is used for electricity generation, 49.4% for heat generation and 10.6% for transport (CBS 2015).

The growth of renewable energy can be mainly assigned to ambitious policy goals. Regarding renewable energy, the Netherlands are bound by the directives from the European Commission, in which every country contributes to energy generation of 20% renewables by 2020 in the EU. For the Netherlands, this goal entails that 14% of the energy production in the Netherlands has to be renewable by 2020. In 2050 100% of all energy should be renewable (Rijksoverheid 2016). In 2011-2012, the Netherlands missed the necessary 5.1% to reach the 14% goal (Deloitte 2012). In the new 'Energieakkord', 16% have to be reached by 2020. Obligations to mix fuel with certain percentages of biofuel and the SDE+ subsidy, which favors projects of renewable electricity and heat generation contribute to the promotion of renewable energy in the Netherlands. Apart from that, it is worth noticing that the Netherlands are European's second largest gas producer, after Norway, because of abundance in gas fields in the North of the country. Due to increasing complaints about earthquakes and declining gas reserves, the government had decided to cut gas productions and let more run on renewable energy. Demand for greener gas is also experienced in the transport sector. Under the Renewable Energy Directive (RED) from the European Commission, 10% of each country's transport fuel must come from renewable energy by 2020 (Rijksoverheid 2016). This does not include aviation bio fuel (Beunis 2017). Each country is required to utilize their own system to follow these goals. With the push of the Dutch government towards the energy transition, big companies such as Eneco, the Port of Rotterdam, Siemens, Shell and Van Oord prefer to pursue these goals quickly as well (NOS 2016). Internationally however, the Netherlands rank quite low in their use of renewable energy (CBS 2015).

In 2014, just 5.5% of total energy production came from renewables. Reasons is the relatively absent hydropower sector, which cannot be optimal due to little elevation differences in the Netherlands. Another reason is the high connectivity to natural gas, which provides most of the Dutch households with energy and makes the utilization of wood more expensive. A third reason is the relative late deployment of subsidies, such as the SDE+ in 2014, whereas European countries like Germany, Denmark or Spain started to promote wind and solar much earlier. Large projects, which are supported by SDE+ have not yet emerged due to the time of planning, requisitioning and realization (CBS 2015).

11. Differences between the energy markets

The previous chapters have highlighted Texas and the Netherlands separately. From the description in these chapters comparisons can be made. This reveals differences and things both parties can learn from. The differences are mostly based on the governance of energy in Texas or the Netherlands. Even if this report seeks to find market opportunities for Dutch businesses, it is important to understand the governmental differences, which determine the mindset of the state or the country and thus has an important impact on entrepreneurs.

11.1. The laissez-faire versus government regulation

From the analysis of Texas' energy market follows, that renewable energy in Texas 'works' next to the often more obvious dominance of oil and gas. How is that possible? Going back to the analysis in the prior chapters, the factor of large geographical and geological potential definitely plays a major role. This potential could be utilized. There has been an economic case for some renewables and with the deregulation of the market by George W. Bush in 1999, the opportunities could be unfolded. Apart from the RPS, the PTC and the ITC, Texas has relative less government intervention as compared to other States. The subsidies and the transmission lines made sense, since investments in wind and solar kept on going. To emphasize the growth in investments; there are more developers chasing off-takers to sign up a contract than there are off-takers chasing developers (Caceres and Jungmann 2016). One can also argue that wind is at a point without need for subsidies (Beceiro 2016). The point is that development of renewables in Texas is attractive enough without the need for more government intervention. ERCOT does not favor any source of energy; in the end, price signals give the answer which energy source will be provided (Hailu 2016), (Shalabi 2016). Frankly, the market takes over. The character of Texas' energy market is emphasized by the fact that Texas is a business-friendly state (Rhodes and Upshaw 2016), (Shalabi 2016), (Texas Wide Open For Business 2014). People in Texas may be not as concerned about the environment as other States (e.g. California), but still renewables find their way into the market by being economic in Texas (Magee 2016).

This is slightly different in the Netherlands, or generally in Europe. The main policy goal there is to reduce CO_2 emissions. Goals of renewable energy are very much stimulated by the government. One example is Germany, which rolled out so many subsidies that prices went negative and generators were paying customers to take their energy. Moreover, it is often considered as risky to let the market take over (Aresu 2016). Even if the Netherland's energy market is quite liberal, the Texan energy market puts the picture into perspective. The abundance of natural gas is embraced in Texas. Instead of seeing it as an impediment towards the growth of renewables, it is often being viewed as a bridge towards renewables and towards emission reductions. The 'all of the above' option, which favors a mix of energy resources to meet energy demand, is also found back in Texas. With abundance in marketing strategies and different plans, the energy market in Texas is very competitive.

11.2. Entering the market

The competitiveness and the market driven way in the Texas' energy market described in 11.1 introduce some barriers to enter the market. These barriers go with the unfamiliarity of anyone being used to a different country with a different energy market. The Netherlands are used to a deregulated electricity market, where trade takes place on EPEX/APX spot market. Still, no electricity market is the same and in the U.S itself, markets are very different. Markets in the North West of the U.S contrast to the ERCOT market in Texas or the PJM in the East. Even among liberal markets, ERCOT stands out as being 100% competitive.

The low prices in ERCOT and the short interval in the real-time market are aspects, newcomers and even domestic developers in ERCOT have to get used to every time in order to keep up with competition.

One thing to get used to is the 15 minute interval at which the electricity real-time market clears and then the day-ahead market, which is co-optimized with ancillary services. This market also allows for long-term contracts and a platform for hedging (ERCOT 2017).With regard to that, developers should be aware of the terms at which contracts are being made and where power is being hedged by retailers in order to serve the load (Magee 2016).

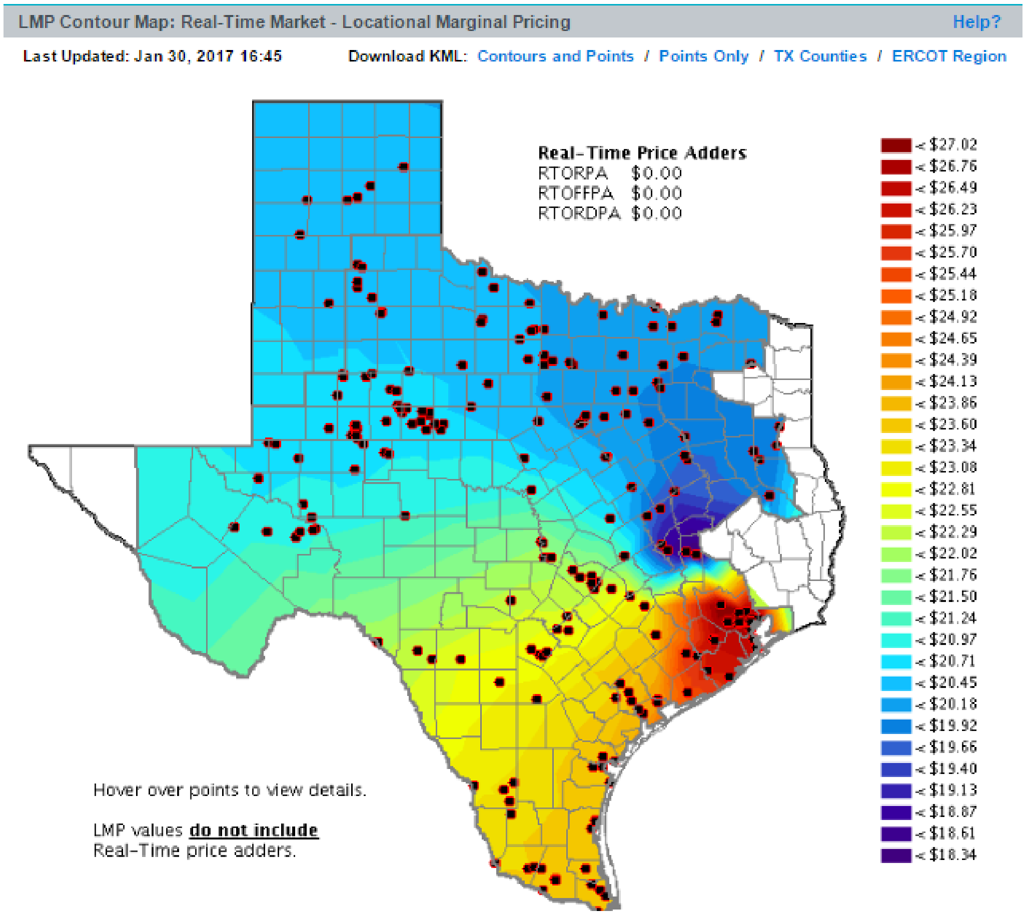


Figure 10. Real Time Market-Locational Marginal Pricing. ERCOT 2017.

The upper map is presented by ERCOT every time of the day. It shows the different nodal prices, which are created every five minutes in the real time market. Load is still charged a load weighted averaged zonal price, but generators are paid a price for every MWh they injects into the grid at a local price. The zonal price is calculated every 15 minutes (ERCOT 2016).

With the zonal electricity in Europe, this presents a clear difference between the Netherlands and Texas. Whereas congestion is managed at the borders of the European Member States in TenneT and costs are included socially in grid charges, congestion management in Texas is more internal, addressing the generators locally. The points are the nodes, which all have their own locational marginal price. The colors serve to distinguish areas of higher and lower prices. One can observe that generators offshore generally pay a higher price for their MWh of electricity, while West Texas is relatively cheap in its energy pricing.

This figure underlines the big local differences and the complexity in ERCOT's real-time market. ERCOT has its own sophisticated market and is very accurate and reliable concerning its data. It is certainly not easy to understand all the structures and mechanisms of ERCOT. Even Texan developers sometimes struggle with this (Magee 2016). There is no one public rate of power, such as in California for example, so market players in Texas have to be timely and well aware of their management and their market environment (Magee 2016).

Moreover, there is information asymmetry between the developers and the retailers (Magee 2016). In contrast to the developers, retailers have the historic data of power usage and the forward curve, which predicts the hourly power prices, and they have the demand charges of T&D.

Another barrier in doing business in Texas' energy market is the lack of clarity of which party is responsible for what. There are many separate elected officials. One state agency may be responsible for subjects, which do not seem directly related to its initial purpose. For instance, the General Land Office, Texas' oldest state agency plays a major role in education as well by managing mineral rights and creating electricity for schools and other public customers (General Land Office 2017). Moreover, the Texas Railroad Commission has overview of the oil and gas industry and alternative fuels despite its name, by licensing companies in both fields, conducting safety evaluations of stationary facilities and providing training to individuals in the alternative fuel industry (Rail Road Commission of Texas 2017). The fact that there are no strict guidelines yet about severance of wind rights is mentioned in Chapter 4.2 and illustrates the importance of knowing the laws and the regulations in Texas.

Zoning is part of the barriers to entry as well and applies to a certain extent in Texas. With high competitiveness, electricity consumers are very flexible to switch their providers. This indicates something about the customer loyalty, too. By merely typing in their zip code on the website 'Power to Choose', 300 and more electricity providers are shown to them, so they can easily switch providers, when desired. However, this differs per city. The state of Texas has a deregulated energy market, but within that state, the level of competitiveness is more moderated in some cities than others. As seen through the prior analysis, municipal owned utilities such as Austin Energy or San Antonio dominate the market in the respective cities, whereas Houston or Dallas have high competitiveness between the many electricity providers. This local dependent situation is not so much the case in the Netherlands, where scales are much smaller.

As a difference between the Netherlands and also many other states in America, Texas has no income tax. Sales taxes range from 6.25% to 8.25% and can significantly influence larger sale portions. The Most Favored Nation import duty tariff for renewable energy products is 8% (Duty Calculator 2017).

12. Resource specialization

The Netherlands and Texas are both very different in sheer size and geography. Yet, there are also some similarities. The endowment of geographical potential mainly determines the resources the country/state specializes in.

12.1. Size matters

With Texas being big and having abundant land, utility scale projects make sense. Quite the opposite applies to the Netherlands, where dense population and a relative small area of land force developers of renewables to expand borders by generating off-shore or favor roof-top solar instead of solar thermal energy. The 'not in my backyard' conflict is indeed often a problem in the Netherlands. Wind farms on the land are perceived as disturbing due the proximity of the noise and the shades the turning blades create. With large unpopulated areas, this problem barely occurs in West Texas.

The size of the state of Texas plays also a role in its potential for biomass. Whereas the distance between power plant and the biomass might represent a problem in Texas, next to hard competition from gas, wind and solar, distances in the Netherlands are more ideal for developing a potential in biomass. This is confirmed with biomass accounting for 70% of the renewable energy generation in the Netherlands. As there are not abundant biomass resources in the Netherlands, most of the biomass is exported from the U.S, consisting for a large amount of wooden pellets (CBS 2015). Furthermore, production of biofuels in the Netherlands exceeds consumption and is shipped abroad from the Port of Rotterdam (CBS 2015). In contrast to that, landfill biomass for heat generation in households is heavily consumed which urges the Netherlands to import more waste from European countries (CBS 2015).

Size plays also a role in the promotion of electric vehicles. The necessary infrastructure can be built relatively easily in collaboration with close cities and involvement of local stakeholders (Reinders 2017). Due to these geographical conditions, the promotion of EVs is stronger supported by the governments' subsidies. Consumers of EVs are exempt from certain vehicle taxes. In the Netherlands, already 11402 charging stations have been created (Rijksoverheid 2016). The goal is independence from further government support by 2020.

12.2. Country specific conditions

One important distinction between the renewable energy economics of Texas and the Netherlands is the demand of heating in the winter, which is much higher in the Netherlands than in Texas. Therefore, the role of heating by (renewable) energy sources is more prominent in the Netherlands, apart from the generation of electricity. This and the fact that the Netherlands prepare themselves to be less dependent on heat generation by natural gas explains the higher demand of biomass to a considerable extent. Biogas, or 'green gas' is gas upgraded to natural gas' qualities and then injected into the pipelines (CBS 2015). For instance, the T&D utility Cogas, uses manure from the circumjacent farmers to convert it into biogas (Aresu 2016). Installation costs of this project are more beneficial since the proximity of the farmers does not require the gas to travel far. Nevertheless, there are many risks associated to such projects, because it takes about 12 years for the installation costs to be paid, while many problems could happen in the meantime to the farmers and their production. Still, the economic sense for this project comes from the big push of the government towards CO_2 reduction and the result that the big T&D utilities in the Netherlands compete on these projects, building pipelines in other utilities' territories (Aresu 2016).

Next to biomass, heat generation in the Netherlands plays a significant role. Just as in Texas, the potential for geothermal energy is there. The Netherlands recognize this potential in many different methods. One way is winning energy by the heat in greenhouses. Another one is the gain of heat through deep wells (CBS

2015). In the Netherlands the skill and knowledge for deep ground exploration and drilling are relatively developed as well, due to the experience from the oil and gas sector (Hanegraaf 2017). Since there is sufficient information about the location of ground layers, their permeability and more criteria, the risks of developing onshore deep geothermal energy are low. Due to high costs of abandoning old oil and gas wells, the option to use coproduction from hot fluids inside the wells for geothermal energy is very attractive and considered as well (Hanegraaf 2017). In addition to that, including geothermal in the SDE+ subsidy helped developing Dutch geothermal substantially (CBS 2015). Further, the project which is carried out in Whisper Valley, Texas and by other private companies is found back in the Netherlands, too: Heat pumps, which mostly warm larger companies' buildings in the winter and cool them during the summer (CBS 2015). The research organization TNO and a couple of companies are active in initiatives concerning aquifer thermal energy storage, which takes geothermal energy potential from shallow grounds to cool or heat buildings (Dutch Ates 2017).

Hydropower in the Netherlands is similarly underutilized like in Texas. Little elevation levels allow for limited development in hydropower. The Netherlands (and Texas), however, show potential in salient gradient power, with the first salient gradient power plant of the world opened at the Afsluitdijk, primarily serving research rather than commercial purposes. This is enhanced by the firms RedStack, FUJIFILM and Wetsus (Blue Energy 2016). Moreover, the worldwide Dutch company Salt Tech is concerned with reverse osmosis as well, which can be applied in the oil and gas sector, for instance for hydraulic fracturing or for desalination and chemical removal. Due to the connection of salt and fresh water resources, salinization and water quality are target issues in the Netherlands. Water management and flood control is a subject of superiority in the Netherlands, however gaining energy from water is relatively limited. Still, due to their history and their geography, the Dutch are inventive when dealing with water. Many Dutch universities carry out outstanding water management and engineering research (Rijksoverheid 2017). One example on how to deal with water energy is present at the Dutch company Tocardo, which employs renewable energy projects worldwide for rivers, inshore,- and offshore areas. Thus, Tocardo is planning on a tidal power plant at the Afsluitdijk in 2018, subsidized by the Dutch government. Currently, the tidal power plant is expected to reach 1,8 MW (Tocardo 2016). Nevertheless, just as in Texas, harvesting ocean power is a relatively new concept that has to be explored worldwide. Most cases of renewable water energy development are still pilot projects and subject to research and subsidies.

13. Implications for business opportunities

With an analysis of the renewable energy market in Texas and an insight into the Dutch situation compared to the situation in Texas, implications for entrepreneurs seeking to enter the Texan energy market can be made. The following chapter will set up an advice for Dutch companies who are interested in carrying out business in the renewable energy sector of Texas. The advice is generalized and does not address a specific size or kind of company.

13.1. Get to know the market

Entering a market, in a different continent than Europe and then in a state where people are not "from the U.S but from Texas" gives rise to unfamiliarity and surprises. The international companies engaging in CPS Energy's New Energy Economy initiative encountered quite some difficulties with the way the energy market works and business is being done in Texas (Caceres and Jungmann 2016). Even domestic producers struggle to understand ERCOT (Magee 2016). With 100% deregulation, high competitiveness and low gas prices, the ERCOT market represents challenges for everybody wishing to engage in renewable energy business activities and enter that market. Entrepreneurs should be aware of distinguishing factors of the Texan energy market emphasized in Chapter 12: The perseverance of market forces instead of government intervention. The internal and accurate methods ERCOT operates with; a nodal electricity market, in which demand and supply are balanced within minutes. The local differences in Texas with regard to municipality owned utilities and private companies. The differences in geographical, climate and economic conditions across the State of Texas. The rights concerning land, and the distribution of responsibilities in relevant sectors of the State.

Before engaging in the renewable energy market in Texas, studying and getting familiar with ERCOT is an often underestimated advice and still very important. The ERCOT website provides courses, modules and manuals about operating procedures in the day-ahead and real time market and also guides about market rules (ERCOT 2017). Another good website is DSIRE, which provides all policy incentives and subsidies in the United States under the topic of renewable energy and energy efficiency. Similarly, the Energy.Gov website from the U.S Department of Energy gives a better perspective into the conditions and constraints for relevant subsidies.

While studying and researching will be biased on one's own perspective, it is worth to consider hiring a broker, who has the knowledge and the skills to execute important deals (Magee 2016). Especially for developers, working with a broker can help to contract with industrial and commercial clients. Then, maintaining these good broker relations is essential.

The lack of guidance concerning wind and solar rights and land surface when developing a project are another thing to take into consideration. It is advised to engage land owners in a lease where the standards are made clear and where both parties agree. Ensure that they do not purpose to severe any wind /solar rights from the surface rights. In any other case, consider and discuss at least the consequences it brings for future development (Thomas 2017). In general, awareness of laws and restrictions in Texas is advised. There are various state agencies responsible for diverse topics. Important ones are for instance the Texas Comptroller of Public Accounts (taxes), the Public Utility Commission (administrating electricity, telecommunications and water projects) or the General Land Office. More information can be found on the respective websites or on the website of the Texas State Government.

Hiring local people is another important advice (Caceres and Jungmann 2016), (Tulloh 2016). By doing this, the pool of knowledge is expanded and ways to deal with the business culture are revealed. Moreover, Texas has a skilled working force given by the many research programs and universities that trained them. Plus, the years of experience in the oil and gas sector serve also well for engaging in construction and exploration for renewable energy projects (Texas Wide Open For Business 2014). Hiring local people may be a difficult venture for itself. International staffing agencies with Dutch origins such as Brunel Energy or WTS Energy are also located in Texas and could help to find fitting employers.

Apart from the critical inclusion of local people and their knowledge, the knowledge of domestic stakeholders in Texas itself can also help, as they understand better than no one else the difficulties they have faced themselves when entering the market. Domestic stakeholders also include governmental parties who have the ability to connect entrepreneurs to the right party. One obvious stakeholder is the Netherlands Business Support Office, who is part of the economic network in the U.S and has many connections in Texas, being located in Houston (the energy capital of the world). Getting connected with entrepreneurs, who were once in the same situation of unfamiliarity with the market, provides learning opportunities and network expansion.

13.2. Concerns about economic and political developments

It has been impossible to ignore the recent developments that have been going on in the entire U.S. First, the energy market and thus the whole economy was severely influenced by a drop in oil and gas prices. With a peaking oil price of $100 per barrel in late 2014, a drop to $45 in fall 2015 and a complete drop to $29 per barrel in January 2016, this was an 'overnight shock' for many companies. Lately, the price has been rising, also partly because of OPEC interference. With a decline in companies' revenue and employment, it has been more important to diversify products and operate on short cycle times (Lance 2016). Diversification underlines the inclusion of renewables, too.

Inclusion of renewables clashed with the recent election of Donald Trump, whose new administration promises to focus more on fossil fuels. It is indeed likely, that Trump will support the expansion of the oil and gas sector. The expansion in this sector however, does also require the inclusion of international trade (ICF International 2016), (McConnell 2017).

Further, the promise that the coal sector is being brought back under Trump's new administration is unlikely, because the competition of low gas prices. Moreover, renewables will not be influenced as much as everybody in favor of it fears, as the most important tax credits; the PTC and the ITC have been extended through Congress and are unlikely to be expired by the Internal Revenue Service soon. However, the IRS may revise the conditions of these credits (ICF International 2016). Renewable Portfolio Standards and net metering are controlled at state level. Further, lower corporate taxes may lead to tighter equity taxes but lower tax rates for projects in general. Import tariffs on cheap solar panels from China may influence the renewable energy sector negatively (ICF International 2016).

All in all, Trump's administration calls for less regulation, also from the EPA, and more expansion in the fossil fuel sector. While his focus is not on renewables, it can also be said that renewables will not be heavily impacted for now. One major takeaway is that in the end, the market might still have the biggest influence. Where technologies are economic, they will be carried out. In addition to that, states play a big role in their own energy policy containing renewables. Especially Texas' energy policy has always been guided by the market. Rick Perry, former governor of Texas, has been proposed by Trump to be the Secretary of Energy. After Perry followed George W. Bush's resignation as Texas governor in 2000 and after the development which is observed in the renewable sector from that time on, it can be said that Perry did not hamper the growth of renewables in Texas. Wind was greatly promoted and there has even been a $5 million grant awarded by him to research biofuel advancements in Texas. An important lesson is that Texas energy policy is mainly market driven and with the accessibility and affordability, renewables are likely to keep making a good economic case in Texas.

Therefore, an advice is to not be too concerned about the politic noise taking place and be aware of the economic factor which always plays a determining role and the fact that Texas has always been less policy dependent and is very open towards business development.

13.3. Engage in municipal collaborations and partnerships

Despite the fact that only some resources are applicable in one country/state, there are things both parties can learn from each other. Even if biomass is not the most logical option in Texas, the Netherlands show innovative ways of including the community (in this case the farmers) to delivering inputs for the particular technology. Community involvement is also present in the development of DER and an attractive option when not every roof is suitable for solar panels. Another example is an initiative taking place in 2009 in Amsterdam, involving multiple stakeholders to develop the electric vehicle market in the Netherlands. Although this issue was first addressed critically with regard to financial hurdles, stakeholders such as T&D utility Alliander, KPN, the City of Amsterdam and BMW resulted into 'standardized, interoperable and brand-independent charging infrastructure for electric vehicles' (GSC3 City 2016), (Reinders 2017). By putting the initiative in the hands of entrepreneurs, cities and people, the promotion of a renewable energy resource can run smoother than relying completely on the government to take action (Reinders 2017). Another example is the New Energy Economy initiative by CPS Energy, where the commitment of international businesses in renewable energy has contributed positively to economic development in San Antonio- under the condition of international companies settling there. Further, Austin Energy has a partnership with the Dutch Alliander (Shalabi 2016), (Reinders 2017). Whisper Valley with partnerships between European manufacturing company Rehau and then Eco Smart LP, Geo Enterprises, Taurus of Texas LLC and the City of Austin is creating a more profitable situation for technologies in geothermal and solar by bundling knowledge, skill and determination.

It is notable, that most of these partnerships and collaborations are being created from a municipal level. As mentioned earlier, the competitiveness in the market in Texas differs between cities. The utilities in San Antonio and Austin are municipally owned and thus essentially owned by the community. They get most of their financial funds from the community. The prior analysis showed that these utilities are more generous in their sustainability goals and more community minded. Hence, it can be beneficial to connect to these utilities, also when less market-mature resources are concerned. Sharing knowledge and bringing together global players of the energy market does certainly enhance business opportunities.

13.4. Exchange in resource specialization

To be successful in any market the knowledge of one's value proposition, the existence of a unique service or product which determines the comparative advantage is certainly valuable. One thing to keep in mind though is that it is not necessarily skills which differ between the Netherlands and Texas, but that the renewable energy specialization depends on the governance, the geography and the geology of the country or state to a great extent. In this globalized world it is hard to find a unique selling point of one entire country or state. Solar has not been growing so much in Texas because the engineers in Texas have more knowledge than engineers in other countries. It is rather because of China who has been driving the price of solar panels down and it is a matter of governance and recognition of potential to make a country or state outstanding in their growth and strength of a certain energy technology. Geographical, geological potential and subsidies, such as the PTC, ITC or SDE+ greatly determine the resource or technology a country/state specializes in. For example, the Netherlands' small scaled environment allows for fast development of electric vehicle infrastructure. The European Commission's ambitious climate goals make way for subsidies in underdeveloped sustainable technologies. On the other hand, utility scale is broadly realized in Texas since vast cheap land allows for it. This dependence on geography, geology and policy is a main point to take into account when assessing the comparative advantage of the Netherlands/Texas.

Profiting from the potential in Texas: Utility Scale business potential

Nevertheless, there are resources and technologies the one country or state is less developed in. Big companies with sufficient capital and an interest for wind or solar energy can start doing business in Texas' wind and solar industry. Wind and solar in the Netherlands grew 30% and 19% in 2015 respectively, so this growth can connect well to the large wind and solar potential in Texas. Benefits such as extended tax credits and vast cheap lands, which are ideal for utility development, call for quick action as there are many projects in ERCOT's interconnection queue waiting to enter the market and the PTC and the ITC are still valid until 2019. Even corporates who are not specialized in energy production should consider and analyze the economic benefits of engaging in the purchase of renewable energy from these large utility scale projects, as many successful corporates are already doing so (Google, Amazon, Mc Donalds, Volvo, Unilever, Lockheed Martin… to name a few). Moreover, there are employment opportunities in the wind manufacturing sector as well. Smaller businesses can find their way into the market by DER projects and energy storage, which are growing trends in Texas. For the competitive utility scale sector, entry barriers are relatively low in Texas, but the first advice to get to know the market should still be taken seriously.

An example of profiting from country specific conditions: Biomass potential

Whereas Texas' resources allow for utility scale development, the Netherlands was able to develop technologies which are dependent on the small geographical scale. Besides, due to stricter policy sustainability goals, there is a demand of many European countries for alternatives to natural gas, which allowed them to develop more expertise and experience in biomass production or geothermal energy. The Netherlands combines this expertise with their knowledge of oil and gas pipelines as second largest gas producer in Europe. This experience can be used to add value to businesses in Texas: Landfill gas utilization companies have an interest from European producers in efficient clean-up technology products. Toro Energy or Waste Management are examples. The Landfill Methane Outreach Program (LMOP) from the EPA provides the necessary data and analyses about existing landfills and landfill candidates in all the States (Hallenbeck 2017), (Bean 2016). Prominent Dutch companies on landfill gas are COSUN and Attero. Moreover, Wageningen University specializes on renewable gas and chemical production from waste, too.

Another initiative from the Dutch business KLM is SkyNRG, which supplies airlines with bio kerosene, a jet fuel. They purchase their renewable fuel from biorefineries, which are also located in the US and have done business with Dynamic Fuels or Haltermann (now known as Monument Chemicals) close to Houston, Texas. However, one of their current producers in the U.S is now AltAir Fuels in California, which benefits of more advanced refinery technologies, vicinity to an airport and two subsidies: the RIN and the LCFS, the latter one only being applied in California (Beunis 2017). This once again emphasizes the importance of subsidies. With the RINs existing in Texas as well, it is still worth looking into business activities given the many biomass power plants in Texas, as shown in Figure 2. SkyNRG has a smart business model in which they trade with subsidized states in the U.S, but also find ways to make their economic case in the Netherlands by selling certificates for bio kerosene (bio jet fuel) to businesses who follow the RED, which excludes aviation fuels. Moreover, they profit from the trend in corporate sustainability goals: As biofuel is more expensive than fossil fuel and is harder to sell to airline businesses, sufficient funds are collected from corporates, who would like to improve their sustainability goals and carbon footprint. This business model makes use of the common trend by corporates which can be observed on utility wind/solar as well. It does also illustrate how to make use of specific country conditions including the dependence on subsidies and resources.

Complementary resources and skills: Geothermal potential

Both Texas and the Netherlands have the knowledge and skills for ground exploration, drilling and pipeline injection. Texas market driven approach allowed for hydraulic fracturing of gas from shale rocks and their development in horizontal drilling. This expanded the surface for drilling and the permeability of rocks. Apart from that, there are temperatures in the South and the East of Texas which allow for conventional deep ground geothermal development. On the other hand, the Netherlands have the expertise in this area as well, given that they are the second largest gas producer of Europe. They recognize the potential of coproduction concerning the waste product in abandoned oil and gas wells and the attractiveness of energy storage by smaller geothermal facilities. Initiatives such as the Dutch Ates Group, including NREL, ENGIE and TNO show that it is possible to look for international collaboration opportunities on the field of geothermal energy. Thermal Energy Partners is connecting with Dutch companies such as Salt Tech to combine their geothermal energy potential with the Dutch expertise in salient gradient (Jackson 2017). Knowledge institutes of Texas and the Netherlands can bundle their strengths to explore business cases of conventional geothermal energy harvesting, as well as other new but promising renewable energy resources, as the potential in Texas is broadly scaled and needs more attention.

13.5. The market demand for energy reliability

ERCOT's main focus is continuing to increase reliable energy delivery. With the inclusion of wind and solar energy they have to take care of intermittent supply during the hours where these resources are not producing at their maximum. Currently, cheap gas can back up this intermittency. However, wind and solar will continue to grow and there are risks of wind curtailment due to an oversupply in wind (Farley 2017), (Bradley 2017). With smart ways to prevent this curtailment, wind and solar energy can be used efficiently. Plus, when these resources can be used efficiently, there is less need for gas to back them up. To keep investments in wind energy attractive and to maintain ERCOT's reliability, means of storing energy form a business opportunity for the next five to ten years (Bradley 2017), (Farley 2017).

The market for energy storage finds itself as mentioned in the provision of ancillary services. Here, studying ERCOT requirements is also critical. Storage projects with 10MW or greater have to engage in an Interconnection Agreement (IA) with ERCOT. An IA between utility and storage provider is required for projects smaller than 10MW. Cooperative and municipality owned projects are exempt from IAs but must follow a separate PUC rule for distributed generation resources (DER) (Lexology 2017).

Batteries are a well-known method to fulfill this demand for reliability, however they are better suited for small grid facilities. Still, battery business cases are often community driven and can be found at T&D utilities, such as Austin Energy (Shalabi 2016). Pecan Street Project Inc. operates a 15kw lithium-ion battery project for the Mueller community in Austin. Further, the largest T&D utility in Texas, Oncor Energy in Dallas is applying a 200kW lithium-ion Tesla battery to integrate and store renewables in their System Operating Services Facility Microgrid in Lancaster, Texas. Being very motivated towards sustainability, Georgetown will be the place where Ormat Technologies and Alevo Battery Technology build a 10MW lithium-ion battery storage system, called the Rabbit Hill Energy Storage Project (Lexology 2017). Other projects are directed by AEP Energy, ERCOT's Fast Response Regulation Service (FRRS) ancillary services pilot project in 2014-15 by the Center for the Commercialization of Electric Technologies or by a microgrid project at Fort Bliss with advanced lead-acid batteries. Small-grid facility storage often goes together with solar developments, which is confirmed by initiatives from CPS Energy, funded by the TCEQ and again, Austin Energy (Lexology 2017). All these examples underline the growth in energy storage projects.

The fact that these projects are often initiated by communities and big T&D utilities with the necessary funds, can give way to strategic partnerships. Funds such as from the TCEQ, the TEF or the TETF were mentioned earlier. Moreover, universities (Texas A&M, University of Texas) and various research institutes can support product development, especially in relatively young technologies like batteries. One example for this is the Dutch enterprise Dr.Ten, which developed a battery with sea salt components and has ongoing relations with the University of Texas at Austin to continue this development. Smart grid initiatives for example GSC3 are another community-driven way of engaging in business activities concerning energy storage and reliability. As it is very stakeholder driven, opportunities for strategic partnerships with start-ups, businesses, research centers, cities and communities arise.

As energy storage has increased popularity in the recent years and entails relatively new ideas which yet have to find their way fully into the market, incubators can also help to foster start-ups and business development in this area. Examples for incubators are CleanTX, the Austin Technology Incubator or the Houston Technology Center.

Apart from batteries, there are more options which are likely to define the future development of energy reliability as well. It is important to not overlook them. One example is compressed air energy storage. The company Apex CAES in Houston, Texas develops a project with 317 MW of generator capacity which is to be completed in 2020. Apex CAES welcomes investors such as developers of the wind and solar sector, who seek to secure their energy (Farley 2017). Further, thermal projects are very interesting in Texas, too. Overall, every technology which contributes to energy reliability can find its way to ERCOT's interconnection and profit from the market of ancillary services. The energy storage market in Texas favors very innovative and diverse approaches, relative to other states, where government incentives are guiding the matter.

14. Management summary

The renewable energy market in Texas holds many opportunities. With low entry barriers and a business friendly environment, Dutch businesses can find their way in this market as well. To inform and advice Dutch businesses on the business opportunities and trade activities in the renewable energy market in Texas, the Netherlands Business Support Office in Texas has commissioned this report, which has the following findings and implications:

Renewable energy focusses on energy resources which are naturally regenerated in a short time and can be harvested directly or indirectly from the sun. Thus, this report focusses on wind, solar, biomass, water- and geothermal energy.

The renewable energy market in Texas is part of the independent Electric Reliability Council of Texas (ERCOT) which is responsible for energy generation, transmission and frequency regulation. ERCOT's market is co-optimized by the market of ancillary services, which consists of resources available at different time responses backing up electricity supply, whenever load serving is stressed.

The success of renewable energy resources is very geographically, geologically and subsidy dependent. Geographical and geological circumstances in Texas allow for broad resource potential. The Production Tax Credit (PTC) and the Investment Tax Credit (ITC) are valuable cost reducers for renewable energy businesses and their expiration to 2019 assures investment decisions. The Energy.Gov website from the U.S Department of Energy and DSIRE give an excellent overview of existing subsidies and their conditions in Texas and the U.S.

With the resources and market structure in Texas there is business potential for renewable energy in Texas. This potential can be translated into an advice for Dutch businesses:

- **Get to know the market, as it is very government independent, liberal and competitive.** Even in the United States, ERCOT is unique by quick price dispatching (matching the supply to the demand to deliver load), accurate and precise data and a nodal market, which charges and pays generators on a locational marginal price rather than a zonal market. On top of that, cities such as Dallas or Houston have more competitiveness between electricity retailers, whereas San Antonio and Austin have one municipal electric utility. The entire situation is different from the Netherlands, where prices and competitiveness are not very locational and renewable energy is much more stimulated by the Government. Local employment, brokers, Dutch economic networks (such as the NBSO) and information sources (the ERCOT website) can help to get familiar with the way how things work here.
- Economic and political concerns should be handled without too much exaggeration. Diversification in energy resources helps to face economic fluctuations in the energy market. **Eventually, the market in Texas is more likely to determine resource allocation than political decisions do.**
- **Engaging in municipal collaborations and partnerships can help to foster economic growth for businesses and their products, where the market would have been too competitive otherwise.** Especially less strong services and products, for instance in geothermal energy can experience uprising, as municipality owned businesses have generally more funding for sustainability goals. Partnerships with different businesses bring knowledge and capital from more actors and help to expand product development.
- **Utility scale solar and wind projects have an advantage in Texas compared to the Netherlands.** Market entry faces much competitiveness. Still, innovative business models can find a niche in smart grid facilities or sell renewable energy to corporates wishing to showcase their sustainable management. Biomass is relatively more utilized and demanded in the Netherlands and brings opportunities of trade with Texas**. Successful equipment for biogas conversion technologies can be sold from Dutch businesses to Texan businesses. Geothermal energy is something both Texas and the Netherlands can exchange knowledge and other resources in.** Water energy allows for research between both parties concerning newer technologies. Conventional water energy such as hydropower has only limited potential for resource exchange between the Netherlands and Texas whereas the **Netherlands can add value to technologies concerning clean water generation.** There is also room for combining different renewable energy resources such as solar and geothermal with each other.

- Businesses developing smart, innovative solutions in **energy storage can find a market in ancillary services**, which promises to become more prominent with the increase of wind and solar in the next five to ten years. Also investors with sufficient capital can invest into larger storage facilities to derive their revenue from the market of electricity reliability.

14.1. SWOT table

To comprise the main points of every renewable energy resource of the last five chapters, the following table serves as a general overview. It is based on the SWOT analysis, an analysis that normally takes place to assess strengths, weaknesses, opportunities and threats for a firm or an organization, thereby stating the possibilities and abilities of an organization or a firm. In the last chapters, geographical, economic and market analyses were conducted to describe the overall environmental conditions of the renewable energy sectors in Texas. The SWOT analysis will sum up the main findings, so that entrepreneurs interested in business in the renewable energy sector in Texas can quickly scan the most important market trends for each renewable energy resource.

Renewable energy resource	Strengths	Weaknesses	Opportunities	Threats
Wind	Grown and relatively strong sector over the years due to sufficient government incentives, cheap land and fast wind Large geographical and geological potential	Cheap gas costs Intermittent electricity supply Wind farm project development requires sufficient capital and time Transmission challenges To a small extent subsidy dependent Limited offshore wind potential No clear guidance in wind rights in Law of Texas	Expected to remain strong and grow Investment opportunities with sufficient capital Partnership with vertically integrated companies Selling renewable power to corporates who pursue sustainability goals Sufficient employment opportunities in the value chain: strong in steel fabrication and transportation PTC and ITC extended until 2019 Intermittent supply offset by development in other resources	Oil and gas supply expansion Many large companies and competitors in the wind sector itself The percentage of the PTC's and ITC's value is declining until 2019

			Energy storage market (ancillary services), e.g Compressed air energy storage potential	
Solar	Strong radiation and vast land for utility scale solar Declined capital costs on the world market on both utility, residential and commercial level Strong push from the market and very strongly growing sector in Texas	Less government support compared to states like California Long way before it equals California in its installed solar capacity Intermittent electricity supply Transmission challenges More subsidy dependent No clear guidance regarding solar rights in Texas	Cheap utility scale solar Selling renewable power to corporates who pursue sustainability goals Growth potential and expansion of DER by roof top solar ICT extended beyond 2019 Energy storage development to offset intermittent supply (ancillary services) Partnerships and initiatives with vertically integrated companies Community solar projects Opportunities for smart grid technologies	Competition from cheap gas and wind sector The percentage of the ITC's value is declining after 2019
Biomass	Sufficient resources and production diversification Knowledge of power plants and refineries by oil and gas sector No intermittent electricity provision	Low electricity price Economics of transport for the resource to the plant Capital intensive Very subsidy dependent	Specialization in fuel production with subsidies Demand for clean-up technologies for renewable gas production Trade with European biomass market	Competition from growth and expansion in gas, wind, solar Expiration of RIN

	Renewable Fuel Program subsidies Power plants cheaper to build in Texas Relatively less stringent regulations for pipeline injection Strong bioethanol consumption and production relative to other States	Stock renewable energy resource Lack of LCFS subsidy as opposed to California	RIN subsidy and demand for 'greener' biofuel Trend of corporates to purchase renewable energy for their sustainability goals	
Water energy	Existing well operating hydropower plants No intermittent electricity provision Much diversification in the technologies Brine in salient gradient technologies can be used as a waste product	Environmental constraints for further hydropower development Relatively limited natural resources for water energy in Texas No comparative resource advantage in ocean power High costs of newer technologies New technologies which still need to be tested around the world	Ongoing research Combinations with other renewable energies (solar) possible Partnerships in research and product development between the Netherlands and Texas Growing demand for freshwater might promote technologies needed for salient gradient power Expertise of water related technologies of the Netherlands	Competition from more profitable renewable energy resources
Geothermal	Ongoing research Geographical and geological advantages Skills and knowledge for subsurface analyses of heat-resources, reservoirs and	Expensive capital costs and great competition from other resources Oil and gas expansion hamper exploration for current co-production in wells	Geo-pressured resources and hot rock resource potential Potential for coproduction in oil and gas wells ITC extended beyond 2019 for geothermal	Further expansion of oil and gas Other more profitable and more common renewable energy resources such as wind

	deep-water availability No intermittent electricity provision Market for heating and cooling systems More efficient heating and cooling compared to conventional methods Strategic partnerships for geothermal heating and cooling in houses in Austin		electricity generation Reliable electricity consumption on a real-time basis is cheaper for consumers Strategic partnerships with Dutch research institutes and companies Knowledge of Dutch parties in exploration and drilling	
Nuclear	Four well operating nuclear power plants Large economic benefits for the region Clean energy Energy reliability	Safety discussions Large investments and costs	Improved technological safety standards License renewal Demand for energy reliability and clean energy in the future	Competition from oil/gas sector More favored energy resources Market uncertainty

15. Conclusion

This report has been occupied with the question: To what extent can there be potential for trade promoting activities on the field of renewable energies in Texas for Dutch businesses?

Renewable energy potential in Texas is promising for wind-and solar developers, off-takers and any position in the value chain. Especially utility scale is fit for companies with sufficient capital. Cooperation opportunities between energy utilities of Texas and the Netherlands exist. There are business opportunities arising from the trend of corporates buying renewables to make a statement on their sustainability plans. Actions for utility scale wind or solar development should come fast and with sufficient knowledge of ERCOT's complexity.

In the next five to ten years, energy storage will play a major role in ERCOT's co-optimizing ancillary service market. Here, entrepreneurs with innovative energy storage solutions but also smaller scaled DER initiatives can find their way into the market. Nuclear energy is another resource that can contribute to energy reliability.

While Texas' wind and solar sector is strong, Dutch biomass businesses can add value to less advanced biogas technologies in Texas and make use of the RIN as well. Export and import possibilities with regard to biomass show themselves in the abundant biomass resources of Texas and the increasing biomass demand of the Netherlands.

Apart from biomass, the Netherlands are well equipped in geothermal energy use and can combine their knowledge and skills with business professionals in Texas, where the geological geothermal potential is great and exploration skills are present as well. Whereas water energy is quite limited in both the Netherlands and Texas, Texas has demand for clean water management, which newer technologies such as salient gradient can provide. Expertise in the area can come from research institutes and companies in the Netherlands and also combine with other renewable energy resources such as solar or geothermal.

Therefore, there are various opportunities for trade promoting activities. To realize these, familiarity with the nodal deregulated electricity market in Texas is crucial. Municipal utilities may support with financial and human resources. Local and domestic stakeholders, such as the NBSO can fuel these trade promoting activities as well. It is striking and it should not be doubted how open Texas' market is for renewable energy resources.

16. Acknowledgements

I would like to thank Saskia Pardaans and Mariëlla Priem from the Netherlands Business Support Office for giving me the opportunity to delve into Texas' fascinating energy market and the NBSO's network and activities. I would like to thank them for supporting me wherever possible. Thanks go out to Jan Peelen from the Embassy of the Netherlands in Washington as well for supporting me.

Also, I would like to thank Wageningen University and Edwin van der Werf from the Environmental Economics and Natural Resources Group for supervising me.

I would like to thank all the persons ranging from business professionals and energy consultants to academic professionals, who exchanged their perspective and knowledge of the (renewable) energy market with me and contributed significantly to the writing of this report.

Further, I would like to thank the people from the Center for Energy Economics, the Greater Houston Partnership and the Norwegian American Chamber of Commerce who opened the doors to great business events and conferences so I could to gain more insights about renewable energy in Texas.

You all made this experience unique, insightful and inspiring.

17. Abbreviations

ACM	Autoriteit Consument en Markt
AWEA	American Wind Energy Association
BTU	British Thermal Units
CBS	Centraal Bureau Statistiek
CREZ	Competitive Renewable Energy Zones

DER	Distributed Energy Resources
DSO	Distribution System Operator
EIA	U.S. Energy Information Agency
EPA	Environmental Protection Agency
EPC	Engineering, Procurement and Construction
EPEX	European Power Exchange Spot Market
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
FRRS	Fast Response Regulation Service
GSC3	Global Smart City & Community Coalition
IA	Interconnection Agreement
ITC	Investment Tax Credit
LCFS	Low Carbon Fuel Standard
LCO	Lithium Cobalt Oxide (Battery)
LFB	Lithium Iron Phosphate (Battery)
LMP	Locational Marginal Pricing
LMOP	Landfill Methane Outreach Program
NBSO	Netherlands Business Support Office
NMC	Lithium Nickel Manganese Cobalt Oxide (Battery)
NPR	National Public Radio
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
PPA	Power Purchase Agreement
PTC	Production Tax Credit
PUC	Public Utility Commission of Texas
PV	Photovoltaic

REC	Renewable Energy Credit
REP	Retail Electricity Provider
RIN	Renewable Identification Number
RPS	Renewable Portfolio Standard
SECO	State Energy Conservation Office
SEIA	Solar Energy Industries Association
STP	South Texas Project Nuclear
SWOT	Strengths, Weaknesses, Opportunities, Threats
TCOON	Texas Coastal Ocean Observation Network
T&D	Transmission and Distribution
TCEQ	Texas Commission on Environmental Quality
TEF	Texas Enterprise Fund
Texas A&M University	Texas Agricultural and Mechanical University
TETF	Texas Emerging Technology Fund
TREIA	Texas Renewable Energy Industries Alliance
TSO	Transmission System Operator
U.S.	United States of America

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