

Potential for renewable energy jobs in the Middle East



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HIGHLIGHTS

- An analysis of the potential for renewable energy jobs in the Middle East is presented.
- With the TIAM-ECN model we inspect the technology requirements for meeting a radiative forcing of 2.9 W/m².
- Wind and solar power account for approximately 60% of total electricity supply in 2050.
- We estimate a total required local work force of ultimately about 155,000 direct and 115,000 indirect jobs.
- Manufacturing jobs are assumed to be partly local, while installation and O&M jobs are all domestic.

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ABSTRACT

Based on employment factors derived from a recent review of publications investigating opportunities for work associated with the diffusion of renewable energy technology, we here present an analysis of the potential for renewable energy jobs in the Middle East. We use energy system optimisation results from the regionally disaggregated TIAM-ECN model as input to our study. This integrated assessment model is utilised to inspect the energy technology requirements for meeting a stringent global climate policy that achieves a stabilisation of greenhouse gas concentrations in the atmosphere with a maximum additional radiative forcing of 2.9 W/m². This climate control target implies a massive deployment of renewable energy in the Middle East, with wind and solar power accounting for approximately 60% of total electricity supply in 2050: 900 TWh of an overall level of 1525 TWh would be generated from 210 GW of installed renewable energy capacity by the middle of the century. For this pervasive renewables diffusion scenario for the Middle East we estimate a total required local work force of ultimately about 155,000 direct and 115,000 indirect jobs, based on assumptions regarding which components of the respective wind and solar energy technologies can be manufactured in the region itself. All jobs generated through installation and O&M activities are assumed to be domestic.

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1. Introduction

Renewable energy technologies are deployed with rapidly increasing shares in many countries, most notably for reasons of mitigating climate change, reducing air pollution and enhancing energy supply independence. It is argued that the deployment of renewables may also be beneficial in terms of the stimulation of employment in a broad range of sectors directly or indirectly related to their use (IRENA, 2011, 2012a). The purpose of this paper is to assess what the regional employment implications could be if the Middle East achieves a renewable electricity share of about 60% in 2050 from solar and wind power, in accordance with a

climate mitigation strategy and renewable energy diffusion scenario generated with the TIAM-ECN model.¹ The reasons for choosing the Middle East as subject of our study are multiple, including, first of all, the vast solar and wind energy potentials in essentially all countries in this region. Another reason for our interest in the development of renewables in this specific geographical area, in addition to their advantages in terms of contributing to cleaning ambient air from pollutants with concomitant health benefits in especially large cities, is the growing awareness by local governments of the eventual finiteness of their national oil and natural gas reserves.

Ambitions in the Middle East to increase renewable energy deployment are driven by at least three other main considerations.

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¹ Middle East in this paper is defined as the region including Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestinian Territories, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates and Yemen.

First, the region's average per capita greenhouse gas (GHG) emissions level is high as a result of fossil fuel intensive energy systems; with climate change mitigation efforts mounting across the world, there is a growing desire to curb emissions in the Middle East (WRI, 2012). Second, in many countries in the region fuel requirements for electricity and fresh water supply consume a significant share of domestic oil production; especially with current high oil prices it is attractive to retain oil predominantly for foreign export (see, for example, Alsayegh and Fairouz (2011)). Third, oil and gas revenues have generated great wealth for the upper classes of Middle Eastern societies, which allows their leaders to invest in a wide variety of fields, including advanced technology and high-tech expertise such as associated with new more sustainable forms of energy. Fourth, over the coming years governments in the Middle East are likely to attempt to enhance the number of jobs in the private sector, in order to meet an imminently increasing demand from new job market entrants in the rapidly growing young-aged populations of their nations. If the claim is true that the establishment of a renewable energy industry generates net jobs (the veracity of which we briefly inspect below, but that still needs to be researched in more depth), then it may constitute an opportunity to also help bridging the foreseen employment gap (see e.g. IMF (2012)).

From a policy perspective, the deployment of renewables in the Middle East constitutes a valuable and interesting subject to investigate, since its primary energy supply currently involves very little renewable energy capacity, apart from low levels of wind and hydro power in a couple of countries. Along with optimally designing policy instruments enabling the deployment of renewables, it is important to rigorously analyse all ramifications and co-benefits ensuing from their diffusion, including in socio-economic terms such as related to employment opportunities. From an analytical point of view this case study is pertinent precisely because of the paucity of renewable energy use in the region today: the job numbers drawn from this employment assessment will be relatively easily verifiable over time as the region's renewable energy use develops. In Section 2 of this article we briefly summarise the findings of an exhaustive review of the literature on employment factors associated with the deployment of renewables, assembled recently by us (Cameron and van der Zwaan, 2012). In Section 3 we describe the TIAM-ECN modelling results that serve as input for our study, and explain how we use them for our employment analysis. We proffer the main outcome of our research, which we think constitutes a new contribution on this subject to the current literature, in Section 4, and summarise our conclusions in Section 5.

2. Literature review

An increasing body of literature is dedicated to the effects of the use of renewables on employment. Articles by Kammen et al. (2004) and Wei et al. (2010) reviewed this literature in order to determine average employment factors, defined in their case as the number of jobs or amount of work generated per unit of produced electricity. In Cameron and van der Zwaan (2012) we have recently also examined this growing body of literature with a special focus on wind and solar energy technologies, which today covers at least 60 publications. In that study we assessed the methods used to determine job impacts from renewable energy deployment, and particularly focused on how to do so based on syntheses of available literature, but proposed an alternative approach that differed in at least three aspects from the earlier two publications. First, we considered a more up-to-date and wider range of published sources. Second, we compared job figures reported by different studies not on the basis of generated

electricity, but rather per unit of installed capacity. Third, we inspected not only median employment factors but also minimum and maximum values in order to illustrate the range of employment outcomes that the current literature reports.

The 'proximity' of a created job vis-à-vis a given technology—in terms of how directly it can be attributed to a certain investment or, in our case, increase in renewable electricity generation capacity hints at another major distinction between studies on employment impacts, regarding the type of jobs they consider. In this regard a common language of 'direct', 'indirect' and 'induced' jobs is found in most of the literature pertaining to renewable energy and employment effects, derived from the more generic use of this terminology in labour studies at large. The International Renewable Energy Agency (IRENA) provides not only a clear and operational definition of these terms, but also elaborates appropriately on the slight but important variations in their interpretation across studies (IRENA, 2011):

- **Direct jobs:** Precise definitions vary, but in general these are jobs related to core activities, such as manufacturing/fabrication/construction, site development, installation, and operation and maintenance (O&M). Direct jobs are relatively easy to measure and their absolute number unequivocally correlates to the rate of growth of renewable technologies. All studies contemplated in Cameron and van der Zwaan (2012) consider direct renewable energy job impacts (and some also inspect corresponding indirect or induced job effects).
- **Indirect jobs:** These are jobs connected to the supply and support of the renewable energy industry at a secondary level. They can best be thought of as jobs associated with activities such as the extraction and processing of raw materials (e.g. to produce copper and steel), marketing and selling (including at trade-fairs), administration at ministries, or the work performed by regulatory bodies, consultancy firms and research organisations. While some types of indirect jobs scale roughly in accordance with installed or domestically manufactured capacity (like jobs in material supply), others such as in support organisations have less obvious linkages. Only a small fraction of available studies calculate indirect jobs. Some studies merely note that indirect effects can be expected, whereas others explicitly estimate these effects via a simple multiplier.
- **Induced jobs:** Induced jobs arise from the economic activities of direct and indirect employees, shareholders and governments (e.g. via associated tax revenues). The spending of their earnings can stimulate other industries that themselves are entirely disconnected from renewable energy, but nevertheless have a substantial job creation potential. Induced jobs can be simply conceptualised. Consider the example of a renewable energy industry employee dining out in a restaurant: this leisurely outing contributes to creating demand for staff in the culinary sector. In practice, however, induced jobs are difficult to accurately determine, since tertiary (and quaternary) employment effects from the deployment of renewables are usually hard to isolate. For this reason, and given the paucity of literature in this domain, we do not include induced jobs in the present study.

Studies of employment opportunities have been performed for many different types of renewables, including wind power (on- and off-shore), solar energy (photovoltaics and thermal), biomass-based energy (from various sources of fuel and feedstock) and geothermal power (for multiple geological formations and depths). A series of conventional energy technologies such as nuclear energy, hydropower and natural gas or coal based power generation have also been subjected to job creation assessments. Studies that focus on renewable technology, however, make up the

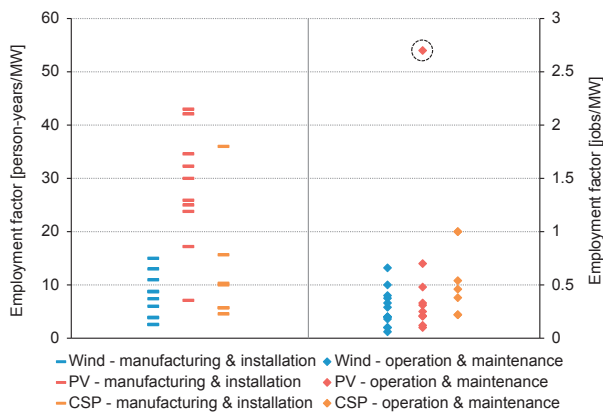


Fig. 1. Comparison of direct employment factors for manufacturing & installation (in person-years/MW, left half) and operation & maintenance (in jobs/MW, right half) for three renewable energy technologies (from Cameron and van der Zwaan (2012)) (One data point, indicated with a circle, is excluded from our analysis.).

majority of the available literature, as only few studies consider fossil-based alternatives. This makes it hard to compare the employment impacts of renewable vis-à-vis conventional energy options, which we therefore do not attempt in this paper.

This study focuses on those renewable technologies that are most relevant for our case study for the Middle East: onshore wind, solar photovoltaics (PV) and concentrated solar power (CSP). Fig. 1 summarises the employment factors related to direct jobs for these three technologies as assembled by Cameron and van der Zwaan (2012), grouped by technology and deployment phase. Employment factors for manufacturing and installation (M&I) are aggregated, since most studies do not distinguish between the two. The same applies for operation and maintenance (O&M). No distinction is made in Fig. 1 between when or where a study was conducted, which methodology was applied or what assumptions were made. These are among the factors at the origin of the wide spread in employment factor values that different studies report. The range of published employment factors for both M&I and O&M stretches roughly over an order of magnitude divergence between minimum and maximum values. We exclude a single data point for the O&M employment factor of PV (indicated with a circle): it is clearly an outlier and we consider it inappropriate for our analysis as it derives from an industry survey conducted in a small unique region of northern Spain (Sastresa et al., 2010). It is possible that an unusually high concentration of companies work on PV O&M centred in this region relative to the actual capacity installed.

Even while the spread in depicted employment factors is large, Fig. 1 unequivocally suggests that the M&I job creation potential of PV technology is typically several times higher than for onshore wind energy, at least when expressed per unit of deployed capacity. Pairs of publications can be found, however, that would contradict this statement. For CSP roughly the same holds as for PV, but the equivalent claim here hinges on one data point of 36 jobs/MW retrieved from a study on South Africa, which makes it less certain. Indeed, leaving out this single number would imply that CSP and wind power have actually very similar M&I employment factors. The median PV employment factor is more than two times the median value for CSP. The fact that M&I employment factors for PV are higher than for CSP may be partly explained, for the installation part of it, by the differing scale at which PV and CSP facilities are typically built. Although CSP facilities can have a more complex set of equipment to install, they are usually large-scale installations, which are relatively efficient in terms of installation labour. For PV, on the other hand, capacity is often distributed in the form of small systems, for instance installed on

rooftops. Such distributed PV is relatively inefficient with regards to labour, since PV systems are often installed by small companies with few employees (DOE, 2011). Differing scales of power plants may also partially clarify the observed differences in manufacturing employment factors between PV and CSP. Fig. 1 suggests that O&M employment requirements for these three technologies are broadly comparable.

3. Case study for the Middle East: methodology

The vast majority of electricity in the Middle East is currently generated from steam based power plants running on oil or natural gas, many of which serve the dual purpose of providing electricity (for notably industry and household consumption) and heat (e.g. for water desalination). The aggregated use of renewables in the Middle East is negligible today, but an increasing number of countries in the region are seriously considering alternatives to the use of domestic reserves of oil and natural gas for power generation, driven both by economic benefits and environmental concerns. For example, over the next two decades the planned capacity for both PV and CSP in Saudi Arabia amounts to approximately 20 GW, Turkey aims at deploying the same level for wind power over this time frame, and most other countries in the region have announced deployment targets for renewable energy of at least 100 MW (REN21, 2012). The International Energy Agency (IEA) foresees 15–25 GW by 2035 in the Middle East for each of the three main renewable energy technologies we consider in this paper: wind, PV and CSP (IEA, 2011).

National and regional scenarios for future energy supply and demand are often developed with, or inspired by, bottom-up integrated assessment models, such as in the ETSAP-TIMES framework. For this study we use the energy system cost minimisation results from the regionally disaggregated global TIAM-ECN model (see e.g. Keppo and van der Zwaan (2012)). We use this model to inspect the energy technology requirements for meeting a stringent global climate policy that achieves a stabilisation of atmospheric greenhouse gas concentrations with a maximum additional radiative forcing of 2.9 W/m^2 . In this climate change control scenario we distinguish between short-term and long-term climate policy. For the near term, until 2020, we assume national measures for countries across the world to reach local targets for GHG emissions reduction, renewable energy deployment and energy efficiency implementation that match the pledges delivered at the UNFCCC conference in Copenhagen in 2009 (and that we extrapolate for the period after 2020). In the absence of Copenhagen pledges for countries in the Middle East, no national climate management measures are implemented until 2020 other than the announced targets for the deployment of renewable energy (that are ambitious in several countries in the region, such as Saudi Arabia, Turkey and the UAE), while after 2020 a GHG intensity reduction rate for the Middle East's overall economy is assumed of 2%/year. For the long run, after 2020, we assume globally coordinated action to mitigate climate change, interpretable as the introduction of a world-wide carbon tax system or certificate market in order to ascertain that by the end of the century, as a result of deep GHG emission cuts, the additional radiative forcing stabilizes at a value of around 2.9 W/m^2 . Reaching this climate forcing target implies an approximately 70% probability that the average global temperature increase on Earth can be limited to 2°C in comparison to the pre-industrial level, which is the formal goal set by the UNFCCC. The Middle East is not only affected by this globally orchestrated climate action plan because of GHG emission reductions it will need to achieve itself—for which it is well equipped, given the resource potential it possesses for renewable energy and the

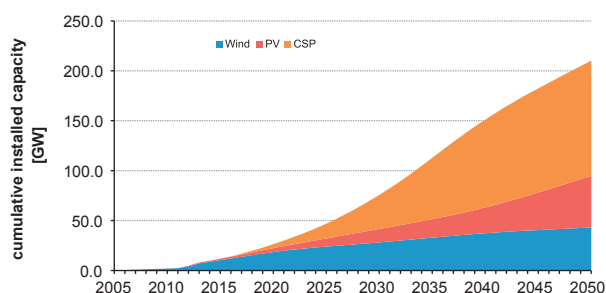


Fig. 2. Cumulative capacity for three renewable energy technologies until 2050 for the Middle East calculated with TIAM-ECN.

capital it has available for clean and innovative technology investments but also through its interrelation with other emission-reducing regions in the world in terms of energy trade and certificate markets.

This climate change control scheme implies a massive deployment of renewable energy in the Middle East, with wind and solar power accounting for approximately 60% of total electricity supply in 2050: according to TIAM-ECN, 900 TWh of an overall level of 1525 TWh could be generated from 210 GW of installed renewable energy capacity by the middle of the century.² This renewable power generation level and associated capacity deployment profile between today and 2050 (see Fig. 2), consistent with actual installation plans in the region, provides the basis for our analysis of the employment effects of renewable energy deployment in the Middle East. We estimate the total work force needed, in terms of required direct jobs, by applying the employment factors from Fig. 1 to this pervasive renewable energy diffusion scenario. We limit our analysis to inspecting the job impacts of the deployment of only three renewable electricity production options—wind, PV and CSP, as these technologies account for the vast majority of renewable electricity generation possibilities in the Middle East. Also, while TIAM-ECN allows for the use of other renewable energy options, such as biomass and geothermal technologies, these do not substantially appear in the optimisation solution space for the Middle East. The drivers for outcomes with TIAM-ECN, that let broadly emerge some renewable energy options while leaving others absent, are primarily assumptions related to costs (and cost evolutions) of energy technologies and the resource base required to operate them. But other factors such as supposed presence of storage facilities (in our case for CSP, but not for wind and PV), assumed technology lifetime (25, 20 and 30 years for wind, PV and CSP, respectively) and presumed production availability (3000, 2800 and 5900 h per year for these three renewables, respectively) also play a determinant role, and help explaining why wind and solar energy become the main renewable power alternatives in our study.

We adopt a simple analytic approach to estimate the job impacts of the renewable energy scenario depicted in Fig. 2. We have chosen for this approach for two main reasons. The first one relates to the transparency of results. A simple analytic approach provides a well-defined link between installed capacity and number of ensuing jobs, which helps clarifying the impacts on employment of our renewable electricity scenario for the Middle East. The alternative approach would be an input–output model, such as used by Hillebrand et al. (2006), Lehr et al. (2008), Tourkoliasa and Mirasgedis (2011), Ciorba et al. (2004), Schwer and Riddel (2004) and Stoddard et al. (2006). For a review of input–output models dedicated to employment

opportunities associated with renewable energy, see Cameron and van der Zwaan (2012). The second reason for using a simple analytic approach for the present study, based on a literature review that comprises many different methodologies rather than picking one single method, is that an input–output model cannot really be used in our case due to a lack of relevant data. No input–output model is available for the Middle East as a single economy, and certainly not one that includes renewables based electricity generation with any level of sufficient detail. Even when a particular country in the region may have an input–output model of its economy, it never includes separate sectors for renewable energy technology manufacturing or installation activities (see, for example, Green (2010)). For only a few individual countries we managed to find input–output tables, but they invariably provided insufficient information, such as in the case of Kuwait, for which the lowest level of dis-aggregation refers simply to “electricity and gas”.

Extending or adapting an existing input–output model to obtain one for the region may in principle be a possibility, but in order to include renewable energy many ad hoc exogenous assumptions are required, since today little renewable energy industry exists in the Middle East on which realistic assumptions regarding domestic inter-sector linkages can be based. The study by Lehr (forthcoming) is unique in the sense that it applies to one particular country, Tunisia, that already has a renewable energy sector, thus enabling both the construction of an input–output model and its use to perform employment studies. Input–output studies of specific countries could probably be used as starting point for creating a model for the region. It cannot *a priori* be assumed, however, that the renewable energy sector in these countries has the same linkages to other sectors in the economy as it would for the Middle East as a whole. Also, market sharing between domestic output and imports are likely to be very different from one country to another, let alone from one country to an entire region, depending on intra-regional trade flows. To make assumptions on input–output linkages based on those from other countries is, arguably, no more precise than adopting the employment factors that have been found for other countries. Our case study thus focuses on calculating direct jobs with a concise analytic method, to which we add a simple calculation for estimating indirect jobs. At first instance we focus primarily on direct jobs, because they can be more reliably attributed to growth in renewable power generation capacity and are more likely located within the region than indirect jobs. Only a couple of studies exist calculating explicitly employment factors for indirect jobs. Our study adopts therefore the approach used by Wei et al. (2010), in which indirect jobs are estimated from direct jobs using a straightforward multiplier.

The direct employment factors listed in Fig. 1 derive from 22 publications that mostly did not provide more specification than for each of the two major phases of renewable energy deployment: manufacturing and installation (M&I) respectively operation and maintenance (O&M). The vast majority of these publications give estimates for both M&I and O&M employment factors, and nearly always do so separately. We present the minimum, median and maximum employment factors for these two phases, and per technology, in Table 1. Most publications aggregate manufacturing and installation related jobs into one single employment factor, and do thus not allow for the individual phases of manufacturing and installation to be examined independently. We nevertheless consider it important to attempt to examine the two phases of manufacturing and installation separately, as installation jobs are more likely to be domestic than manufacturing jobs in many countries, and probably for the Middle East as a region, given that it does not yet have an established renewable energy technology manufacturing industry. In Cameron and van der Zwaan (2012) we report 10 publications that provide employment factors for the

² The high average overall capacity factor implied by these figures, of approximately 49%, is explained by the large contribution to renewable power production from CSP with associated heat storage (see Fig. 2).

individual phases of manufacturing and installation (7 for onshore wind, 8 for PV and 2 for CSP). From this subset of 10 data sources we determine the average ratios between the employment factors for each technology for manufacturing and installation activities, respectively, and apply these ratios to the aggregated M&I numbers. This allows us to also report individual figures for M and I in Table 1. Note the different units used for M and I (and M&I) on the one hand, and O&M on the other hand, given the different nature of these technology phases: because of the transient nature of jobs associated with the construction of power production capacity, M&I activity is expressed in person-years/MW, whereas jobs related to O&M are best reported in terms of jobs per MW, as they usually last during the entire lifetime of the plant and so, in some sense, constitute permanent positions (see Cameron and van der Zwaan (2012), for further reflections on this matter).

Table 1

Minimum, median and maximum direct employment factors for the main phases of deployment for wind, PV and CSP.

Option	M&I (person-years/MW)	M (person-years/MW)	I (person-years/MW)	O&M (jobs/MW)
Wind				
Minimum	2.6	2.1	0.5	0.1
Median	8.1	6.6	1.5	0.2
Maximum	15	12.2	2.8	0.6
PV				
Minimum	7.1	3.2	3.9	0.1
Median	28	12.6	15.4	0.3
Maximum	43	19.4	23.6	0.7
CSP				
Minimum	4.6	2.3	2.3	0.2
Median	10.2	5.1	5.1	0.5
Maximum	36	18.0	18.0	1.0

The range of direct employment factors listed in Fig. 1 and Table 1 results from a large number of factors, including: (i) differences in methodology used for calculating employment impacts, (ii) varying coverage of what types of labour are accounted for under the notion of direct job, (iii) variable country context in terms of the degree of local job content, (iv) diverging country context in terms of average overall employment intensity, (v) different assumptions with regards to the types of technology deployed, and (vi) especially for those studies in which no methodological description is provided—differences regarding representing renewables favourably or unfavourably in terms of job creation potential given possible vested commercial or ideological interests of the institutions behind the publications.

The different nature of employment in M&I versus O&M can be most accurately represented by using separate units. Such a justified bifurcation yields a disadvantage, however, in terms of ease of interpretation of job figures across different phases of energy technology deployment and use. In order to compare total average job impacts between diverse technologies it can be necessary to aggregate employment factors over different phases of deployment and use, for which they need to be normalised to a common unit of measurement. We thus transform M&I jobs expressed in person-years/MW and O&M jobs expressed in jobs/MW to absolute overall job numbers at any given point in time for the results described in the next section. We therefore explicitly do not adopt the approach of Kammen et al. (2004) and Wei et al. (2010), who present an expression for average full-time permanent jobs across all technology phases by converting M&I jobs (in person-years/MW) into O&M units (jobs/MW) by averaging M&I employment over the life of the facility: in our study we do not average out M&I employment over the life of the plant. Yet our approach allows transient jobs in M&I, concentrated at the beginning of a plant's life, to be compared to long-term jobs in O&M, by using the same unit.

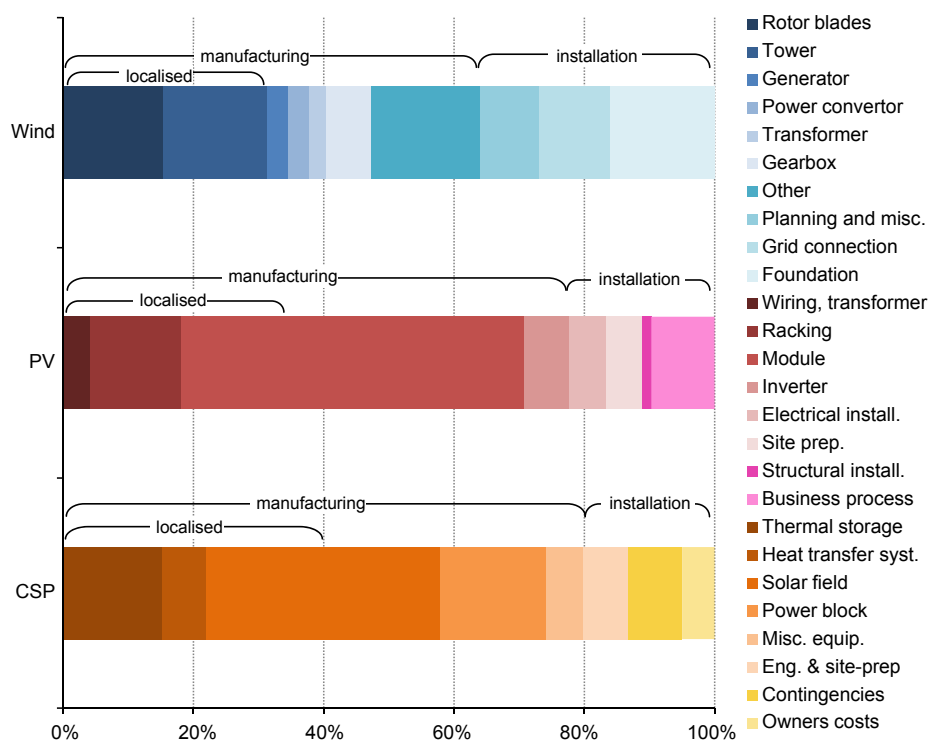


Fig. 3. Capital cost breakdown for wind, PV and CSP manufacturing and installation activities, with an indication of which manufacturing components can be domestically produced in the Middle East (adapted from Blanco (2009), Bony et al. (2010), Fichtner (2010), IRENA, 2012b).

The literature behind the employment factor estimates reported above rarely makes a clear distinction with regards to where specific manufacturing activities take place. Whether or not a technology is manufactured domestically, and whether certain components or entire systems are imported from other regions but assembled locally, matters substantially for a regional employment study like ours. Naturally, assumptions on how much of the manufacturing process takes place abroad impacts the job creation potential that can be expected locally. In the absence of explicit assumptions on the extent of local content for many of the reviewed studies, and given that the majority of studies are for OECD countries that have established domestic renewable energy technology manufacturing sectors, it is assumed that the employment factors in Table 1 account for nearly all labour related to manufacturing. The renewable energy technology manufacturing situation in the Middle East is quite different though, since almost an entire renewable energy industry still needs to be developed. It is unrealistic to assume that all of the necessary components for wind, PV and CSP technologies can be produced in the Middle East itself in the short to medium term. Hence we have attempted to estimate a realistic level of local manufacturing in the Middle East, based on those components that we considered could be readily produced domestically. Of course, this level could change in the long term, but for now we take a relatively conservative position in this regard.

Fig. 3 shows the cost shares of all main components of wind, PV and CSP technology, and indicates how these can be grouped into two main classes of manufacturing and installation costs, respectively. Whereas we can reliably assume that all installation activities are domestic, for manufacturing in the Middle East a fair share is likely to take place abroad. We indicate in Fig. 3 the cost contribution of those combined manufacturing components that we suppose can be produced domestically. While only a rough approximation, we assume that the cost share of locally produced components in the overall manufacturing process is a reasonable proxy for the local labour percentage for each technology with respect to the total manufacturing job requirements (that include local plus foreign employment content). This yields a local manufacturing content of 49% for wind, 46% for PV and 50% for CSP technology. In particular, for wind power we assume that the manufacturing of rotor blades and turbine tower takes place domestically. For PV, we suppose that wiring and racking are local activities, while one third of all modules are fabricated within the region. For CSP we stipulate that the thermal storage and heat transfer parts of the total system, as well as half of the solar fields themselves, are produced in the Middle East. The above overall percentages are used to interpret the manufacturing employment factors in Table 1, that is, to revise them downwards in order to reflect more realistically regional employment opportunities in our renewable power production scenario for the Middle East. Exports of manufactured technology from countries in the Middle East are not considered: while they are not realistic at present, they may of course materialise as their renewable energy activities expand. To obtain Fig. 3, we have adopted cost breakdown data from the literature (Blanco, 2009; Bony et al., 2010; Fichtner, 2010; IRENA, 2012b), and have ourselves classified the reported cost components under the categories of ‘manufacturing’ and ‘installation’, respectively, and estimated which parts of the former are likely to take place locally (and hence which ones are not, for the foreseeable future at least).

4. Case study for the Middle East: results

We apply the employment factors given in Table 1 to the renewable electricity scenario developed for the Middle East with

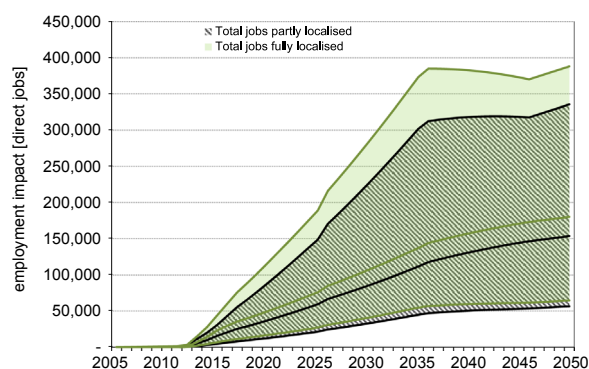


Fig. 4. Direct employment until 2050 for our Middle East renewable electricity scenario, with uncertainty ranges, in two cases: (1) all manufacturing is produced locally (green) and (2) the local content is 49% for wind, 46% for PV and 50% for CSP (hatched grey). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

TIAM-ECN. The result is depicted in Fig. 4 in terms of the evolution of the total number of direct jobs aggregated over all three technologies and all phases of their deployment. Two different ranges are shown, depending on the extent to which manufacturing occurs in the Middle East or abroad. In the upper case (in green) all manufacturing is assumed to be localised, while in the lower case (hatched in grey) only the components shown in Fig. 3 are assumed to be manufactured domestically. In each of these two cases, minimum, median and maximum graphs are plotted, based on our earlier findings. The simulated overall employment patterns account for the transient nature of manufacturing and installation activities, in the sense that jobs are calculated from the corresponding incremental capacity produced every year. Unlike in a previous version of our work, manufacturing and installation jobs are thus not averaged out over the lifetime of renewable energy capacity, but are accounted for when they are exercised. As for O&M activities, jobs in any given year are calculated based on the cumulative installed capacity. Given their nature, O&M activities are ‘automatically’ spread over the lifetime of installed capacity (and are applied under the assumption that also within a single year they are spread uniformly).

Fig. 4 demonstrates that our two diverging assumptions with regards to the local content of manufacturing result in a wedge of as high as 50,000 direct jobs in 2050, if one considers the maximum estimated employment pathways. By comparing the maximum and minimum pathways depicted in Fig. 4, we see that the most optimistic values for the employment factors result in about six times more jobs at any given point in time than the most conservative ones found in the literature. Hence uncertainty in this domain matters a lot. Real employment figures are likely to lie somewhere in between these two extremities, so henceforth we adopt median employment factor values for further comparison. These imply approximately 155,000 direct jobs in the Middle East in 2050 if we assume that the local manufacturing content amounts to 49% for wind energy, 46% for PV and 50% for CSP.

Examining these 155,000 direct jobs by phase of deployment and technology, as we do in Fig. 5, we see that by the middle of the century the largest share of total employment derives from O&M activities, mostly because by 2050 CSP is broadly deployed and thus requires lots of O&M. O&M activities in the Middle East in 2050 amount to about 75,000 of the total level of necessary direct jobs. The next largest contributor is installation activity, with approximately 55,000 direct jobs in 2050, followed by local manufacturing with approximately 25,000 jobs. Even while wind power produces a comparable amount of electricity as PV in 2050, it accounts for only about 15% of the jobs associated with PV,

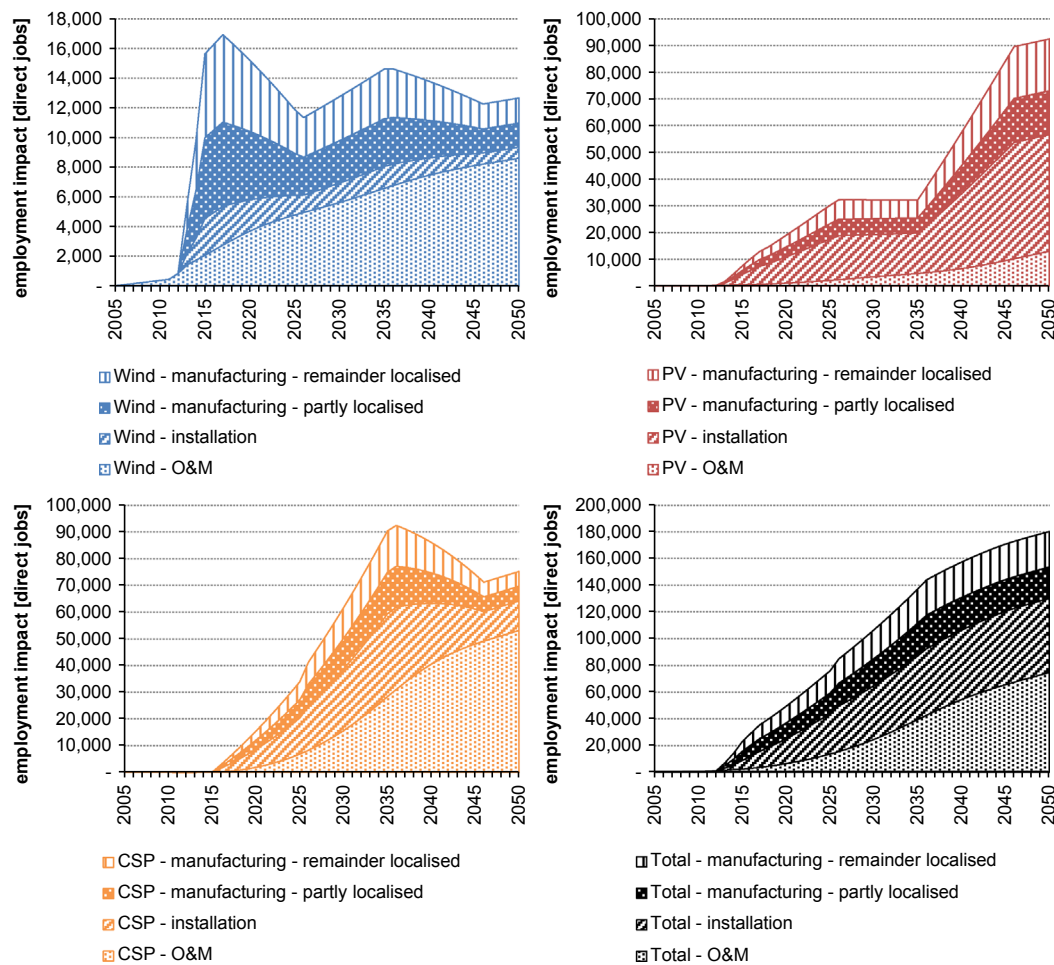


Fig. 5. Direct employment until 2050 for our Middle East renewable power scenario split by project phase and technology. Median employment factors are assumed and partly localised manufacturing of 49% for wind, 46% for PV and 50% for CSP.

partly as new year-on-year capacity installations have slowed for wind power by 2050, and largely because of the lower M&I employment factors for wind energy—which is another way of saying that the relative maturity of wind power has rendered it a less labour-intensive electricity generation option than the solar technologies considered here.

We estimate indirect employment impacts by using a simple multiplier of 0.75 applied to the level of direct jobs. Even while the current literature suggests using a more sophisticated method of estimating indirect job effects, such as through an input–output model, the case of the Middle East does not allow a more refined approach, as explained above. Although the use of a multiplier is admittedly a somewhat simplistic way of calculating indirect jobs, it serves fairly well our purpose of providing a rough conservative estimate for the sum of direct and indirect employment impacts for our Middle East renewable electricity scenario. While the application of different multipliers for distinct technologies and deployment phases may well be justifiable on several grounds, there is at present little information on a more refined specification of multipliers (or, for that matter, of direct versus indirect employment factors) available in the literature³ (see [Cameron and van der Zwaan \(2012\)](#), for both a sensitivity analysis with regards to the value of this multiplier and more description on the availability of distinct multipliers and/or indirect employment

factors across technologies and deployment phases). We therefore abstain from further specification in this respect in the present paper, also in view of the large uncertainties we observe for the values of direct employment factors (that suggest even larger ones for those of indirect employment factors). Our findings are shown in [Fig. 6](#), which indicates that indirect employment adds another 115,000 jobs to the primary level of 155,000 direct jobs. In particular, an additional 17,500 jobs in (local) manufacturing, 41,500 in installation and 56,000 in O&M are created in indirect employment in 2050. Total direct plus indirect employment creation in 2050 is thus estimated at approximately 42,500 (local) manufacturing jobs, 96,500 installation jobs and 130,500 O&M jobs, totalling almost 270,000 positions across all technologies and phases of their deployment. [Fig. 6](#) also indicates what possible overall employment scenarios could be if improvements are assumed in the job intensities of the three renewable energy technologies. The red dashed line shows the impact of employment factors reducing over time based on an annual rate of 0.75%/year. The green dotted line depicts a learning curve approach towards employment factor reductions: we assume that with every doubling of installed capacity the job intensity reduces with 10% (that is, we suppose a learning rate of 10%).

The results reported in this article are *gross* employment effects associated with growth scenarios for wind, PV and CSP technologies. We did not calculate whether there are *net* employment effects resulting from our renewable electricity scenario, with respect to a reference case with no or less renewable energy capacity but with more conventional fossil fuel based power

³ [Tourkolias and Mirasgedis \(2011\)](#) is among the few exceptions, but their study applies to a very unique case.

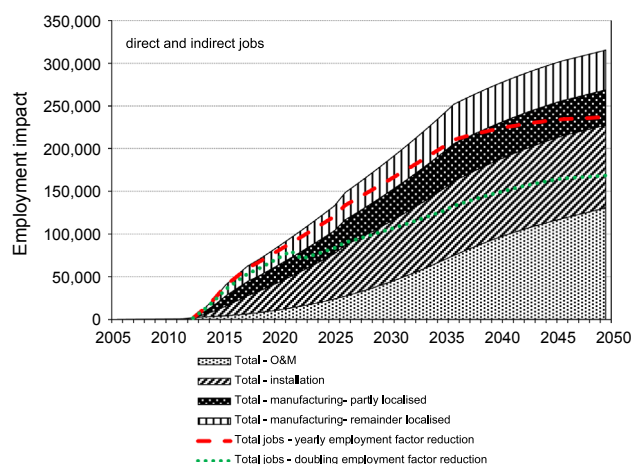


Fig. 6. Total direct and indirect employment until 2050 in our Middle East renewable power scenario split by project phase. Median employment factors are assumed and partly localised manufacturing of 49% for wind, 46% for PV and 50% for CSP. The red dashed line shows the impact of employment factors reducing over time based on a rate of 0.75%/year. The green dotted line depicts a learning curve approach towards employment factor reductions with a 10% learning rate. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

production. We think that until it has been soundly proven that such a net employment effect exists, one cannot be sure that the replacement of fossil fuels by renewables actually generates jobs. Still, it is quite likely that such a net impact exists, for at least two reasons. First, the available studies we consulted are in broad agreement that renewable technologies are today probably stimulating more jobs expressed per MW than conventional power generation, even when one bears in mind the limitations of most of these studies, both in terms of their total number and the robustness of their findings. See, for example, the study by IRENA (2011), in which one can read that “net effects are generally ... shown to be positive”. Second, the reference case (without climate policy) developed with TIAM-ECN suggests that in the Middle East 80 GW less overall power production capacity is installed in a non-renewable scenario by 2050. The lower capacity factor or intermittency of renewables probably works in their favour when job impacts are concerned, since a much larger installed capacity is required to generate the same amount of electricity. The much larger total capacity in the renewable energy scenario in comparison to the reference case may mean that net employment effects are indeed positive, although for the definite answer to this question more research will need to be undertaken.

Other than the two job intensity improvement lines depicted in Fig. 6, we do not further elaborate on employment factor reductions following e.g. efficiency improvements, economies-of-scale and learning effects in this case study for three main reasons, even while Cameron and van der Zwaan (2012) point out that there may be significant reductions in employment factors as the deployment of renewables expands over time. First, the employment factors listed in Table 1 are largely drawn from studies focusing on OECD countries with established renewable energy markets. These employment factors are therefore, arguably, already on the low side for a region like the Middle East that would largely be developing a new industry. Second, the Middle East has a higher average overall employment intensity than most OECD countries (ILO, 2005, 2011), so that more jobs are typically needed across sectors for the same unit of economic output.⁴ This higher

employment intensity similarly implies that employment factors drawn from OECD country studies are likely to be rather optimistic. Third, the range of quoted employment factors in Table 1 that we use for our sensitivity analysis is rather large, in comparison to which relatively small potential reductions as a result of efficiency improvements, economies-of-scale and learning effects are probably out-shadowed. We thus think it is appropriate to adopt the range of employment factors summarised in Table 1 until 2050 for our Middle East case study.

5. Discussion and conclusions

Our case study for a renewable electricity expansion scenario for the Middle East shows that when median employment factors from the available literature are adopted, renewable sources of power generation could account for about 180,000 direct jobs in the Middle East in 2050 if all manufacturing activities were domestically located. If more conservative assumptions on local content are used, this figure would drop to approximately 155,000 direct jobs. Approximately 36% of these 155,000 jobs are related to installation, 15% to (local) manufacturing and 49% to O&M activities in 2050. Indirect jobs are estimated to provide roughly 115,000 additional jobs when determined using a simple multiplier of 0.75 with respect to the figure of direct jobs.

In addition to a lack of information on specific renewable energy careers, there is little data available on the number of people directly or indirectly employed in the renewable energy sector working in ‘standard’ professions such as accountants, computer analysts, secretaries, factory workers and truck drivers. A study by the American Solar Energy Society (ASES) found that the majority of jobs created by the renewable energy sector are ‘standard’ jobs as opposed to specialised ones (ASES, 2009). The same study proposes that most employees in renewable energy related firms perform the same types of activities as employees in firms that have little or nothing to do with renewable energy. The authors give the example that the occupational distribution of a typical wind turbine manufacturing company differs relatively little from that of a company that manufactures other products. If one assumes this to be true, the ASES study suggests that many non-renewable energy industries can provide a starting point for estimating the split of different types of professions likely to be required for the deployment of renewable energy. At this stage, what can be said, is that with a negligible renewable energy industry in the Middle East today, a shift to renewable energy sources will require a number of relatively new professions that are specific to renewable energy technologies (IRENA, 2011). A better understanding of what types of jobs must be created may help designing necessary educational and academic programmes as well as public policies to meet these needs (Kammen et al., 2004).

Even though increasing private sector employment is likely to be an important priority for the Middle East in the future, to which a gradual transition from state-run oil companies to a renewable energy industry orchestrated by independent power producers could contribute, job benefits should not be considered as the primary reason to deploy renewables (IRENA, 2011). The probable beneficial employment impacts as quantified in this case study must be considered alongside essential features of renewables in terms of them possessing the ability to contribute to mitigating

(footnote continued)

figures for 1999–2003, which show a high employment factor in comparison to OECD countries (ILO, 2005). Recent regional studies similarly conclude that employment factors are relatively high in the Middle East and North Africa, i.e. labour productivity is relatively low (ILO, 2011).

⁴ Reliable data on the relative employment intensity of many of the national industrial sectors in the Middle East are hard to find. We only found economy-wide

climate change, reducing air pollution and enhancing energy security. In particular for the Middle East, the economic gains obtainable from reducing the consumption of domestic fossil fuel reserves may be substantial. We hope though that the present analysis can contribute to designing optimal strategies and taking balanced decisions with regards to the role that renewables could play in the Middle East's future electricity system.

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