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Chapter 7. Measuring the Rent Size from Solar Energy Exports for the Five North African Countries

7.1 Rent size and its Combination with Poor Institutional Quality

In Section 4.3, resource rents is qualified as a boundary-line to measure the resource curse because the resource curse itself would not have become an issue if it were not for resource rents. In section 5.1 and 5.2, the rent size is tested to see whether it can be the boundary-line to identify the resource curse by comparing the average GDP growth. Unfortunately, though certain improvements are achieved after adding the 'development status' filter, the average GDP growth comparison method does not appear sufficient enough to be used as the boundary-line. On the other hand, the institutional quality comparison method is qualified as the boundary-line, and it was possible to project which North African countries have the potentials to suffer from a solar energy curse. However, if there is no rent from solar energy exports, the institutional quality comparison method becomes irrelevant as there is no reason for the five North African countries to be affected by a solar energy curse.

As mentioned earlier, it is often argued that one of the main reasons for the existence of the resource curse is the enormous size of resource rents, unearned revenue, from the natural resources export. For example, Mehlum et al. (2006a, p.1119), who accentuate on the importance of institutional quality, also suggest that the combination of a vast amount of resource rents and the poor institutional quality can lead a country to suffer from rent-seeking which is one of the resource curse effects. In chapter 6, it is witnessed that the North African energy exporters have poor institutional qualities, and it appears that they are already suffering from the resource curse. Of course, these North African energy exporters receive a vast amount of rent from exporting oil and natural gas. A solar energy curse, therefore, may occur if there is a combination of poor institutional quality and a sizable rent from solar electricity exports. It means that one should project the rent size from the solar electricity exports and see whether it is comparable to the current rent size of the natural resource, or energy, exports. Therefore, the aim of this chapter is to compare the rent size from the natural resources export and solar electricity exports in order to see whether solar energy can produce enormous amount of rent for the five North African countries.

7.2 Rent from Solar Energy Exports for the Five North African Countries

The five North African countries and the MENA countries have high potential to become solar energy exporters in the future. As illustrated in Section 3.2, there are different types of solar energy such as PV and CSP technologies. Of course, both technologies are valuable sources that will help in meeting the future energy demand. However, when considering the five North African countries and the other MENA countries, the CSP technology has been receiving more attention due a number of factors such as its fast development, energy storage, and high irradiation in the region.

As mentioned earlier, organizations such as DESERTEC and DII pay high attention to the MENA region due to its high electricity production potential to satisfy the future domestic electricity demand and also for Europe in the future. Therefore, the projection of the solar energy rent for the five North African countries will be based on the CSP technology.

7.2.1 Causes for the Increase in the Electricity Demand

There are two important factors which are considered to be the key drivers of the energy demand. One is the population growth. It is considered important because its size affects the size and composition of energy demand, directly and through its impact on economic growth and development (Green Peace 2012, p.5). The world population is expected to reach 9.3 billion by 2050, and most of the population growth is expected to occur in developing countries. For example, it is projected that, between 2011 and 2050, the population of the less developed regions is to rise from 5.7 billion to 8 billion, and the population of the least developed countries is to grow from 851 million to 1.7 billion. Conversely, the population of the more developed regions is to remain around 1.3 billion (UNCTAD 2011, p. 1).

Another factor that is considered to be the key driver for energy demand is economic growth. According to International Energy Agency (IEA 2009, p.58), energy projections are sensitive to underlying assumptions of the GDP growth which is considered as the principal driver of demand for energy service. Also, they find that the economic development pattern has impacts on overall energy demand and the fuel mix. The correlation between the GDP growth and the energy demand has been identified, between 1971 and 2007, as the global GDP rose each year with 1 percent increase rate which was accompanied by a 0.7 percent increase rate in primary energy consumption (IEA 2009, p. 58). Similarly, Green Peace (2012, p.54) also finds that, since 1971, each 1 percent increase in GDP has been accompanied by a 0.6 percent increase in primary energy consumption until recent years. Furthermore, the world GDP growth is expected to grow in the future, over the period 2007-2030, by

an average of 3.1 percent per year (IEA 2009, p.62) which indicates the growth in energy demand.
As the projections for the key drivers of the energy demand, population growth and economic growth, are expected to grow in the future, it can be argued that the demand for energy, therefore, is also expected to grow.

7.2.2 Electricity Export from the Five North African Countries to Europe

When considering electricity exports from the five North African countries, they are closely related with Europe because they are expected to be the biggest electricity importers from the five North African countries and the rest of the MENA countries. Also, as mentioned earlier, organizations, such as DESERTEC and DII, consider solar energy from the five North African countries and the rest of the MENA countries as an important future energy source for Europe. In other words, one can expect that the electricity transfer between the five North African countries and Europe will play an important role in projecting the solar energy rent size. Of course, the CSP technology is in the centre of this matter.

As the electricity transfer between the five North African countries and Europe is to play an important role in projecting the solar energy rent size, it is important to be aware of the electricity demand of the both regions. According to Schellekens et al. (2010, p.15), the current power systems and power consumption between Europe and North Africa differ greatly due to the differences in their economic development, and the abundance of oil and natural gas in North Africa. The current European power consumption is much higher, 3300 trillion watt per hour (TWh)/y, compared to the five North African countries, 180 TWh/y.

Regarding the growth in electricity demand, the five North African countries' electricity demand has increased rapidly which is about double the size in the last 20 years. The demand growth continues to increase by up to 8 percent year. By contrast, the electricity demand in Europe has increased 1-2 percent per year, which has grown about 30 percent between 1990 and 2006. However, when calculated in absolute number, it is found that the growth of the electricity demand is increasing faster in Europe because the growth rate of 1.5 percent in 2005 is equivalent to increase of 50 TWh/y, whereas the electricity demand growth rate of 8 percent per year is equivalent to 15 TWh/y in North Africa (Schellekens et al., 2010, p. 15).

According to Schellekens et al.'s (2010, p.15) projection, the total consumption of electricity in Europe and North Africa together will reach at least 5000 TWh/y in 2050. Although they project that 25 percent (1250 TWh/y) of the demand will be from North Africa, only 60 percent (3000 TWh/y) of the system-wide electricity supply is produced in Europe, and 40 percent (2000 TWh/y) is produced in North Africa. In other words, one can speculate that about 20 percent of electricity demand in Europe is expected to be met by electricity imports from North Africa. The main reason for the increase in the electricity demand in Europe is expected to be from the fuel switch to electricity such as introduction of electric cars, whereas population growth, and the economic growth are the main reasons for the electricity demand growth in North Africa as can be seen from table 31.

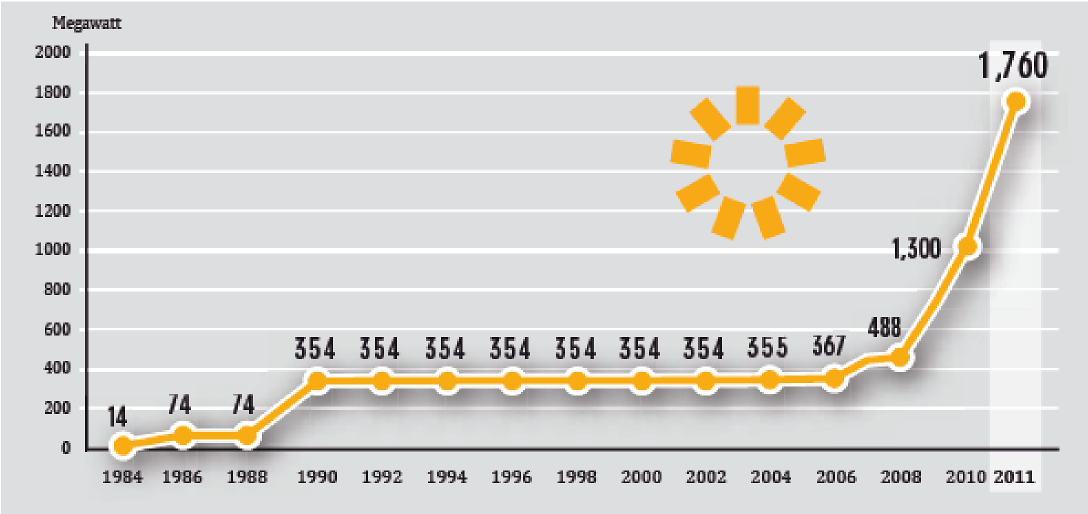
Table 31: UNPD's Prediction of the Population Growth in the Five North African Countries with Medium Variant (Thousand)

	2010	**2020**	**2030**	**2040**	**2050**
Algeria	35468	40180	43475	45490	46522
Egypt	81121	94810	106498	116232	123452
Libya	6355	7083	7783	8360	8773
Morocco	31951	35078	37502	38806	39200
Tunisia	10481	11518	12212	12533	12649
Total	165375	188669	207470	221421	230596

Source: United Nations, Department of Economic and Social Affairs Population Division, Population Estimates and Projections Section

Despite the predicted electricity demand growth in both regions, one is still faced with certain difficulties in projecting the solar energy rent size. As can be seen from figure 17, the capacity of the CSP has been increasing in recent years. For example, according to Zickfeld et al. (2012, p. 47), approximately 1 GW of CSP was installed worldwide at the end of 2010, and 1.6 GW was installed worldwide by the end of 2011, or 1758 MW according to REN21 (2012, p.102). However, despite the recent rapid growth, the capacity of the CSP is still small, and its use does not have a long history or data such as oil, natural gas, or other renewable energies. In other words, one lacks concrete data in order to calculate the rent size from the electricity export via CSP for the five North African countries.

Figure 17: Concentrating Solar Thermal power, Total World Capacity (1984-2011)



Source: REN21 (2012, p.51)

Despite these obstacles, in order to project the solar energy rent size, it is important to know the amount of electricity that could be exported, or transferred, from the five North African countries to Europe. DLR (2006), the TRANS-CSP scenario, provides the estimates of the projected amount of electricity that will be transferred from the MENA region to Europe. Here, it must be mentioned that MENA countries in DLR (2006) are not clearly defined.

Table 32: TRANS-CSP SCENARIO Projected Amount of Electricity Transfer between Europe and MENA from 2020 to 2050

Year		2020	2030	2040	2050
Transfer Capacity GW		2 x 5	8 x 5	14 x 5	20 x 5
Electricity Transfer TWh/y		60	230	470	700
Capacity Factor		0.60	0.67	0.75	0.80
Turnover Billion €/y		3.8	12.5	24	35
Land Area km x km	CSP HVDC	15 x 15 3100 x 0.1	30 x 30 3600 x 0.4	40 x 40 3600 x 0.7	50 x 50 3600 x 1.0
Investment Billion €	CSP HVDC	42 5	143 20	245 31	350 45
Elec. Cost €/kWh	CSP HVDC	0.050 0.014	0.045 0.010	0.040 0.010	0.040 0.010

Source: DLR (2006, p. 4)

As can be observed from table 32, DLR (2006, p.78) projects that the amount of electricity transfer from the MENA region to Europe will gradually increase and reach 700 TWh/y with a total transfer capacity of 100GW in 2050. As mentioned earlier, the electricity consumption in Europe and North Africa will reach 5000TWh/y by 2050 (Schellenkens et al. 2010, p. 15). Here, about 25 percent (1250 TWh/y) of this demand is from North Africa and the remainder (3750 TWh/y) is from Europe. However, Schellekens et al. (2010, p.15) project that, out of 5000TWh/y electricity, 60 percent (3000 TWh/y) of the electricity is to be produced in Europe, whereas 40 percent (2000 TWh/y) is to be produced in North Africa. In other words, about 750 TWh/y amount of electricity is projected to be exported from North Africa to Europe. The North African power system in 2050 is projected to be based mainly on wind power and solar, including CSP plants with storage and PV, with differences dependent on 'resource availability' (Schellekens et al., 2010, p. 21). The majority of power generation via CSP is expected to be from the central desert regions. Also, due to the high overall share of CSP, they expect that electricity for local consumption and for export will be dispatchable throughout the year, using CSP plants with storage, in conjunction with other renewable as appropriate (Schellenkens et al., 2010, p. 21). In more recent study, Trieb et al. (2012, p. 349), the five North African countries are projected to export 632 TWh/y by 2050. By looking at various studies, one can expect that quite a large amount of electricity will be exported, or transferred, from the five North African countries, and MENA countries, to Europe by 2050. In this section, the projected amount of electricity which will be exported from the five North African countries is 694 TWh/y, which is the average value of the three studies mentioned above. It must be noted that, in the actual calculation, 700 TWh/y will be applied instead of 694 TWh/y in order to avoid unnecessary digits. Furthermore, as it is a projected value, and is also partially based on DLR's (2006)s study which include other MENA countries, the projected amount of electricity exports from the five North African countries to Europe will be within the range of ±100 TWh/y from 700 TWh/y in this section rather than a fixed value.

When looking at table 32, one is able to see that DLR (2006) projects that the electricity cost will gradually decrease in the future. In 2050, for example, the average electricity cost is expected to reach as low as 5 €cents/kWh. The projected cost of electricity in 2050 by DLR (2006) composes of 4 €cents/kWh for solar electricity production by CSP plants in MENA and 1 €cent/kWh for the transmission to Europe which include electricity losses, capital cost and cost of operation, and assumes a discount rate of 5 percent/y as for the other technologies (DLR 2006, p. 78). Here, it should be noted that, regarding the transmission technology, the High Voltage Direct Current (HVDC) grid is chosen. THE HVDC grid is perceived as the most essential technology regarding electricity transfer between the two regions. The distance that the electricity has to transfer between Europe and MENA is over 3000 km. According to DLR (2005, 2006) and Schellekens et al. (2010), HVDC's biggest advantage, that it would only have about 10-15 percent of transmission losses, makes this technology the most crucial element for the electricity transfer plan between Europe and North Africa (DLR 2006, p. 2).

The 5 €cents/kWh electricity cost projection by DLR (2006) is often mentioned and used as the base of many recent calculations regarding the electricity transfer from North Africa to Europe such as in Lilliestam Johan & Saskia Ellenbeck (2011). If one is to calculate the value of the amount of the electricity transferred from MENA to Europe (600-800 TWh/y) based on 5 €cents/kWh electricity cost, it would be between €30-40billion/y.

Although, it is possible to project the value of the amount of the electricity transferred, this does not present one with the actual rent size that this thesis is looking for. Of course, 5 €cents/kWh does include the rent size. However, the included rent size is for the investors. For example, the decision for investors whether to build a power plant is dependent on the returns to investment which is often referred to as discount rate. As mentioned earlier, within 1 €cent/kWh for the transmission to Europe includes a discount rate of 5 percent/y.[61] In this thesis, one is not looking for the projected rent size for investors. One of the reasons for the resource curse is due to the enormous resource rent size or excess earning above normal profits (Rosser 2006, p. 11). Kolstad & Wiig (2009, p.5317) also mention that the return in excess of costs often occurs in many natural resource industries. Therefore, the priority task here is to find a way to project the rent size, 'the excess earning', on top of the production cost.[62]

One possible way to project the rent size for the North African countries is to learn the rent size and its proportion from the total cost of electricity in other countries with more experiences with solar energy and apply them on the five North African countries or MENA countries.

Spain and Germany are considered as the leading countries in promoting renewable energies such as solar energy and wind energy. Regarding solar energy, especially the CSP technology, Spain has been one of the leading countries with the United States. Spain has the largest CSP capacity in the world. A significant amount of capacity has started to come online in Spain between 2009 and 2010. During 2011, nearly 420 MW of capacity was added, and ended the year with the capacity of almost 1150 MW in operation, in response to an adequate "Feed-in-tariff" (FiT), and legal framework (REN 2012, p.51). However, on January 27, 2012, as part of Royal Decree-Law (RDL1/2012), the Spanish government temporarily put a halt to awarding new FiT contract starting in January 2013. The main reason for this action was due to the country's over €24 billion electricity system deficit

[61] A discount rate of 5 percent/y means a return of 5 percent on the invested capital.
[62] The rent size in this thesis, thus, refer to the 'excess earning'.

(Couture Toby D 2012, p.1).

A FiT is a policy mechanism that is designed to accelerate investment in renewable energy projects. The principle of FiT policies is to offer guaranteed prices for fixed periods of time, usually 10-25 years, for electricity produced from Renewable Energy Sources (RES). These fixed prices are usually offered in a non-discriminatory matter for each kWh of electricity produced and can be differentiated dependent on the technology type, the installation size, the resource quality, the project location and also a number of project-specific variables. FiTs are implemented in 63 jurisdictions worldwide (Couture & Ganon 2010, p.955). In Germany and Spain, countries that are considered 'more successful' with FiTs, the payment levels of FiT offered to particular projects are determined as closely as possible in relation to the specific generation cost. More specifically, FiTs are designed to make it possible for efficiently operated RE installations to cost effectively developed (Couture & Ganon 2010, p. 955). The FiT will be a crucial element which will help in projecting the solar energy rent size for the North African Countries in chapter.

If a country has implemented FiT, the task of calculating the rent size becomes simpler. As mentioned earlier, FiT offers guaranteed prices for fixed periods of time. If one is to subtract the cost of electricity production from FiT, it is possible to obtain the additional rent size, and calculate the proportion of the rent size from the FiT. However, as one may suspect, the cost of electricity production can vary dependent on many factors such as investment cost. This is the reason why LCOE is often used to represent the cost of electricity production. LCOE is considered as a useful tool for comparing the unit costs of different technologies over their economic life. More specifically, according to NREL (2011, p. 51), LCOE is defined as the ratio of an electricity generation system's amortized lifetime costs to the life time of the system's electricity generation. LCOE, therefore, includes all costs through the lifetime of a system such as initial investment cost, operations and maintenance cost (O&M), fuel cost, and cost of capital. Furthermore, LCOE is considered as the most transparent consensus measure of the cost of electricity generation and widely used to compare the costs of different power, or electricity, generation technologies in modeling and policy decisions as well (IEA 2010, p.33).

As can be seen above, one can see that it is possible to calculate the rent size, and its proportion, of the CSP technology. A simple formula is presented below.

Formula I:

Feed in Tariff (FiT) = Levelized Cost of Electricity (LCOE) + Rent
Rent = FiT - LCOE
Rent rate = (Rent/FiT) × 100

Here, one may question how reliable it is to use the FiT and Formula I in projecting the rent size. For example, Zickfeld et al. (2012, p. 58) consider that the RES production in the MENA countries, due to the expected cost reduction, to be competitive with traditional power production in Europe. They see that public support and incentives will only be necessary in the initial phase of the system integration. As this thesis is projecting the rent size for the 2050, therefore, it is uncertain that there will be the continuous use of the FiT in the future for both Europe and MENA. However, it is also not possible to guarantee that the RES will be as competitive as many 'optimistic studies' claim. Also, for example, considering the fact that FiT is still used for onshore wind power in Germany, which is considered as one of the most advanced renewable energy technologies, indirectly suggests that, if FiT is to be introduced in North Africa and other MENA countries, one may still see the use of FiT for CSP in 2050 in the North African countries and other MENA countries. Nevertheless, as the purpose of this thesis is to investigate whether the rent size from solar energy will be comparable to the oil and natural gas rent size, the existence of FiT in the future is not so relevant.

As mentioned earlier, Spain has been one of the leading countries regarding the CSP technology. As Spain has the most experiences with the CSP technology, their solar energy rent size and its proportion from FiT will be calculated first. It must be mentioned that the global CSP market has been dominated by parabolic trough plants, account for 90 percent of CSP plants, for nearly all existing capacity operation (REN21 2011, p. 25). The parabolic trough technology also dominates the market in Spain because of the Royal Decree conditions set up in 2009. It boosted the development CSP in the country, and also gave a strong position to parabolic trough which was then the most mature solar energy technology (REN21 2012, p. 51). Therefore, when calculating the rent size of the CSP in Spain, and the five North African countries as well, the parabolic trough technology will be chosen as the base technology.

In order to calculate the rent size from the electricity exports via CSP technology in Spain, one should first identify the FiT and LCOE for the CSP technology in Spain. The most recent FiT for CSP in Spain can be seen in the Royal Decree (RD) 661 in 2007 which is 26.9375 €cents/kWh for the first 25 years (Ministerio ITC, 2007).[63] The Spanish FiT law stipulates a maximum electrical output of 50 MW for eligibility (IRENA 2012a, p.22). When regarding the LCOE for the CSP parabolic trough technology in Spain, there are few data which one can use. According to Schellekens et al. (2010, p. 115), the LCOE for CSP parabolic through technology in Spain is 17.3 €cents/kWh. As Schellenkens et al.'s (2010) study and their estimation are based on data from the DLR and the American National Renewable Energy Laboratory (NREL), which are the most widely used sources when projecting the LCOE for the

[63] In the actual calculation, 27 €cents/kWh will be used in order to avoid too many digits. 27 €cents/kWh or €0.27/kWh as the FiT for Spain often can be seen in articles such as from Williges et al. (2010, p.3090).

CSP technology, one can speculate that the given number is rather accurate. The model power plants considered in their study are 50 MW with 3 hour storage for parabolic trough with DNI of 2000 kWh/m²/y (Schellekens et al., 2010, p.114). CSP Today (2008, p. 13) estimates that the LCOE of the 50 MW CSP units around 17-18 €cents/kWh. In a more recent study, according to IRENA (2012a, p.32), the estimated LCOE of the 50 MW CSP units in Spain are between US$0.30 kWh to US$0.35 kWh. As the parabolic trough technology dominates the market in Spain, this given range of 17-18 €cents/kWh (CSP Today 2008, p.13) and US$0.30-0.35 kWh (IRENA 2012a, p.32) will be considered as the LCOE of the parabolic trough in Spain. Here, one can notice that various studies use different currencies. Therefore, it is necessary to choose one currency in order to obtain accurate result regarding the comparison between the oil and Natural gas rent size and the projected rent size from solar energy. The US dollar will be selected as the standard currency in this thesis. The reason for choosing the US dollar is because the majority of resource rents are calculated in US dollar, notably the price of oil and natural gas.

Regarding the comparison among rent sizes, as Euro was introduced as an official accounting currency on 1 January 1999 to world financial markets, the average exchange rates between Euro and the US dollar (1999-2009) will be applied. Table 33 presents the yearly average exchange rate from Euros to the US dollar and the US dollars to Euros between 1999 and 2009. As can be seen from table 33, the average exchange rate from Euros to the US dollars and from the US dollar to Euro during the period of 1999-2009 are 1.1768[64] and 0.8752[65], respectively. Each exchange rate will be applied when appropriate.

Table 33: Yearly Average Exchange Rate between Euro and US Dollar 1999-2009

Yearly Average Exchange Rate from Euro to US Dollar											
1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Average**
1.0658	0.9236	0.8956	0.9456	1.1312	1.2439	1.2441	1.2556	1.3705	1.4708	1.3948	***1.1768***
Yearly Average Exchange Rate from US Dollar to Euro											
1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Average**
0.9396	1.0959	1.1175	1.0609	0.8858	0.8049	0.8051	0.7972	0.7308	0.6835	0.7190	***0.8752***

Source: European Central Bank
http://www.ecb.int/stats/exchange/eurofxref/html/eurofxref-graph-usd.en.html (accessed: 09.10.2012)

When calculating the solar energy rent size of Spain -as most of data presented above are in Euros- the estimated LCOE, US$0.30 kWh to US$0.35 kWh, from IRENA (2012a, p.32) will be calculated into Euro first and the final result will be recalculated into the US dollar in order to avoid

[64] In the actual calculation, the exchange rate will be rounded up to 1.18 in order to avoid too many digits.
[65] In the actual calculation, the exchange rate will be rounded up to 0.88 in order to avoid too many digits.

frequent changes in currency during the calculation. The FiT and LCOE range of CSP parabolic trough in Spain after applying the exchange rate is presented in table 34 below.

Table 34: FiT and LCOE Range of CSP Parabolic Trough in Spain

Spain CSP FiT	27 €cents/kWh
LCOE from difference Sources (€cents/kWh)	17.3 €cents/kWh from Schellenkens et al. (2010, p.115)
	17-18 €cents/kWh from CSP Today (2008, p. 13)
	26.4-30.8 €cents/kWh from IRENA (2012a, p.32)

As can be observed from table 34, the LCOE provided by IRENA (2012a) is much higher compared to the LCOE provided by other sources. Even within the data given from IRENA (2012a), the range of the LCOE is rather wide. More importantly, when looking at IRENA's (2012a) highest value of the LCOE range, 30.8 €cents/kWh, one can notice that it is higher than the FiT in Spain. This may be due to the fact that the Spain's FiT is from 2007 and the LCOE range provided by IRENA (2012a) is from a very recent year. Also, furthermore, this may be one of the explanations for Spain to temporarily put a halt to awarding new FiT contract from 2013 which is perceived to be due to the over €24 billion electricity system deficit. One is faced with a peculiar task of deciding whether to include or exclude the LCOE provided by IRENA (2012a) because the range is much higher than the LCOE from other sources, and its highest point of the LCOE range is higher than the FiT in Spain. Here, it is decided to use the data from IRENA (2012a) as it is the most recent data, and the use of it seems appropriate especially when the purpose of this thesis is to project the future electricity export rent size. Here, the highest point (30.8 €cents/kWh) in the range given by IRENA (2012a) can not be used because it is higher than Spain's FiT. Also, the average of the given range, 28.6 €cents/kWh, is still higher than Spain's FiT. Therefore, only the lowest value of the given range of the LCOE (26.4 €cents/kWh) will be included in the calculation which is slightly lower than Spain's FiT. Consequently, one is given with the LCOE range of 17-26.4 €cents/kWh from all the sources presented in table 34. In the calculation, the average value of the given LCOE range (21.95 €cents/kWh)[66] above will be used. The process of the calculation in obtaining the rent size and its proportion is illustrated below.

27 €cents/kWh = 22 €cents/kWh + Rent
Rent = 27 €cents/kWh – 22 €cents/kWh = 5 €cents/kWh
Rent rate= (5 €cent/kWh / 27 €cents/kWh) × 100 = 18.5%

[66] In the actual calculation, 22 €cents/kWh will be used in order to avoid too many digits.

As presented above, the solar energy rent size via parabolic trough technology in Spain is 5 €cents/kWh, and its proportion from FiT is around 18.5 percent. By using this rent rate, one is able to project the rent size from the electricity export via parabolic trough in the five North African countries. One obstacle is that the five North African countries, except for Algeria (CSP Today 2008, p.34), do not have specific FiT for the CSP. However, fortunately, there are few projected LCOE of the parabolic trough for the five North African countries and other MENA countries provided by a number of studies, which enables one to still project the rent size.

As mentioned earlier, DLR (2006, p.78) projects the average electricity cost to reach as low as 5 €cents/kWh. Schellekens et al. (2010, p.115) project that the LCOE for the parabolic trough for the five North African countries to be 13.7 €cents/kWh. In a more recent study by Zickfeld et al. (2012, p.44), they project that the LCOE of the EUMENA CSP to reach approximately €50/MWh (5 €cents/kWh) in 2050. Of course, these sources provide different size of the LCOE because they apply, for example, different capacities, storage hours and other factors.[67] However, what one should note from the given LCOE sizes above is that data from DLR (2006) and Zickfeld et al. (2012) consider the EUMENA LCOE. On the other hand, the LCOE size provided by Schellekens et al. (2010, p.115) is referring to the LCOE size of the parabolic trough technology only in North Africa. Therefore, the LCOE from Schellekens et al. (2010) will be used to project the rent size for the five North African countries. Table 35 presents the available data for one to calculate the projected solar energy rent size for the five North African countries.

[67] There are many determining factors that can change the LCOE of CSP, and the most important parameters that determine the LCOE of CSP, according to IRENA (2012a, p. 30), are the initial investment cost, (including site development, components and system costs, assembly, grid connection and financing costs), the plant's capacity factor and efficiency, the O&M costs (including insurance) costs, and the cost of capital, economic lifetime, etc. Also, the LCOE of CSP is closely correlated with the DNI and the amount of thermal energy storage and the size of the solar multiple. For an accurate projection to be achieved, these factors should all be considered. However, this thesis is projecting the CSP rent size in 2050. It would be, for example, hard to say that all energy storages for CSP will remain the same in North Africa. The projection made in this thesis will be mostly based on the average size of LCOE from various sources as one can not project the exact LCOE of CSP in the future.

Table 35: FiT, LCOE, and Rent for Spain and the Five North African Countries

	FiT	**LCOE**	**Rent**
Spain	27 €cents/kWh	22 €cents/kWh	5 €cents/kWh (18.5%)
The 5 Countries	**Y** €cents/kWh	13.7 €cents/kWh	**X** €cents/kWh

Source: Ministerio ITC (2007), Schellekens et al. (2010, p.115)

If one is to speculate that the rent rate for the five North African countries is the same as in Spain (18.5 percent), then the rate of the LCOE for the five North African countries is 81.5 percent. The LCOE of the parabolic trough is 13.7 €cents/kWh as illustrated in table 35. By using the available data, one is able to calculate the FiT for the five North African countries which will be used to project the solar energy rent size. Here, it must be mentioned that the calculated FiT for the five North African countries does not have any real value, and it is just calculated to project the rent size.

FiT for the five North African countries = Y €cents/kWh
LCOE for the five North African countries and its proportion = 13.7 €cents/kWh (81.5%)
Rent size for the five North African countries and its proportion = Y €cents/kWh (18.5%)

13.7 €cents/kWh = Y €cents/kWh × (81.5/100)
Y €cents/kWh = 13.7 €cents/kWh / (81.5/100)
Y €cents/kWh = 16.8098 €cents/kWh

As the FiT for the five North African countries is projected to be 16.8098 €cents/kWh, the projection of the rent size can be proceeded. In the calculation, FiT will be set as 16.8 €cents/kWh.

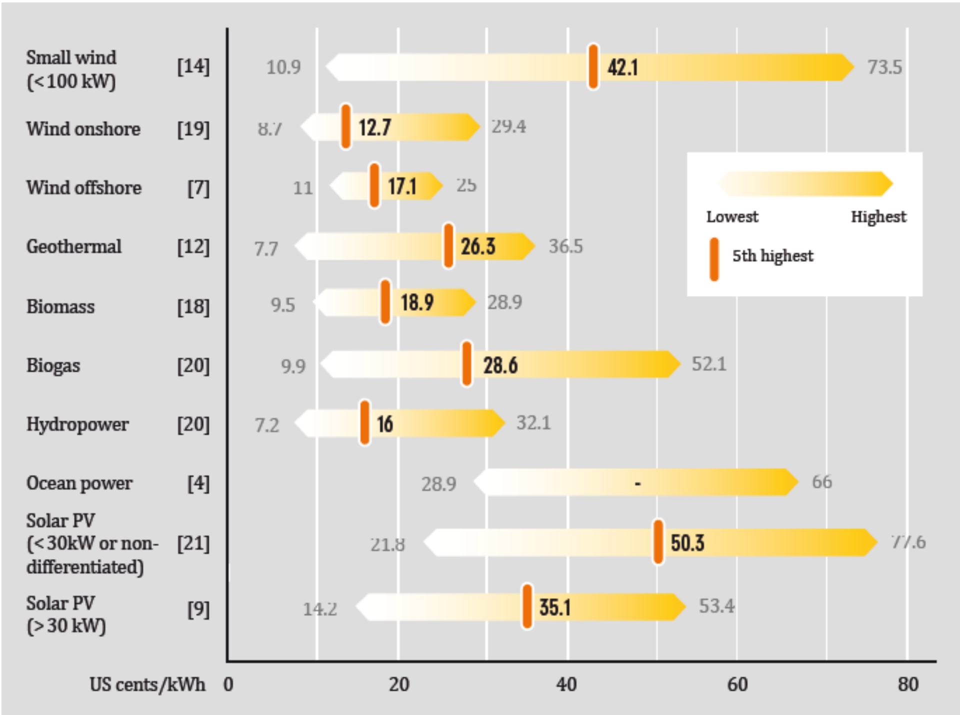
CSP rent for the five North African countries = 16.8 €cents/kWh – 13.7 €cent/kWh
= 3.1 €cent/kWh

As can be seen above, the projection for the solar energy rent for the five North African countries is 3.1 €cent/kWh under the assumption that proportion of the rent size from the FiT is considered the same as in Spain (15 percent). As mentioned earlier, the projected total amount of electricity that is to be exported from the five North African countries to Europe is between 600 TWh/y and 800 TWh/y in 2050. This means that solar energy exports can incur the rent size of €18.6-24.8billion/y.

Here, one should note that the calculation has been made with the projected amount of electricity transferred in 2050 (±700 kWh/y) and the recent year's LCOE. As can be seen from table 32, DLR's (2006) projection shows that the electricity production cost is projected to decline in the future due to a number of factors such as the improved efficiency and technology development. This is also the case for both FiT and LCOE. Therefore, one can argue that this will have great impact on the rent size. In other words, applying the current FiT and LCOE of Spain to project the future electricity export rent size appears problematic. Therefore, one is required to apply more suitable FiT, LCOE, and rent size proportion from FiT, in order to project the rent size from electricity export via parabolic trough, or any other renewable energy sources, in the future.

The design of FiTs and the levels of support provided under FiTs vary widely due to technology cost, resource availability, and installation size and type. According to REN21 (2012. 74), FiTs usually decline over time, and tend to be lower for the more mature technologies such as geothermal, hydropower, and wind power which can be seen from figure 18.

Figure 18: FiT Payments for a Range of Renewable Energy Technologies, Selected Countries, 2011/2012



Source: REN21 (2012, p. 74)

The CSP technology is considered to be an immature renewable technology compared to other technologies such as wind power. This can be observed by comparing the total capacity of the renewable technologies which is shown in table 36 below.

Table 36: Renewable Electric Power Capacity, World and Top Regions/Countries, Total year-End 2011

Technology	Capacity (GW)
Biomass Power	72
Geothermal Power	11.2
Ocean (tidal) power	0.5
Solar PV	70
Concentrating Solar Thermal Power (CSP)	1.8
Wind Power	238

Source: REN21 (2012, p.98)

Although it would be more ideal for one to project the rent size from CSP by applying other CSP experiences, as mentioned earlier, the CSP technology is still immature compared to other renewable energies. Therefore, in order to project the rent size from CSP in 2050 with current data, the best way is to obtain the proportion of the LCOE and rent size from FiT from the currently most advanced and matured renewable technologies. By applying the obtained proportion rates, one is more likely to obtain accurate solar energy rent size for the five North African countries.

As mentioned before, wind power is considered to be one of the most matured renewable energy sources. Germany is the European leader in wind energy with 29,060 MW of installed capacity in 2011 (GWEC 2012, p.39). Table 37 presents the wind power capacity development from 2001 to 2011 in Germany.

Table 37: Total Installed Wind Power Capacity in Germany From 2001 to 2011

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity	8.754	11,994	14,609	16,629	18,415	20,622	22,247	23,903	25,777	27,191	29,060

Source: GWEC (2012, p.39)

Although FiT for wind power existed in Germany since 1991, it was the year 2000 that the Renewable Energy Sources Act (EEG) provided the main stimulus to the German wind market. The EEG is amended regularly in order to adapt tariffs to the current market condition and new technological development. The latest amendment was made in recent years. The German Bundestag adopted the “Act on the amendment of the legal framework for the promotion of electricity generation from renewable energies” (Gesetz zur Neuregelung des Rechtsrahmens für die Förderung der Stromerzeugung aus erneuerbaren Energien) on 30 June 2011 which revised the EEG. The revised version entered into force on 1 January 2012 (BMU 2012b, p.1). Table 38 presents the changes of FiT for wind power (onshore) in Germany between 2001 and 2012 and the projected FiT changes in the future. The duration of tariff payment is 20 years with the degression rate of 1.5 percent. Each year shows the higher initial tariff for five years and normal tariff in brackets. The years 2004, 2009, and 2012 are the years the EEG amended FiT.

Table 38: The FiT changes from 2001 to 2012, and the Projected FiT until 2020 for Onshore Wind Energy in Germany

Year	Initial tariff (€cents/kWh)	Basic tariff (€cents/kWh)	Regression rate
2001	9.1	6.19	1.5%
2002	8.96	6.10	1.5%
2003	8.83	6.0	1.5%
2004	8.70	5.50	2%
2005	8.53	5.39	2%
2006	8.36	5.28	2%
2007	8.19	5.17	2%
2008	8.03	5.07	2%
2009	9.2	5.02	1%
2010	9.11	4.97	1%
2011	9.02	4.92	1%
2012	8.93	4.87	1%
2013	8.80	4.80	1.5%
2014	8.66	4.72	1.5%
2015	8.53	4.65	1.5%
2016	8.41	4.58	1.5%
2017	8.28	4.52	1.5%
2018	8.16	4.45	1.5%
2019	8.03	4.38	1.5%
2020	7.91	4.32	1.5%

Source: BMU 2008a, b, BMU 2012a, b, German Energy Blog, Grotz (2008), and GWEC (2010)

Table 39: PV FiT Changes in Germany 2009-2012 (€cents/kWh)

Type		2009[68]	2010[69]	2011[70]	2012[71]
Rooftop mounted	Up to 30 kW	43.01	30.14	28.74	24.43
	Over 30 kW	40.91	37.23	27.33	23.23
	Over 100 kW	38.58	36.23	25.86	21.98
	Over 1 MW	33.00	29.37	21.56	18.33

Source: Germany Energy Blog

68 http://www.germanenergyblog.de/?page_id=834 (accessed: 11.01.2013)
69 http://www.germanenergyblog.de/?page_id=965 (accessed: 11.01.2013)
70 http://www.germanenergyblog.de/?page_id=4984 (accessed: 11.01.2013)
71 http://www.germanenergyblog.de/?page_id=8617 (accessed: 11.01.2013)

As can be observed from table 38, Germany's FiT for onshore wind energy has been declining since 2001 to 2012, and it is also projected to decline further in the future. In other words, it shows that FiTs decline over time while technologies mature. This is also the case in other renewable energies such as PV in Germany which can be seen in table 39. With data presented above, one is also able to compute the rent size changes. One difficulty is that it is hard to find the LCOE for the onshore wind power in Germany. It can be argued that the exact cost of wind energy in general would be difficult because of the fluctuation of wind speed, different size of the turbine and other factors. For example, if compared to the DNI in Sahara desert, the measurement of the LCOE of the wind power should be more difficult than the LCOE of the solar energy because wind speed can not be as stable as the DNI. Nevertheless, there are a few studies which present the LCOE of the onshore wind power in Germany. According to Schwabe et al. (2008, p. 48), the LCOE[72] of onshore wind power in 2007 and 2008 were €79/MWh (7.9 €cents/kWh) and €85/MWh (8.5 €cents/kWh), respectively. Here, one can notice that, according to Schwabe et al.'s (2008) study, the LCOE of the onshore wind power in German between 2007 and 2008 increased. When one compares Germany's FiT and LCOE of the onshore wind power in 2008, it is possible to see that LCOE is higher than the FiT which does not make sense. Perhaps, this is the reason why FiT was amended in 2009 as can be seen from table 38. In Krohn et al.'s (2009, p.56) study, the costs of onshore wind generated power ranges between approximately 5-6.5 €cents/kWh at sites with high average wind speed and approximately 7-10 €cents/kWh at sites with low average wind speed. The cost of the onshore wind generated power at sites with normal average wind is approximately 7 €cents/kWh. Germany is considered to be in the medium wind areas of Europe. Therefore, one can estimate that the cost of the onshore wind generated power in Germany is approximately 7 €cents/kWh. Here, the cost of onshore wind generated power from Krohn et al. (2009) will be considered as LCOE. The LCOE of the onshore wind power in Germany given above are from similar periods. Therefore, the average size of the give LCOE (7.8 €cents/kWh) will be used in calculating the rent size rate in Germany.

Here, one may question why the LCOE in 2008 provided from Schwade et al. (2008, p.48) -though it is higher than the FiT in 2008- is included in the calculation, whereas IRENA's (2012a, p.32) highest LCOE range for CSP is excluded. The reason for the exclusion for the CSP LCOE in Spain was that the given range is too wide, and its highest value in the given range exceeds Spain's FiT. In the case of the onshore wind power LCOE in 2008 for Germany from Schawade et al. (2008. p.48), it is not so much higher than the FiT in 2008. Of course, this is not the only reason. As mentioned earlier, Germany is

[72] In Schwabe et al.'s (2008) study, the LCOE refers to the sum of all costs over the lifetime of a given wind project, discounted to present time, and levelized based on annual energy production. It does not include residual costs nor benefits incurred beyond the project's assumed operation life.

considered as one of the leading countries in terms of promoting and managing renewable energy which has been amending its FiT when necessary accordance of the purpose of FiT. As can be seen from table 38, also mentioned earlier, the FiT of onshore wind power was amended in 2009. This shows the immediate reaction to, though it may not be the entire reason, the fluctuation of the LCOE which makes it possible for one to rely on the LCOE provided by Schawade et al. (2008) for 2008. Furthermore, the fact that wind energy is one of the most mature renewable technologies support in using the LCOE given by Schawade et al. (2008) as well.

In order to calculate the rent size and its proportion, the period of 2009-2012 will be chosen. The reason for choosing this period is because the FiT in 2009 and 2012 are the most recent official amended FiT by EEG (BMU 2008a,b, 2012a,b). Though it may not be the most suitable value for the period of 2009-2012 as it is the average value of the earlier years, 7.8 €cents/kWh will be used as LCOE value. As wind energy is one of the most matured renewable technologies, it will be assumed that the LCOE of onshore wind power in Germany does not change as much. Also, one can not always assume that the LCOE only declines throughout the time, though also influenced by other factors, as wind speed is not as stable as, for example, the DNI in the Sahara desert. As the formula for the calculation of the rent size and its rate is illustrated earlier, only the result is illustrated in table 40 below.

Table 40: Projected Onshore Wind Energy Rent Size and its Proportion Change in Germany 2009-2012

Year	**2009**	**2010**	**2011**	**2012**
Rent size /Proportion	1.4 €cents/kWh (15.2%)	1.31 €cents/kWh (14.4%)	1.22 €cents/kWh (13.5%)	1.13 €cents/kWh (12.7%)

As can be seen from table 40, the onshore wind energy's rent size and its proportion rate have been, or are still, declining over time. Also, when compared to the rent size and its proportion of the parabolic trough presented earlier, this matured technology has much smaller rent size. Therefore, as the purpose of this section is to project the rent size from solar energy exports for the five North African countries in the future, it proves that the use of current, or recent, Spain's rent size and its proportion does not provide an accurate projected solar energy rent size for the five North African countries.

Although it appears that the use of the rent size proportion from the onshore wind power in Germany is more accurate in projecting the solar energy rent size for the five North African countries in the future, it may not be wise to project the rent size just by relying on the onshore wind power rent proportions due to the 'matureness' gap between the CSP and onshore wind power.

The operating capacity of CSP, during the period from the end of 2006 through 2011, increased around 37 percent annually. During the same period, the Solar PV appears as the fastest growing renewable technology with operating capacity increasing by an annual average of 58 percent. On the other hand, the operating capacity of wind power increased by an annual average of 26 percent which is after CSP (REN 2012, p. 13). By looking at the growth rate, it is possible to see that CSP is one of the fastest growing renewable technologies. Therefore, in order to achieve a more accurate result, rather than assuming that the FiT, LCOE, rent size, and rent size proportion are to decline throughout the time just by relying on data regarding the onshore wind power in Germany, this section will also include the fast growing renewable technology data in projecting the rent size for the five North African countries.

As mentioned in section 3.1.2, solar PV appears to be the fastest growing renewable technology. In 2011, it is estimated that almost 30 GW of new solar PV capacity came into operation worldwide, increasing the global total by 74 percent to almost 70 GW. The European Union dominated the global PV market (REN21 2012, p. 47). Again, Germany is considered the leading country in the PV market. In late 2011, Germany connected its one-millionth PV system, and continued to lead in total installed and operating PV capacity. It is estimated that nearly 7.5 GW was newly installed by the end of 2011 (REN 2012, p.47). Therefore, the rent size and its proportion of PV in Germany will be also calculated and will be used in projecting the solar energy rent size for the five North African countries.

As presented in Table 39 earlier, the PV FiTs, during the period of 2009-2012 have declined in all categories. As for LCOE, IRENA (2013, p.57) suggests that, by the second quarter of 2012, the LCOE of typical small-scale system, which are considered the residential PV system[73], in Germany had fallen to US$0.19-0.27/kWh (14.8-20.3 €cents/kWh)[74]. Here, an obstacle occurs in choosing the suitable FiT and LCOE of PV.

The FiT provided in table 39 and the LCOE range provided by IRENA (2013, p.57) are not in the same categories because the LCOE range provided by IRENA (2013, p.57) is for the residential PV system which do not usually exceed 20 kW, whereas the FIT presented in table 39 are for the PV up to 30 kW capacity. Here, as can be observed in table 39, the FiTs of PV with more capacity are lower. Then, if a new category of PV FiT is made for 'up to 20 kW' in Germany, it can be argued that, though not always, the FiT would be higher than the current PV FiT for up to 30 kW. This means that, when

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[73] Typically do not exceed 20kW and are usually roof-mounted (IRENA 2012b, p. 22).

[74] As IRENA(2013, p.57) presents the LCOE in the second quarter of 2012, the exchange rate of the average of 02.04.2012 – 29.06.2012 is applied in calculating into Euro.

applying the LCOE for PV up to 20 kW for the PV FiT up to 20 kW, it would make more sense to use the higher LCOE in the given range because the LCOE tends to decline throughout the time due to the capacity and technology development. Therefore, from the given range of the PV LCOE for Germany, the highest point (20.3 €cents/kWh) will be used as the LCOE value in the calculation. As for the PV FiT, due to the rapid decline in PV FiT in Germany, and also the fact that LCOE provided by IRENA (2013, p.57) specifically for the second quarter of 2012, only the FiT of 2012 will be used in the calculation. As a result, the rent size from PV is 4.13 €cents/kWh, and its proportion is about 16.9 percent.

The last task before proceeding with the calculation for the projected rent size is to obtain a suitable LCOE because the use of current, or recent, LCOE is likely to result in providing an inaccurate rent size for 2050, as seen earlier from the first projection.

The FiT and LCOE tend to decline throughout time which has been observed in other renewable technologies. IRENA (2012a) projects significant reduction for the LCOE of CSP plants, though projection is for 2020, due to several GW of CSP power plants are under construction and announced. If aggressive deployment policies are to be applied, one can expect the reduction of learning effects. IRENA (2012a, p.32) suggests that greater research and development investment, greater operational experience and the scaling up of plants will add additional elements for reductions in the LCOE of CSP plants.

There are a number of studies which also project the reduction in the LCOE of parabolic trough. Table 41 presents the projected LCOE for parabolic trough from various sources.

Table 41: Projected LCOE for Parabolic Trough from Various Sources

Sources	**2011**		**2020**		**Projected Reduction (%)**
	Low Estimate	High Estimate	Low Estimate	High Estimate	
A.T. Keanrney. 2010[75]	0.23	0.32	013	0.16	43.5-50%
Based on Kutscher et al., 2010	0.22		0.10	0.11	50-54.5%
Fichtner, 2010	0.22	0.24			
	0.33	0.36			
	0.22	0.23			
Hinkley et al., 2011	0.21		0.13		38.1%
IEA, 2010	0.20	0.295	0.10	0.14	50-52.5%

Source: IRENA (2012a, p.33)

[75] Include both Parabolic trough and solar towers.

According to the studies presented in table 41, the LCOE of parabolic trough technology is expected to decline by 38.1-65 percent[76] in the future.[77] By applying the projected reduction rate in LCOE for parabolic trough, one is able to project a more accurate rent size. As the range of the reduction rate is wide, 38.1-65 percent, different reduction rate will be applied.

Table 42: Reduced LCOE for Parabolic Trough and the Rent Size and its Proportion for Spain

Reduction rate	**35%**	**45%**	**55%**	**65%**
North Africa's CSP LCOE after applying reduction rate	**11.2**	**9.5**	**7.8**	**6.1**
Rent size/proportion from CSP in Spain (18.5%)	2.54	2.16	1.77	1.38
Rent size proportion from PV in Germany (16.9%)	2.28	1.93	1.59	1.24
Rent size proportion from onshore wind power in Germany (14%)[78]	1.82	1.55	1.27	1
The average rent size proportion of the three technologies (16.4%)	2.21	1.88	1.54	1.21

Table 42 presents the LCOE of the parabolic trough for the five North African countries after different reduction rates have been applied.[79] Each LCOE and different rent proportion from CSP in Spain (18.5 percent), PV in Germany (16.9 percent), onshore wind power in Germany (14 percent), and the average rent size proportion of the three technologies (16.4 percent) are then applied to the formula I which is presented earlier. The range of the parabolic trough LCOE for the five North African countries is 1-2.54 €cents/kWh. As it has been decided to use the US dollar as the currency in comparing the rent sizes, the given rent size range will be then 1.18-3 US$pense/kWh. This means that the five North African countries' projected range for the total rent size from electricity export via solar energy is around US$7.1-24billion. The projected rent sizes, 1.18-3 US$pense/kWh and US$7.1-24billion in total, provide one with two ways to make rent size comparison between the solar energy rent size and the natural resource rent size. With the 1.18-3 US$pense/kWh rent size, one can directly calculate the projected amount of rent size for individual North African countries. This is possible because of recent studies, such as by Trieb et al. (2012), which provide projected amount of electricity that will be exported from individual North African countries. However, the limitation of this method is that the comparison can be only made between the projected rent size and natural

[76] 65 percent reduction rate is provided by Schellekens et al. (2010, p.65) which is for the year 2050.

[77] The projected LCOE reduction rate is mostly made between 2011 and 2020. As there is limited data regarding the LCOE reduction rate by 2050, except for the date provided by Schellekens et al. (2010), this data will be applied in obtaining the LCOE reduction rate.

[78] Average value of the calculated rent proportion in table 40.

[79] The reduction rates have been applied on the LCOE used earlier, 13.7 €cents/kWh, for the five North African countries from Schellekens et al. (2010, p. 155).

resources rent size of the energy exporters. In other words, by using this method, one is not able to project whether the North African energy importers will have the potentials to suffer from a solar energy curse. Therefore, in order to also project whether the North African energy importers are to suffer from a solar energy curse or not, it is necessary to use the total projected rent size of US$7.1-24billion. This projected rent size can be compared to the average rent size of the natural resource in the MENA region.[80] By using this method, one is able to see whether the projected solar energy rent size will be as high as the average natural resource rents. If the projected rent size is as high as the average natural resource rent size under the circumstances that the poor institutional quality is to be remained in the future, one could argue that the five North African countries, including both the energy exporters and importers, have the potentials to suffer from a solar energy curse. In this thesis, though the latter method covers both the energy exporters and importers, both methods will be applied. In order to make the comparisons, the next section will present the average natural resource rent size of the North African energy exporters and the MENA energy exporting countries.

7.3 The Rent Size from the Natural Resources in the Five North African Countries and the MENA Countries

The aim of this section is to measure the rent size from the natural resource export in the five North African countries and the MENA countries in order to compare with the projected solar energy rent size which is made in section 7.2 As this thesis is focusing on 'energy sources', the rent size from the natural resource will be referred to as the rent size from exporting energy sources. Here, oil and natural gas will represent the energy sources because they are considered to be important and crucial energy sources in electricity production.

Oil and natural gas rents will be calculated from data obtained from the WDI. WDI provides the nations' GDP, and oil rent and natural gas rent percentages from the GDP which one can use to calculate the amount of rents. The average GDP, oil rent, natural gas rent, and sum of the oil and natural rents during 1993-2009[81] will be calculated. First, as the focus of this thesis is in North Africa, the resource rent for the North African energy exporters will be calculated in order to have general idea of how much rent they receive from exporting oil and natural gas.

[80] The reason for making the comparison between the solar energy rent from the five North African countries and the natural resource rent from the MENA region will be explained in the next section.

[81] The reason for choosing this period, instead of 1993-2011 in section 5.1, is that it was the most recent data available.

Table 43: The average GDP, Oil rent, Natural Gas Rent, and the Sum of Oil and Natural Gas Rents in Algeria, Egypt and Libya 1993-2009 (US$ Billion)

	GDP	Oil Rent	Natural Gas Rent	Rents Combined
Algeria	77.1	12.4	10.8	23.2
Egypt	94.5	6.93	5.18	12.11
Libya	39.3	16.9	1.42	18.32

Source: World Development indicator (WDI)

Table 43 presents the average GDP, oil rent size, and natural gas rent size of the North African energy exporters during the period 1993-2009. As can be observed, the oil and natural gas rents take quite high proportions of their GDP. Algeria and Libya received much higher rents from oil and natural gas than Egypt. As mentioned in section 7.2, due to recent studies made such as Trieb et al. (2012), an individual country's rent size from oil and natural exports can be compared to their projected solar energy rent size. Though it is only possible to make comparisons among the energy exporters, the outcome of this comparison may be more accurately as it is for individual countries. The comparison will be made later in this thesis.

As mentioned earlier, the solar rent size can be projected for individual countries. However, the limitation of this method is that it is only able to make the comparison among energy exporters. Therefore, one has to compare the projected solar energy rent size to the average oil and natural gas rent size in order to see whether the projected solar rent size will be comparable to the oil and natural gas size. As this thesis is focusing on the five North African countries, the average oil and natural gas rent size can be calculated amongst them. However, there are only three energy exporters in North Africa. In other words, the average oil and natural gas rent size from only three North African countries may not provide a fair and accurate average rent size to be compared to the projected solar energy rent size due to factors such as difference in the reserves, export amount, and production rate. For instance, solar energy reserves, DNI which fairly strong in the MENA region in general, will not be so different among the countries unlike oil reserves. In other words, one needs to obtain the average oil and natural gas rent from broader range in order to make a 'fairer' comparison. Therefore, in this section, the average oil and natural gas rent size will be calculated from the MENA countries which are in the same region with similar development statuses.

Table 44: The Average GDP, Oil Rent, Natural Gas Rent, and the Sum of Oil and Natural Gas Rents in MENA Countries 1993-2009 (US$ Billion)

	GDP	Oil Rent	Natural Gas Rent	Rents Combined
Bahrain	10.4	2.06	0.951	3.011
Iran	155	47	12.5	59.5
Iraq[82]	34.3	29.5	0.295	29.795
Kuwait	56.6	27.8	1.51	29.31
Oman	24.9	8.96	2.35	11.31
Qatar	33.6	7.8	6.27	14.07
Saudi Arabia	234	103	8.46	111.46
Sudan	22.4	4.17		4.17
Syria	24.3	5.11	0.723	5.833
UAE	137	25.7	5.83	31.53
Yemen	12.1	3.8	-[83]	3.8

Source: World Development indicator (WDI)

Table 44, therefore, presents the average GDP, oil rent, and natural gas rents in other MENA energy exporters during the period of 1993-2009. In table 44, one can see that Saudi Arabia, considered to be affected by the resource curse[84], received an average rent size of US$111.46 billion from oil and natural gas export which is higher than the total average oil and natural gas rent size of other MENA countries during the same period.

What one can see from table 43 and table 44 is that the rent size from oil and natural gas vary in all countries. Some MENA countries, despite the size of the rent, are already considered to be affected by the resource curse due to their poor institutional quality. Here, one can make a small test whether the resource curse can be detected only by comparing the rent size. Therefore, table 45 illustrates the rent from oil and natural gas for the countries which are considered as the resource cursed countries.[85]

[82] 1993-1996 and 2003 are missing.
[83] Data is only available for the year 2009, and it was 0.33 percent which is very low.
[84] See table 19, 20.
[85] See table 19, 20.

Table 45: The Average GDP, Oil Rent, Natural Gas rent, and the Sum of Oil and Natural Gas rents in Resource Cursed Countries 1993-2009 (US$ Billion)

	GDP	Oil Rent	Natural Gas Rent	Rents Combined
Angola	23.6	12.9	0.0681	12.9681
Ecuador	28.9	5.33	0.0613	5.3913
Equatorial Guinea	4.52	2.92		2.92
Nigeria	77.6	24.2	2.61	26.81
Sudan	22.4	4.17		4.17
Venezuela	133	36	3.96	39.96

Source: World Development indicator (WDI)

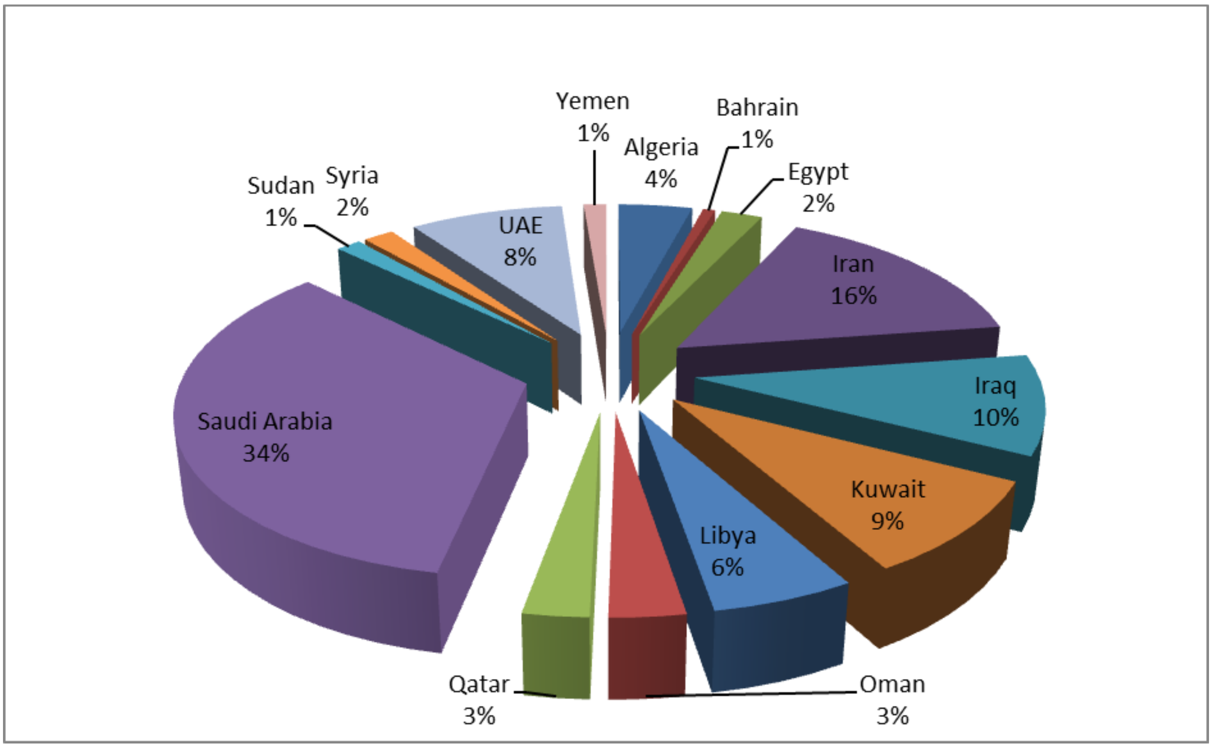
As can be seen from table 45, among the resource cursed countries, Venezuela received the largest amount of rent from oil and natural gas exports which is higher than Algeria, Egypt, and Libya. However, it may not be sufficient to conclude that the North African energy exporters are not affected by the resource curse just because they received less rents from the exports of oil and natural gas. Unlike the institutional quality comparison, the rent size comparison between the resource cursed countries and the other MENA countries does not provide any sort of pattern which enables one to identify the resource curse. This is due to the fact that individual countries have different production capacity, proven reserves, price, and other factors. Therefore, the rent size alone can not be used as the boundary-line to find whether a country is affected by the resource curse or not. In other words, one can suspect that the sizable rent can only determine a country to be affected by the resource curse when accompanied by poor institutional quality.

As for the average oil and natural gas rent size in the MENA countries, it is possible to use the data illustrated in table 43 and 44. However, before calculating the average rent size, one should carefully look at the rent size for individual MENA country.

Figure 19, 20, and 21 present individual country's average oil, natural gas, and oil and natural gas rent size in percentage form during the period of 1993 and 2009. The MENA countries' total oil rent, natural gas rent, and both rents combined during the period of 1993-2009 are US$301 billion, US$56.3 billion, and US$357 billion, respectively. As can be seen from figures below, Saudi Arabia has substantially higher rent proportion in oil rent (34 percent) and oil & natural gas rent (31 percent). In the case of natural gas, it is Iran which has the highest proportion (22 percent) among the MENA countries. These findings should be carefully observed when comparing the average rent size of oil, natural gas, and solar energy. This is because the difference in the rent size of the solar energy among individual country will not be as wide as for oil or natural gas. The differences in the proven reserves and production of oil and natural gas are quite high among the energy exporting countries.

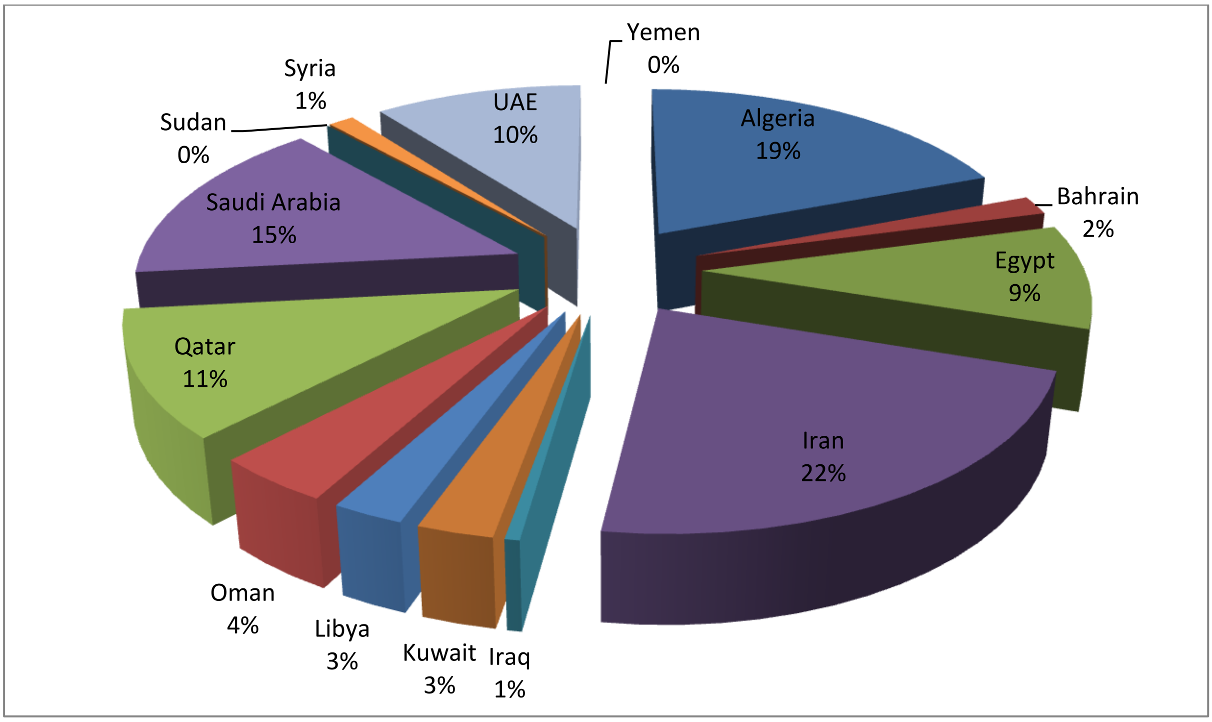
As mentioned earlier, however, as the DNI is fairly strong in the entire MENA region, the difference in the solar energy 'reserves' and electricity production are expected to be smaller. Thus, in other words, the difference in rent size from the solar energy is also expected to be smaller among the MENA countries. Therefore, countries that receive substantially higher rent from oil and natural gas, such as Saudi Arabia, may have to be excluded in order to make 'fairer' comparison among oil, natural gas, and solar energy rent.

Figure 19: The Average MENA Oil Rents Proportions 1993-2009



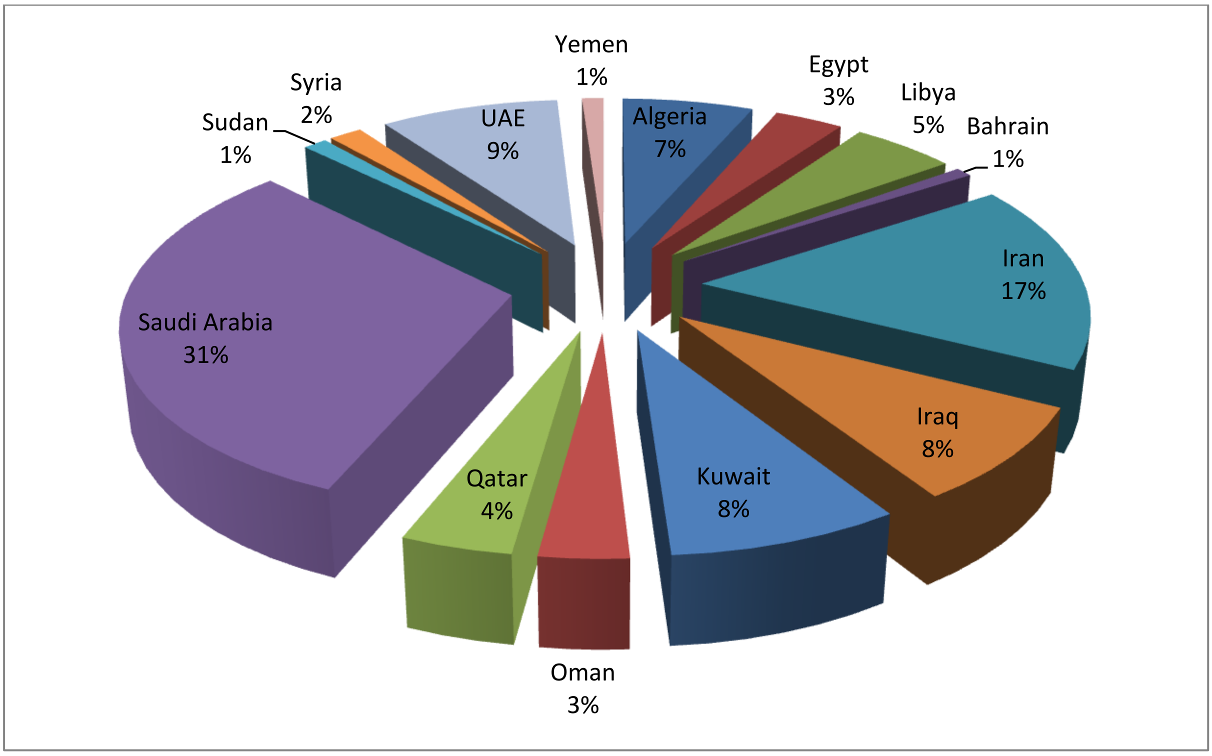
Source: World Development Indicator (WDI)

Figure 20: The Average MENA Natural Gas Rents Proportions 1993-2009



Source: World Development Indicator (WDI)

Figure 21: The Average MENA Oil & Natural Gas Rent Proportions 1993-2009



Source: World Development indicator (WDI)

As mentioned earlier, Saudi Arabia and Iran have relatively higher rents from oil and natural gas compared to the other MENA countries. If one is to exclude Saudi Arabia's oil rent from the total average oil rent and oil & natural gas rents during the period of 1993-2009, the rents are US$198 billion and US$254 billion, respectively, which shows substantial reduction in the total rent in both cases. Therefore, Saudi Arabia's oil rent will be excluded when making the comparison among the rent size of oil, oil & natural gas, and solar energy. In the case of natural gas, as Iran received relatively higher rent compared to the other MENA countries, one may consider to exclude Iran when calculating the total average rent size of natural gas. However, as the rent size from natural gas itself is much lower than the oil rent size in general, one should question whether it is necessary to exclude Iran from the total natural gas rent. For example, it makes sense to exclude Saudi Arabia's oil rent because the difference between the oil rent from Saudi Arabia and Iran (which received the second highest rent from oil) is US$56 billion. This means Saudi Arabia's oil rent size is about 219 percent higher compared to Iran. On the other hand, the difference between the natural gas rent size between Iran and Saudi Arabia (received the second highest rent from natural gas) is US$4.04 billion. This means Iran's natural gas rent was about 148 percent higher compared to natural gas rent from Saudi Arabia. Though there are differences in the rent size, the natural gas rent size difference can be considered small when compared to the oil rent size. In other words, there is no need in excluding Iran's natural rent.

Table 46: The Sum of Average Oil, Natural Gas, and Oil & Natural Gas Rent of MENA 1993-2009 (US$ Billion)

<table>
<tr><th></th><th>Total Average Oil Rent</th><th>Total Average Natural Gas Rent</th><th>Total Average Combined Rent</th></tr>
<tr><td>MENA</td><td>301</td><td rowspan="2">56.3</td><td>357.3</td></tr>
<tr><td>MENA Excluding Saudi Arabia's Oil Rent</td><td>198</td><td>254.3</td></tr>
</table>

Source: World Development Indicator (WDI)

Table 46 present the sum of average oil, natural gas, and oil & natural gas rent sizes from the MENA countries, both including and excluding Saudi Arabia's oil rent, during the period of 1993-2009. The purpose of presenting the rent size for the MENA both including and excluding Saudi Arabia's oil rent size is to show how dominant Saudi Arabia is in regarding the rent size proportion of the total MENA countries' energy rent sizes. As a substantial difference in the total rent size can be observed by comparing the rent sizes from the MENA region, when including and excluding Saudi Arabia, the decision that was made to exclude Saudi Arabia appears sufficient. Accordingly, the projected solar energy rent size will be compared to the sum of MENA countries oil and natural gas rent sizes excluding the oil rent size from Saudi Arabia.

7.4 Comparison

The aim of this section is to compare the projected solar energy rent size and the average oil and natural gas rent size in order to see whether the projected solar energy rent size will be as high as the rent size from oil and natural gas. As mentioned earlier, two methods in comparing the rent sizes will be applied in this section.

7.4.1 Comparison with the Projected Solar Energy Rent Size of 1.18-3 US$pense/kWh for Individual North African Energy Exporters

One of the projected rent sizes made in section 9.2 is 1.18-3 US$pense/kWh for the North African countries. As mentioned earlier, due to the recent study made by Trieb et al. (2012), it is possible to project the solar energy rent size for individual North African countries. Trieb et al. (2012, p.349) present the average projected amount of electricity which will be exported from the five North African countries and also Jordan and Saudi Arabia to Europe. Table 47 presents their projection for individual North African countries.

Table 47: Projected Amount of Electricity Exported from the MENA Countries in 2050

Countries	Algeria	Egypt	Libya	Morocco	Tunisia
Projected amount of Exported electricity in 2050 (TWh)	230	74	71	213	71

Source: Trieb et al. (2012, p. 349)

By using the data given in table 47, one is able to project the solar energy rent size for individual North African countries. Table 48 presents the projected solar energy rent size and the average oil, natural gas, and oil & natural gas rent size during the period of 1993-2009 for the five North African Countries.

Table 48: Projected Rent Size from Solar Electricity Exports for the Five North African Countries in 2050, and the Average Oil, Natural Gas, and Oil & Natural Gas Rent Size 1993-2009 (US$ Billion)

Countries	Algeria	Egypt	Libya	Morocco	Tunisia
Average GDP (1993-2009)	**77.1**	**94.5**	**39.3**	**49.5**	**26.6**
Projected rent size from Electricity export via solar energy in 2050 (US$ billion)	2.7-6.9	0.87-2.2	0.84-2.1	2.5-6.4	0.84-2.1
Oil Rent size	12.4	6.93	16.9	-	-
Natural Gas	10.8	5.18	1.42	-	-
Oil & Natural Gas	23.2	12.1	18.32	-	-

As can be observed from table 48, the projected rent sizes from solar energy exports for the North African energy exporters are not at all close to the rent size from the fossil-fuel exports. Their oil and oil & natural gas rent sizes are substantially higher than the projected solar energy rent size. In the case of natural gas rent size, the projected solar energy rent size can be comparable to Libya's natural gas rents. However, as can be seen from table 48, Libya's main fossil-fuel rent is from oil and its rent size is substantially higher than the natural gas rent size. Therefore, even under the circumstance that their institutional quality is to remain poor in future, by looking at the rent size comparison, it is hard to see the possibility of solar energy becoming a new curse for the energy exporters because their projected solar energy rent sizes are substantially lower than the average oil and natural gas rent sizes. As for the energy importers, as it is pointed out as the limitation of this method, it is not possible to project their potential to suffer from a solar energy curse because the comparisons between the projected solar energy rent and oil and natural gas rents can not be made. Therefore, in order to project the potential for energy importers to suffer from a solar energy curse, the second method will be applied in the next section.

7.4.2 Comparison between the Projected Solar Energy Rent of $7.1-24billion and the Sum of Average & the Average Oil and Natural Gas Rent Size

In this section, the total projected solar energy rent for the five North African countries will be compared to the sum of MENA countries' rent size of oil, natural gas, and oil & natural gas. Table 49 presents the projected rent size from the solar energy and the sum of average oil, natural gas, and oil & natural gas rent sizes from the MENA countries during the period of 1993-2009.

Table 49: The Sum of Average Rent from Oil, Natural Gas, and Oil & Natural Gas of MENA Energy Exporters, and the Projected Solar Energy Rent Size for North Africa 1993-2010 (US$ Billion)

Oil Rent	Natural Gas Rent	Oil & Natural Gas Rent	Projected Solar Energy Rent
198	56.3	254.3	7.1-24

As can be seen from table 49, there is a substantial difference between the projected solar energy rent size and the rest of the summed rent sizes. Even if one is to take natural gas rent separately, which is much lower than the sum of oil rent, the projected solar energy rent size is substantially lower. Therefore, based on the result in table 49, and also based on the assumption that the institutional quality is to remain poor, the five North African countries do not appear to have the potentials to suffer from a solar energy curse. Here, however, one should note that there is a limitation in this method in identifying a solar energy curse for the five North African countries.

As mentioned earlier, the projected amount of electricity that will be exported from the five North African countries is based on studies from DLR (2006), Shcellekens et al. (2010), and Trieb et al. (2012). Here, one should remember that the DLR's (2006) projected amount of exported, or transferred, electricity is not only from the five North African countries, but from the MENA countries. In other words, this section has been indirectly relying on the assumption that the amount of electricity that will be exported from the five North African countries and the entire MENA countries will be similar. This is why the comparison between the projected solar rent size and, for example, the sum of the average oil rent size of the MENA countries has been possible. The problem is that, as mentioned earlier, DRL (2006) does not specify exactly which countries are involved in their MENA countries. Therefore, comparing the projected solar energy rent to the sum of the average fossil-fuel rent size from the MENA countries may be inaccurate as one is unsure which countries' fossil-fuel rent should be included or not. For example, it may be that only few MENA countries are involved in DRL's (2006) study like in Trieb et al.'s (2012, p.349) study which projects that 831 TWh/y amount of electricity to be exported from the MENA countries, Algeria, Egypt, Jordan, Morocco, Saudi Arabia, and Tunisia, which is more than DRL's (2006) projection. If the six countries in Trieb et al.'s (2012) study are the only countries included in MENA countries from the DLR's (2006) study, then the specific countries' sum of oil rent from the MENA countries can be compared to the projected solar energy rent size. Unfortunately, this is not the case. One may argue that this section could just rely on Trieb et al.'s (2012) study to compare the rent sizes. However, though specific countries are given, their study involves Saudi Arabia which is decided to be excluded in section 7.3. Due to a number of mentioned obstacles, therefore, one can not be so certain that the result found in Table 49 is accurate.

Despite the unsatisfying result in this section, one can find a more reliable way of finding whether the five North African countries will have the potentials to suffer from a solar energy curse in the future. Instead of using the sum of average oil, natural gas, and oil & natural gas rents of the MENA countries, one can use the average of all the MENA countries' rent sizes during the period of 1993-2009 which is presented in table 50. Each average rent size presented in table 50 can be compared to the individual North African country's projected solar energy rent size which is presented in table 48. In other words, the average rent sizes that are presented in table 50 will be used as the boundary-line. This is likely to bring fairer outcome because the average rent sizes presented in table 50 are based on the MENA countries which are considered to rely heavily on their energy exports.[86] Therefore, if the five North African countries' solar energy rent is as high as the results in table 50, one can suspect that they may suffer from a solar energy curse.

Table 50: The Average Oil, Natural Gas, and Oil & Natural Gas Rent Sizes of the MENA Countries 1993-2009 (US$ Billion)

Oil Rent	Natural Gas Rent	Oil & Natural Gas Rent
15.2	4.02	19.22

When one compares individual country's projected solar energy rent to the 'boundary-line' rent size presented in table 50, it is possible to see that the projected solar energy are far from reaching the average rent size of oil, and oil & natural gas. In the case of natural gas, only the projected solar energy rent from Algeria and Morocco may be as high the average natural gas rent size. However, when compared to the oil rent size, the natural gas rent size is still substantially low.

7.4.3 Perceiving All Rent Sizes as the Proportion of GDP

So far, by looking at the results from section 7.4.1 and 7.4.2, it appears that the projected solar energy rent size is not likely to be comparable to, except for few cases of natural gas rent size, the average fossil-fuels rent sizes. Therefore, based on the assumption that the institutional quality is to remain poor in the future, the five North African countries, and MENA countries, are less likely to suffer from a solar energy curse as much as they suffer from the current resource curse. However, it could be argued that the results from section 7.4.1 and 7.4.2 are not specific enough as they only show that the projected solar energy rent size is smaller than the average fossil-fuel rent sizes. Therefore, this section will transform all the obtained rent sizes from section 7.4.1 and section 7.4.2

[86] See table 6.

into the proportion of GDP form in order to make more precise and specific comparisons. Here, as mentioned earlier in section 5.1, if the projected solar energy rent in a country is higher than, or as high as, 10 percent of GDP, which is considered high rate according to Mehlum et al. (2006b, p.1), it will be considered to have the potential to suffer from a solar energy curse.

Table 51: Rent Sizes from Table 48 in the GDP Proportion Form[87]

Countries	Algeria	Egypt	Libya	Morocco	Tunisia
Average GDP (1993-2009) US$ billion	**77.1**	**94.5**	**39.3**	**49.5**	**26.6**
Projected solar rent size proportion (% of GDP)	2.7-6.9	0.87-2.2	0.84-2.1	2.5-6.4	0.84-2.1
Oil Rent size proportion(% of GDP)	16.1	7.3	43	-	-
Natural Gas (% of GDP)	14	5.5	3.6	-	-
Oil & Natural Gas (% of GDP)	30.1	12.8	46.6	-	-

Table 51 presents the results from table 48 in the form of GDP proportion. When looking at table 51, it is possible to see that the projected solar energy rent size for all five North African countries does not exceed 10 percent of their average GDP. Especially, when looking at the energy exporters, their projected solar energy rent size is substantially lower than their fossil-fuel rent sizes.

Table 52: Rent Sizes from Table 49 in the GDP Proportion Form

Sum of Average GDP of MENA Countries (1993-2009)	Oil Rent (% of GDP)	Natural Gas Rent (% of GDP)	Oil & Natural Gas Rent (% of GDP)	Projected Solar Energy Rent (% of GDP)
$956billion	20.7%	5.9%	26.6%	0.7-2.5%

Table 52 presents the results from table 49 in the GDP proportion form. Although the result from table 49 is not considered fully reliable, it is still possible to see that the projected solar energy rent does not exceed 10 percent of the GDP and are also not close to any other fossil-fuel rent sizes.

Table 53: Rent Sizes from Table 50 in the GDP Proportion Form

Average GDP of MENA Countries (1993-2009)	Oil Rent (% of GDP)	Natural Gas Rent (% of GDP)	Oil & Natural Gas Rent (% of GDP)
$68.3billion	22.3%	5.9%	28.1%

[87] The oil, natural gas, and oil & natural gas as % of GDP are different from table 6 because the calculation is made based on table 43 and 44 which are rounded values.

Table 53 presents the results from table 50 in the GDP proportion form. When the rent sizes in GDP proportion form from table 53 is compared to the projected solar energy rent size in the GDP proportion form from table 51 for individual countries, their projected solar energy rent size is not as high as the fossil-fuels rent sizes in the GDP proportion form. However, as observed earlier in the comparison between the results from table 51 and 53, the projected solar energy rent size in GDP proportion form for Algeria and Morocco can exceed the natural gas rent size in the GDP proportion. Nevertheless, their projected solar rent sizes in the GDP proportion still do not exceed 10 percent of the total GDP.

As can be seen from the rent size comparisons in the GDP proportion form, it is possible to see that the projected solar energy rent size is not likely to be as enormous as the fossil-fuel rent sizes. Also, considering that the five North African countries' GDP is expected to grow in the future, see table 54, the proportion of the projected solar energy rent in GDP will likely be smaller compared to the results above as the GDP values in this thesis have been based on the average GDP during the period of 1993-2009.

Table 54: Projected GDP for the Five North African Countries in the Future (US$ Billion)

	2010	2011	2012	2013	2014	2015	2016	2017
Algeria	160.779	190.709	206.502	213.067	218.180	224.959	234.128	245.422
Egypt	218.465	234.719	252.458	253.380	269.033	291.631	318.625	348.724
Libya	80.442	36.874	79.691	96.036	96.700	99.996	104.419	107.709
Morocco	90.803	99.241	100.354	107.341	115.027	123.669	133.349	144.946
Tunisia	44.278	46.360	46.146	47.701	50.239	53.615	57.186	61.017

Source: World Economic Outlook Database April 2012
http://www.imf.org/external/pubs/ft/weo/2012/01/weodata/weorept.aspx?sy=2009&ey=2017&scsm=1&ssd=1&sort=country&ds=.&br=1&c=612%2C686%2C469%2C744%2C672&s=NGDP_RPCH%2CNGDPD&grp=0&a=&pr.x=44&pr.y=5 (accessed: 15.01.2013)

So far, by looking at the outcome of the rent size comparison, the projected solar energy rent size is less likely to become as high as the fossil-fuel rent sizes. Under the assumption that the poor institutional quality of the five North African countries is to remain poor, the five North African countries are less likely to suffer from the solar energy curse because the projected rent size is small. Here, it must be noted that the projected solar energy rent size achieved in this section is based on studies, such as DLR (2006) and Trieb et al. (2012), which only, or mainly, focus on the electricity export via CSP from North Africa and MENA to Europe via direct connection. This means that the CSP technology is assumed to be the dominant renewable technology in North Africa in the future. In other words, the estimated amount of exported electricity of ±700 TWh/y via CSP in the future may be rather an 'optimistic' projection. In a recent study by Zickfeld et al. (2012), for example, it is projected that the annual power exchange between MENA[88] and Europe will be total of 1110 TWh by 2050 in their Connected Scenario.[89] Within the total amount, 1087 TWh/y amount of electricity is projected to be exported from MENA to Europe and 23 TWh/y from Europe to MENA. Thus, the net trade balance amounts 1064 TWh/y from MENA to Europe (Zickfeld et al., 2012, p. 54).

Figure 22 presents the projected EUMENA electricity production shares in Connected Scenario and Reference Scenario[90] in Zickfeld et al.'s (2012, p.62) study. As can be observed from figure 22, Zickfeld et al. (2012) project that the EUMENA electricity mix in 2050 is projected to be made up of 91 percent from renewable energies and 9 percent from natural gas. Here, their projection is that the wind energy[91] will contribute to 53 percent of the EUMENA electricity production share which is projected to be installed everywhere in EUMENA, and 16 percent is contributed from CSP which is almost entirely located in MENA (Zickfeld et al., 2012, p.12).

If one is to take the Connected Scenario from figure 22, and make a rough calculation, the electricity production share of the CSP technology would be approximately 1344 TWh/y which is 16 percent of the total projected amount of electricity production of 8842 TWh/y. Of course, this is a rough projected amount of electricity production via CSP of EUMENA. However, as Zickfeld et al. (2012, p.12) project, most CSP capacity is projected to be allocated in MENA. Therefore, if one is to estimate that, again a very rough projection, 16 percent of the electricity export from MENA to Europe is via CSP technology, it would be approximately 170 TWh/y which is much lower than ±700TWh/y. Despite the rough projection made above, by looking at figure 23 which presents the projected electricity generation and interconnector capacity in Zickfeld et al.'s (2012) connected Scenario, though exact amount is not presented, it is possible to see that the Middle East is projected to have more CSP capacity, in terms of ratio, than North Africa. In other words, it is possible that the electricity exports via CSP from North Africa to Europe may be even smaller.

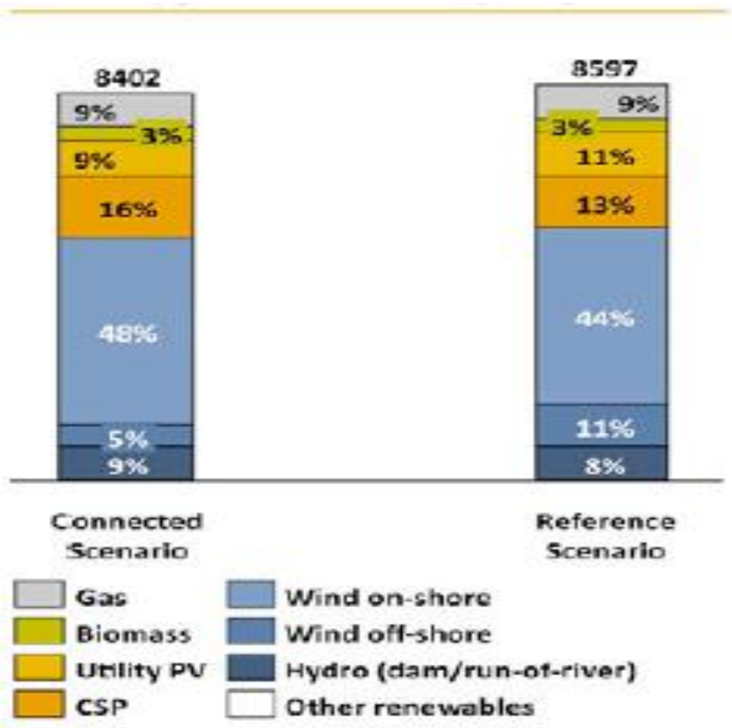
[88] Zickfeld et al. (2012) refers to MENA Countries as Algeria, Egypt, Libya, Morocco, Tunisia from North Africa, and Jordan Saudi Arabia and Syria from Middle East.

[89] Connected Scenario examines a power system with full, EUMENA-wide integration (Zickfeld et al., 2012, p. 9).

[90] Reference Scenario depicts a situation where each region, Europe and MENA, is fully optimized in itself but without cooperation between the two systems (Zickfeld et al., 2012, pp. 9-10).

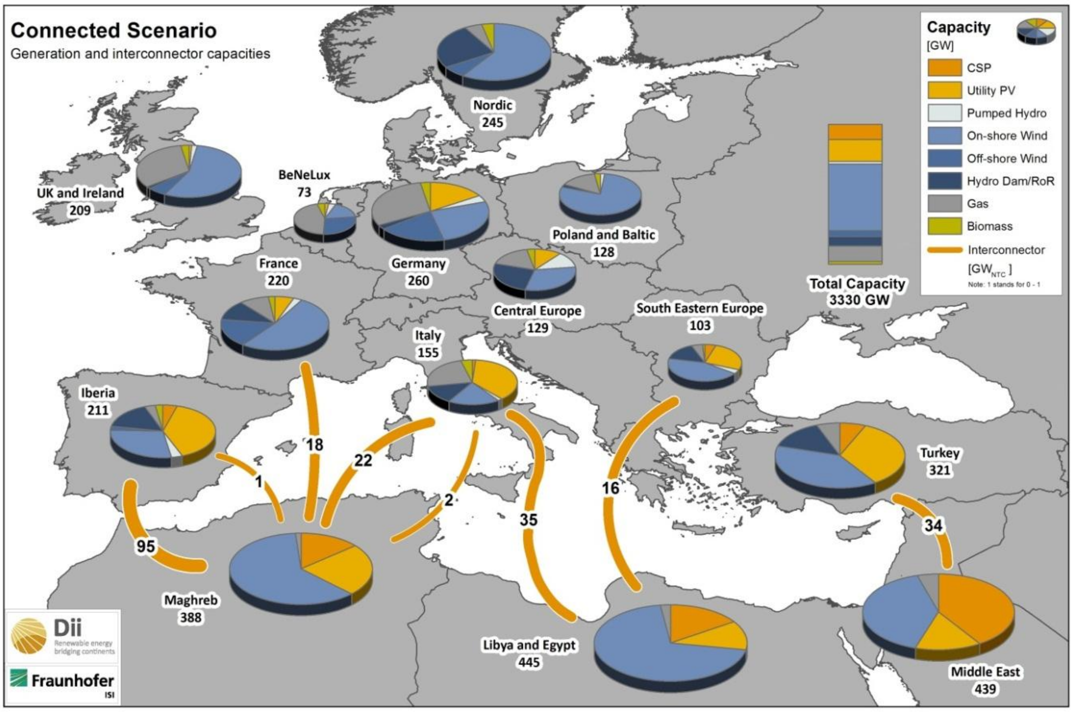
[91] Wind on-shore and off-shore.

Figure 22: The Projected EUMENA Electricity Production Shares in Connected Scenario and Reference Scenario (TWh)



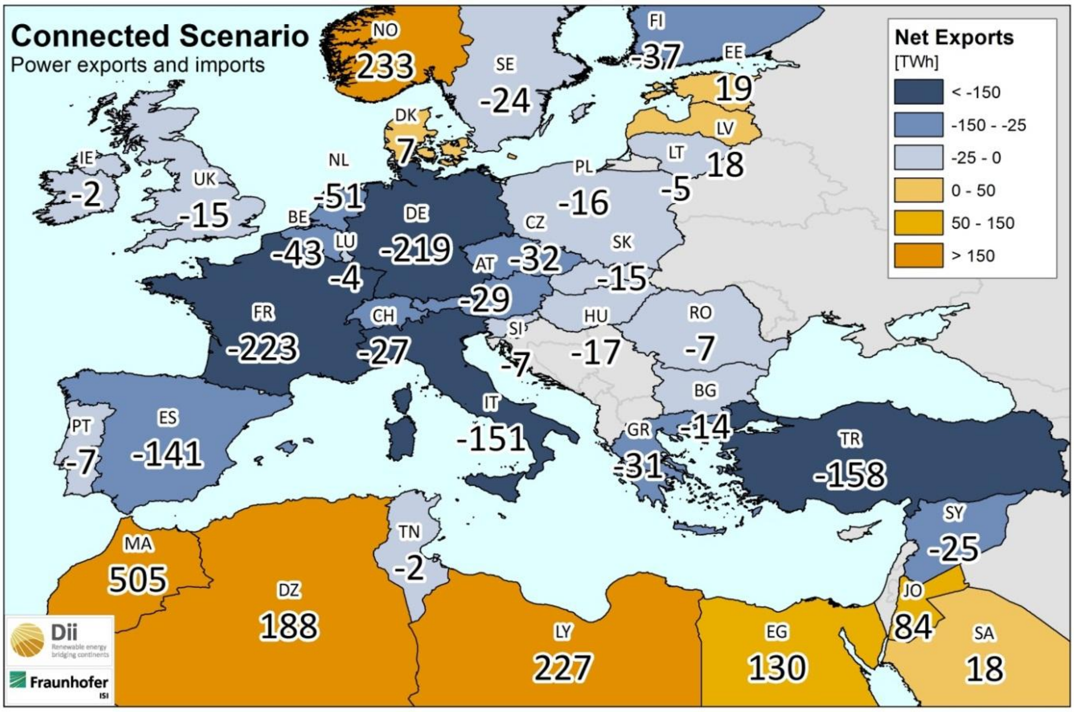
Source: Zickfeld et al. (2012, p.62)

Figure 23: Generation and Interconnector Capacity, Connected Scenario



Source: Zickfeld et al. (2012, p. 12)

Figure 24: Net Exporters and Net Importers in EUMENA, Connected Scenario



Source: Zickfeld et al. (2012, p.76)

It is possible to make a further, more detailed, projection based on Zickfeld et al.'s (2012, p.76) study as they present projected amount of electricity export and import from individual North African country as can be seen in figure 24. The most noticeable finding from figure 24 is that, unlike the other studies such as Trieb et al. (2012), Tunisia is projected to become an electricity 'Importer'.[92] Zickfeld et al. (2012, p.84) consider Algeria, Libya, and Morocco to become 'Super Producers'[93] which are projected to export electricity amount of 188 TWh/y, 227 TWh/y, and 505 TWh/y, respectively. Furthermore, Egypt, which is consider as 'Balancers'[94], is projected to export 130 TWh/y amount of electricity. Of course, the amount of electricity they are projected to export is not only expected to come from the CSP technology. Table 55 presents the projected total amount of exported electricity, and via CSP from the five North African countries based on Zickfeld et al.'s (2012) study.

[92] Zickfeld et al. (2012, p.16) refers to importers as countries with a high demand and limited potential of good renewable resources in comparison to demand.

[93] Countries with excellent renewables resources and relatively low demand, which have enough excess in cheap renewable potentials for significant exports (Zickfeld et al., 2012, p.16).

[94] Countries with levels of demand and renewable resources that are largely proportionate to each other (Zickfeld et al., 2012, p. 17).

Table 55: Projected Total Amount of Exported Electricity, and via CSP from the Five North African Countries based on Zickfeld et al.'s (2012) Study[95]

Countries	Algeria	Egypt	Libya	Morocco	Tunisia
Projected amount of Exported electricity in 2050 (TWh)	188	130	227	505	-2
Projected amount of Exported electricity Via CSP 2050* (TWh)	19	21	36	81	-

As can be seen from table 55, the projected amount of exported electricity via CSP is much smaller compared to the projected amount presented in table 47. The total projected amount of exported electricity via CSP based on table 55 is 157 TWh/y which is far smaller compared to ±700 TWh/y. Of course, difference occurs as, unlike the other studies such as Trieb et al. (2012), Zickfeld et al.'s (2012) work does not solely focus on solar energy and rather projects that the wind power will have a much larger capacity than solar energy. Also, the projection made above, based on Zickfeld et al.'s (2012) study, may not be considered so accurate as it is not possible to predict exactly how much electricity is exported via CSP in the future. More specifically, once electricity is produced, it is impossible to tell which share of electricity in specific part of the grid comes from which technology. Nevertheless, this rough calculation is not worthless as it shows the possibility that the rent size from solar energy may be even smaller than the projected solar energy rent size made earlier as the projected amount of electricity exports from North Africa to Europe may be even smaller.

Here, though it is mentioned that it may not be accurate to project the possible rent size for each technology, it may be worthwhile to make another rough projection of the rent size from the electricity export via other renewable energies whether the rent size can be comparable to the fossil-fuel rent size. As the capacity of the wind power and CSP are projected to be high in energy mix from Zickfeld et al.'s (2012) study, their rent size will be projected.

Zickfeld el al. (2012, p.44) project that the LCOE of CSP will be approximately €50/MWh (5 €cents/kWh), and LCOE of wind power will be around €35-45/MWh(3.5-4.5 €cents/kWh) in 2050 for EUMENA. When the exchange rate from table 33 is applied, the LCOE for CSP and wind Power will be 5.9 US$pense/kWh and 4.13-5.31 US$pense/kWh, respectively. The total projected amount of exported electricity from the five North African countries to Europe will be obtained from figure 24 which will be total of 1048 TWh. Here, the obstacle is projecting the amount of electricity that will be produced from each technology. As used in the projection made earlier, when looking at figure 22,

[95] This projection is made under the assumption that 16 percent of the total electricity export from individual North African countries, except for Tunisia, to Europe is via CSP.

the electricity production shares in EUMENA for CSP is 16 percent and 53 percent for the wind power including both wind on-shore and off-shore. As the capacity of CSP is projected to be mainly allocated in MENA, the proportion of the exported electricity via CSP will be assumed to be 16 percent of the total electricity export. As for wind power, it is mentioned earlier that the wind power will be installed everywhere in EUMENA. When looking at figure 23, one can see that the wind power share is projected to be high in North Africa. Though it does not present the exact proportion, as it appears that wind power capacity is to be more than 50 percent of the total capacity in North African in figure 23, the 53 percent proportion will be used as the wind power proportion in the projected amount of electricity export from MENA to Europe. This means the electricity amount of 555 TWh via wind power and 173 TWh from CSP are projected to be exported from North Africa to Europe. As the purpose of this projection is to project the rough rent size from two technologies, the total electricity amount of 728 TWh will be used. In section 7.2.2, the rent size proportion for wind energy, though only for onshore, is 14 percent and 18.5 percent for CSP. As this projection is for the rent size from both technologies, the average rent size proportion of the two technologies (16.25%) will be used. Since the average rent size proportion of the two technologies will be used, the average LCOE of the two technologies will be applied as well. However, as the wind power LCOE has quite a range (4.13-5.31 US$pense/kWh), and it is projected to have the highest capacity, the average LCOE of CSP and the lowest LCOE of wind power and highest LCOE wind power will be separately calculated and used as the range of the LCOE. Therefore, the range of the average LCOE of two technologies is 5-5.31 US$penses/kWh. When above values are applied in the formula I, the projected rent size is around 0.93-1.03 US$penses/kWh. Therefore, the total projected rent size is around US$6.8-7.5billion. Although it is a very rough calculation, this range of the projected rent size is even lower than the projected rent size achieved earlier. Thus, solar energy, or renewable energy, rent size is not projected to be as enormous as the average fossil-fuel rent size from the MENA countries during the period of 1993-2009.