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Discussion Paper

Measuring Green Jobs in Saudi Arabia
Saudis in Green Occupations

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Abstract

This paper offers the first estimate of employment in Saudi Arabia that can be linked to the energy transition. Using a task-based taxonomy devised by the United States Bureau of Labor Statistics applied to detailed administrative data on Saudi workers, it is estimated that in 2022 almost 30% of all Saudi workers in the private sector were employed in “green” occupations. Tracking job growth from 2018-2022, these occupations are growing at a faster rate than total employment, indicating that they are a major source of employment growth in the country. Possible policy applications are given for the results, such as the comparatively low uptake in green employment by Saudi females, and monitoring the level of green employment is recommended to aid both labor and education policy development. Overall, monitoring and publicizing the level of green jobs can show the public that the socioeconomic benefits of the energy transition are more than just a vague promise of possible jobs in the future, but something that is already here and that many are benefitting from.

1. Introduction

Saudi Arabia has ambitious plans in the coming years in its bid to both aid in climate mitigation and benefit economically from the energy transition. In 2021, the Saudi Minister for Energy announced a 50% renewables target for domestic electricity production by 2030, and this was shortly followed by a pledge to reach net-zero emissions by 2060 (Saudi Ministry of Energy 2021). Also in 2021, the country launched the Saudi Green Initiative and the broader regional Middle East Green Initiative that aim to unite all sustainability efforts in the country and region, respectively (Saudi Vision 2030 2021). Further, Saudi Arabia is expected to be a global leader in the commercial production and export of clean hydrogen (Hasan and Shabaneh 2022).

Much attention is given to the employment benefits of the energy transition, with potential employment from each investment regularly detailed in the press releases of new initiatives.[1] Renewable energy production, as the most tangible output of the energy transition, is often the focus of this attention. This focus does make sense for Saudi Arabia, as the country's climate enables the potential for a lucrative new solar photovoltaic (PV) industry, as well as viable onshore wind production along the Red Sea coast and in the mountainous north. Jobs will be created as a result of renewable energy production. However, only emphasizing this part of the employment potential of the energy transition would hide a lot of its true benefits.

Employment resulting from the energy transition – green jobs – goes far beyond the production of renewable energy, and reflects the economic transformation that will take place in the coming decades as countries realize their climate goals and materialize these commitments. Quantifying this employment can be a complex task, as many green jobs are not solely focused on the energy transition. Some, for example, may only have a few skills, tasks or responsibilities that contribute to sustainability or increased energy efficiency. Capturing this employment is fundamental in monitoring the socioeconomic benefits of the energy transition and contributing toward the Paris Agreement's goal of a just and equitable transition (UNFCCC 2015).

This paper offers a first attempt at quantifying green employment in Saudi Arabia. Applying a method of isolating green occupations using standardized occupational classifications developed by the United States (U.S.) occupational database O*NET, adapted for other countries by Sofroniou and Anderson (2021), and utilizing detailed Saudi employment data, a baseline is established to measure green job growth between 2018-2022. It is found that, in this period, the number of Saudis in green jobs grew from 511,000 to 767,000, representing an increase of over 50%. This growth rate outpaced growth in all other occupations, indicating not only that there are green jobs in Saudi Arabia, but that their growth is contributing to the country's employment goals.

[1] *See, for example, Neirim and Cunningham (2018) and Mai (2023).*

2. Green Jobs

The employment possibilities of the energy transition have been a popular topic in both national and supra-national spheres for almost two decades. The International Labour Organization (ILO) and Organization for Economic Cooperation and Development (OECD) have produced research streams on the topic of "green" jobs in this period (ILO 2012; OECD 2023), with the ILO in particular seeing green jobs as an opportunity to transform the world of work (ILO 2018). The International Renewable Energy Association (IRENA) has been publishing its annual report on jobs in renewable energy, seeing consistent growth year-on-year, even during the COVID-19 pandemic, when millions of jobs were expected to be lost (IRENA 2023). At the national level, job estimates are a common selling point of public investment in renewable energy projects (Sofroniou and Anderson 2021).

In Saudi Arabia, for example, initial reports claimed hundreds of thousands of jobs would be created by 2030 through the production of renewable energy (Shalhoub 2017). Market studies indicate that, generally, more jobs are created per gigawatt of renewable energy generated (Consoli et al. 2016) and per million dollars invested than in traditional energy (Pollack 2012). There is conflicting evidence about whether these green jobs offer higher wages (Bluedorn et al 2022). Yet there is enough data to suggest renewable energy is a powerful tool of public policy through its twin benefits of creating employment and contributing to climate goals.

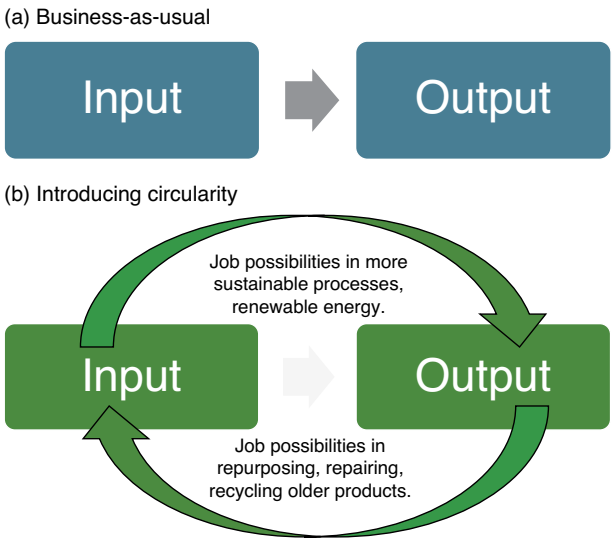
While jobs in renewable energy are the simplest way to conceive of the employment benefits of the energy transition, this focus can mask the level of green jobs in the economy. Public interest in the future of work typically concentrates on artificial intelligence and robotics (Saurabh et al 2023). Yet the argument can be made that the key skills required for employment in the coming decades will be to aid economies increase their sustainability and adapt to climate commitments. Implementing the Paris Agreement at the 21st Conference of the Parties (COP21) and associated climate pledges, such as net-zero targets, indicate that the global economy is set to undergo a major economic restructuring affecting every sector and industry. The United Nations Framework Convention on Climate Change (UNFCCC) recognized this and included a commitment to monitoring employment creation and destruction as a part of the "just transition" aspect of the Paris Agreement (UNFCCC 2020).

As with any economic restructuring, adapting to and mitigating climate change will bring winners and losers, with some sectors (such as renewable energy) incentivized and promoted, and others (such as fossil fuel production) potentially phased down. The ILO's flagship study on green jobs estimates that the Paris framework will produce a global net gain of 18 million jobs by 2030 compared to business-as-usual (ILO 2018). This net gain also includes millions of job losses, particularly in the developing world and resource-rich countries in the Middle East (ILO 2018). Identifying the winners and losers of climate policies is therefore important for policymakers in order to plan for and react to the effects of these policies. Tracking and monitoring the areas of green job growth can help policymakers adapt and react to the possible adverse effects of climate commitments, informing active labor market interventions, such as reskilling or upskilling those affected. It is thus important to gain an idea of how many and what kinds of green jobs are already present in a country.

2.1 Where are the Green Jobs?

To get an idea of the exact nature of the green jobs that will result from climate adaptation and mitigation, we can conceive of a simple model of how economies will change in the coming decades. Illustrated in Figure 1(a), the standard model involves a linear process where inputs are used to produce outputs. The idea of circularity is introduced in Figure 1(b), with forward and backward linkages between inputs and outputs, which is important for an economy geared toward sustainability. It is in this circularity where we will see employment growth as the economy adapts to a new method of production. For example, in the backward linkage going from output back to input, we will see how used products can be altered to be reused as inputs. This will impact occupations involved in repairing items or in the sorting of recycling. Additionally, in the forward circularity from inputs to outputs, new jobs will be created as new methods of sustainable production must be found (and will not necessarily be as efficient as the business-as-usual case). We will see employment creation in renewable energy production as well as sustainable construction and the emerging field of green finance.

Figure 1.



Source: Author's illustration.

2.2 Quantifying Green Jobs

While it is useful to illustrate the nature of green jobs, precise measurement can be complex. The measurement of green jobs has primarily been conducted by international organizations, such as the ILO, through the use of input-output tables (IOT) (GAIN 2017). IOT analysis offers a lot of potential and gives policymakers a simple way of understanding how different sectors of the economy could respond to different policies, including employment estimators. The true value of IOT analysis is its potential to offer projections, possibly all the way to the middle of the twenty-first century, when many national net-zero commitments will be nearing completion. While IOT analysis is a powerful tool for projecting the value of the green economy, much work is needed upfront to gauge an accurate picture of the current state of "greenness" in each sector to provide a baseline for IOT projections. This work includes qualitative surveys of stakeholders from each sector that aid in separating the inputs and outputs of each sector into binary values of "green" and "brown" (GAIN 2017). The green share is used to feed into other sectors, and multiplier values emerge from the model that can inform policy. A drawback of the IOT methodology is that it focuses on sectoral outputs and value added and does not consider job quality or the skills needed for these projected green jobs.[2] An IOT multiplier can show which economic sectors will benefit from green jobs, but it cannot inform policymakers about the skills needed for these jobs and thus cannot prepare workforces for the coming changes.

2.3 Green Occupations

An alternative and possibly complementary approach to the IOT method is the measurement of green jobs using occupational standards, developed by Dierdorff et al. (2009) for the U.S. Bureau of Labor Statistics (BLS). Using a database from the BLS network of occupational skills (O*NET), the authors devised a taxonomy of green occupations that could be segregated from the U.S. Standard of Occupations (SOC), thus providing a measure of the types of jobs that could result from the energy

[2] *See Appendix 1 for definitions and examples of jobs, occupations, tasks and skills.*

transition. The authors sought to isolate occupations affected by the green economy, which was defined as economic activity related to:

> i) reducing the use of fossil fuels, ii) decreasing pollution and greenhouse gas emissions, iii) increasing the efficiency of energy usage, iv) recycling materials, and v) developing and adopting renewable sources of energy. (Dierdorff et al. 2009)

The authors then defined the greening of occupations as:

> the extent to which green economy activities and technologies i) increase the demand for existing occupations, ii) shape the work and worker requirements needed for occupational performance, or iii) generate unique work and worker requirements. (Dierdorff et al. 2009)

A taxonomy was formulated based on a designation of specific tasks within standardized occupations as green tasks, and occupations that contained one or more of these were classified as green occupations and could therefore be counted as green jobs. By focusing on tasks within occupations, the analysis recognized that the level of "greenness" within occupations varies greatly. The authors went beyond the usual focus on renewable energy, also taking into account how the energy transition affects the nature of work in different occupations and changes worker requirements in some existing occupations. As a result, occupations in industries we would not associate with the energy transition can include green tasks and can therefore be counted toward the total.

Three categories of green occupations were defined by O*NET, based on the definition of "greening" occupations, above. The first category, "New and Emerging Occupations" (NEOs), are the jobs that we traditionally view as related to the energy transition. These are occupations that simply would not exist without a pivot to a greener economy, such as solar PV engineers or corporate sustainability officers. The second category, "Enhanced Skills Occupations" (ESOs), are existing occupations that are required to take on extra skills to perform their tasks in a green transition. For example, architects and some engineers are required to have sustainability considerations, which would not be required in a business-as-usual situation. Similarly, corporate leaders are required to lead their organizations through the transition due to increased regulation or ESG requirements. Many NEOs emerge when the work of an ESO becomes focused on the energy transition, such as a green finance expert, for example. Finally, the last category is "Increased Demand Occupations" (IDOs). These are existing occupations that do not require extra skills but see increased demand for their services due to green economy concerns. An example of IDOs are passenger train drivers, whose job function remains unchanged, yet could see increased job growth due to policies that incentivize public transport over private vehicles and short-distance air travel.

The designation of green occupations is useful as it takes into account not just the new jobs directly created from the technology inherent to the energy transition but also the effect on current jobs and subsequent indirect and induced employment. While the O*NET methodology was originally created for the U.S. SOC, the work of Cambridge

Table 1. Categories of green occupations.

Green occupation category	Definition	Example
New and Emerging Occupations (NEO)	Completely new occupations that arise due to the energy transition.	Corporate sustainability officer; solar PV installer (some still to be created).
Enhance Skills Occupations (ESO)	Existing occupations that require a skills upgrade.	Legal professionals working on environmental legislation; architects and engineers with sustainability commitments.
Increased Demand Occupations (IDO)	Existing occupations that remain fundamentally unchanged, yet are more in demand due to the energy transition.	Repairpersons; train drivers.

Source: Dierdorff et al. (2009).

Econometrics (2011) and Sofroniou and Anderson (2021) allows us to apply the taxonomy to the International Standardized Classification of Occupations (ISCO-08). This means that, with access to data from any statistical agency that adopts an ISCO-08 framework in their data collection, we can apply the green occupations taxonomy and quantify the level – and quality – of green jobs in that country.

2.4 Saudi Standard Classification of Occupations

In 2019, the Shura Council of Saudi Arabia approved the adoption of the Saudi Standard Classification of Occupations (SSCO), a variant of the ISCO-08 framework that allows for the classification of certain occupations unique to the country or not included in the original list. The SSCO was proposed by the Saudi General Authority for Statistics (GaStat) to bring labor statistics in the country more in line with international standards (GaStat 2019). The SSCO lists 2015 unique occupations (six-digit level), and these are divided into units (four-digit level), minor groups (three-digit level), sub-major groups (two-digit level), and finally major groups (single-digit level). Table 2 outlines an example of how the specific occupations relate to the major groups, showing how the occupation becomes more specific as we move from the single-digit major group to the six-digit specific occupation. There are 10 major occupation groups and, with the exception of the armed forces group, these are hierarchically organized from 1-9 by skill level and education. For example, Groups 1 (managers) and 2 (professionals) both require at least one university degree and the highest skill level, whereas as Group 9 has the most modest requirements (elementary occupations). This hierarchy also largely correlates with wage levels. Table 3 gives an overview of the major groups and some example occupations.

Green occupations are classified at the minor group (three-digit) subdivision, meaning that we have some level of granularity within each major group about where green occupations might be located. The minor group level is not perfect for analysis, however, as there is some level of generality within these groups, and there is a high chance of including employment that does not necessarily correspond to that intended for inclusion by the original skills analysis. Analysis at the four- or six-digit level would be ideal, and research is ongoing to match the original SOC occupations to the six-digit ISCO-08 codes.[3] In the meantime, analysis at the minor group level allows for a window into the skill requirements and subject areas for green jobs. Appendix 2 reports all three-digit codes and occupations, and Table 4 offers an overview of how each major group fares in relation to the three types of green occupations.

Overall, 34% of all SSCO occupations can be classified as green under the Dierdorff et al. (2009) classification, with broadly similar shares for ESOs, IDOs, and NEOs. As for group shares, 55% of all green occupations are contained in major Groups 2 (professional) and 3 (technicians). However, it must be clarified that these

Table 2. Hierarchy of SSCO classification codes from specific occupation to major group.

Group	SSCO code	Example	# of occupations
Major	2	Professionals	628
Sub-major	26	Legal, social, and cultural professionals	118
Minor	263	Social and religious professionals	38
Unit	2,631	Economists	2
Occupation	263,101	Economics specialist	1

Source: GaStat (2023).

Table 3. Overview of the Saudi Standard Classification of Occupations (SSCO).

Group #	Occupation group	Minimum education level	Examples
0	Armed forces	Variable	Soldier, royal guard
1	Managers	Bachelor's degree	CEO, government minister, village chief, research manager
2	Professionals	Bachelor's degree	Scientist, engineer, designer, teacher
3	Technicians and associate professionals	Post-secondary diploma	Plant supervisor, artists, prayer caller, professional athletes
4	Clerical support	Secondary	Customer service worker, data entry, bank teller
5	Service and sales	Secondary	Driving instructor, shop salesperson
6	Skilled agricultural, forestry, and fishing	Secondary	Farmer, coastal fisher
7	Craft and related trades	Secondary	Carpenter, stone mason, house painter
8	Plant and machine operators	Secondary	Offshore drilling rig operator, textile machine operator, train driver
9	Elementary occupations	Primary	Cleaner, construction worker, refuse worker

Source: GaStat (2023).

groups contain 49% of all occupations, indicating that their share of green occupations is possibly a result of much specification within these major groups. Regarding the share of green occupations within each group, 61% of all plant and machine operator jobs can be classified as green, while technician and craft and trade both report green shares approaching 50%. Finally, focusing on the different types of green occupations, it is noteworthy that all the NEOs are contained in the professionals and technicians groups.

This analysis gives a broad view of the types of occupations that will be generated by the energy transition, indicating opportunities at all skill levels and levels of educational attainment. With this, we can now apply the taxonomy to the available labor force data and quantify the level of green employment in Saudi Arabia.

[3] *While it could be feasible for IDOs and ESOs to be reported at the four- or six-digit level, the nature of NEOs necessitates a more scattershot approach, and thus this group would remain at the three-digit level.*

Table 4. Overview of Green Occupations within SSCO.

SSCO major group	ESO	IDO	NEO	Total green occupations	Total occupations in group	% of green occupations within group	Group share of all green	Group share of all
Managers	32	0	0	**32**	311	10%	5%	15%
Professionals	90	0	115	**205**	628	33%	30%	31%
Technicians	20	54	95	**169**	370	46%	25%	18%
Clerical Support	0	23	0	**23**	52	44%	3%	3%
Services and sales	0	12	0	**12**	109	11%	2%	5%
Skilled agriculture	14	4	0	**18**	53	34%	3%	3%
Crafts and trades	48	40	0	**88**	179	49%	13%	9%
Plant and machine operators	54	79	0	**133**	218	61%	19%	11%
Elementary	4	0	0	**4**	77	5%	1%	4%
Total	**262**	**212**	**210**	**684**	**2015**	**34%**		

Source: Author's calculations based on GaStat (2023), Dierdoff et al. (2009), and Sofroniou and Anderson (2021).

3. Data

Administrative data detailing anonymized individual subscribers to the country's General Organization for Social Insurance (GOSI) was obtained from Saudi Arabia's National Labor Observatory (NLO).[4] GOSI is a governmental organization that provides social protection and insurance coverage to private sector workers and an increasing number of public sector employees.[5] However, most of public sector workers are covered by civil insurance and are thus excluded from the sample. At the end of 2023, around 90% of registered workers in Saudi Arabia (Saudis and non-Saudis) were covered by social insurance rather than civil insurance (GaStat 2023). This falls to 69% for Saudi workers due to a long-standing preference among this group for public sector employment. The data also excludes military workers and police officers, those employed on electronic delivery applications, and individuals not registered for social insurance benefits.

A drawback of the NLO data is that it only details Saudi workers. While such a limitation would be notable in an analysis of any labor market, in Saudi Arabia it poses a major problem due to the large number of foreign workers in the private sector. Using the aggregated publicly available GOSI quarterly data, Figure 2 illustrates the nationality split, showing that 75% of those covered by social insurance in Q4 2022 were non-Saudis. This labor market scenario is also present in neighboring countries, such as the United Arab Emirates, Qatar, Kuwait, and Bahrain, which all pursue policies to increase employment in the private sector for their own citizens. Labor market nationalization policies (given domestic titles such as Emiratization, Qatarization, and, in this case, Saudization) are so ingrained in Gulf Cooperation Council employment policy that it is normal to analyze the employment of nationals and expatriates separately. For example, the main employment indicator in Saudi Arabia is the *Saudi* unemployment rate. It is therefore possible to use the available administrative data for Saudi GOSI subscribers and apply the proposed green occupation classifications to gain relevant results for Saudi employment policy; if all data were available, this segregation would still be in place. While the dataset does not cover the entire labor market, it does capture Saudi employment in the private sector, which is a key priority for policymakers in the country. In this regard, for the subsequent analysis, the data coverage is referred to as the "Saudi private sector."

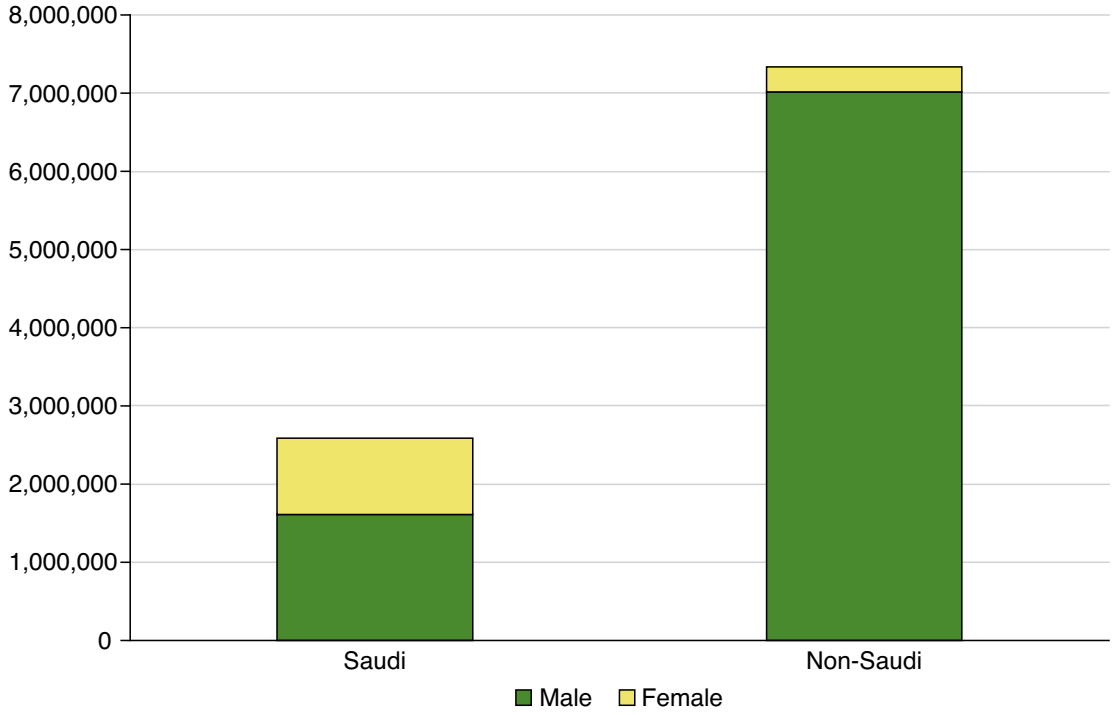
The GOSI dataset covers annually reported employed Saudi social insurance subscribers during the years 2018-2022, a period during which registered participants grew by over 38%. The gender, age, and region of each participant is reported, as well as employment details such as main economic activity (International Standard Industrial Classification - ISIC4), occupation (full six-digit SSCO), and wages. Table 5 offers relevant statistics, and Figure 3 illustrates the sectoral and occupational distribution.

High private sector employment growth is observed in this period, particularly for Saudi females. It is notable that this period saw many policies encouraging female participation in the workforce, most notably the removal of the female driving ban in June 2018. In 2018, 29.5% of all social security subscribers were female, rising to 37.4% in 2022. The age structure of employed Saudis is also of note, with 75% of the subscribers aged 15-39 in 2022.

[4] *Data is aggregated for individuals with identical values to all variables reported, and wages are averaged.*

[5] *The more recent public sector employees are required to subscribe to GOSI, with plans to eventually phase out the civil insurance option, most recently by a merging of the two pension systems. (SPA 2021)*

Figure 2. Saudi private sector employment by nationality and gender (Q4 2022).



Source: GaStat (2023)..

In 2022, clerical support, services and sales, technicians and associate professionals, and professional occupations were the SSCO major groups favored most by Saudi workers. We saw in the previous section that most of the green occupations are in the professionals and technicians major groups. However, it is important to note that these groups also contain the most occupations overall, and going beyond the major group level reveals much variance within these groups. From this, we apply the green occupation taxonomy at the three-digit SSCO level to ascertain the level of green occupations during the period.

Table 5. Description of GOSI data.

		2018	2019	2020	2021	2022
Gender						
	Male	1,331,994	1,334,865	1,345,985	1,479,589	1,608,343
	Female	577,356	608,211	638,934	768,909	965,265
	Total	**1,909,350**	**1,943,076**	**1,984,919**	**2,248,498**	**2,573,608**
Age						
	15–29	449,235	512,951	588,481	791,360	1,031,442
	30–49	1,206,317	1,197,618	1,179,778	1,255,894	1,342,968
	50–64	232,797	215,920	203,149	190,628	189,735
	65+	21,001	16,587	13,511	10,616	9,463
	Total	**1,909,350**	**1,943,076**	**1,984,919**	**2,248,498**	**2,573,608**
Nominal average wage (SAR/month)						
	Male	7,793	8,037	8,270	8,258	8,345
	Female	5,101	5,348	5,641	5,792	5,877
	All	**6,979**	**7,196**	**7,424**	**7,415**	**7,419**

Source: Author's calculations based on GOSI data provided by the National Labor Observatory (NLO).

Note: SAR = Saudi Arabian riyal.

Figure 3. Saudi employment by SSCO group and gender, 2022.

Source: Author's calculations based on GOSI data provided by the National Labor Observatory (NLO).

4. Results

In 2022 there were 767,465 Saudis employed in green occupations, an increase of more than 50% from the total in 2018 (510,921). Green occupations started out at 27% of all occupations in 2018 and grew consistently to almost 30% in 2022. There was also a surge in overall employment from 2018 to 2022 of 35%, indicating that these occupations are a significant source of employment growth in the country.

Looking at the three categories of green occupations in 2022, IDOs made up 47% of the total, followed by 31% for ESOs, and 22% for NEOs. However, much of the growth in the period can be attributed to ESOs, with a yearly growth of around 40,000 jobs. NEOs also recorded steady growth, while IDOs fell slightly before rising again in 2021 and 2022.

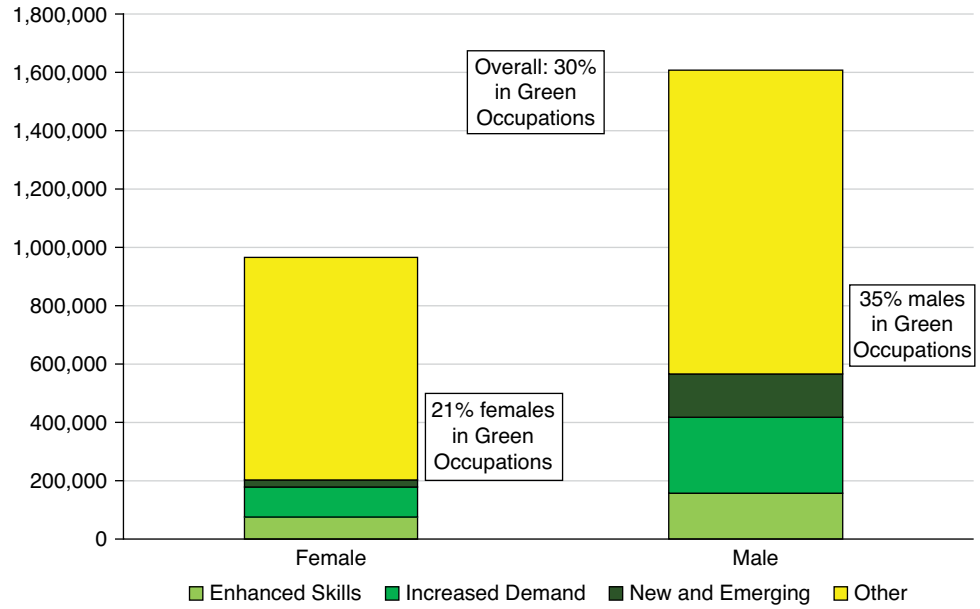
The dataset allows for tabulation by gender, and therefore we can also specify the performance of men and women in the uptake of green occupations. Figure 4 implies that women lagged in these occupations in 2022. In total, 21% of Saudi females worked in green occupations that year compared to 35% of Saudi males. It is notable, nonetheless, that female employment in green occupations doubled between 2018 and 2022, with male green employment growing by 38%. Saudi females accounted for 40% of all growth in green occupations during a period when they were also responsible for 58% of total job growth.

Table 6. Saudis in green occupations.

	2018	2019	2020	2021	2022	Growth 2018–2022
Enhanced skills	*94,446*	*113,400*	*143,340*	*193,348*	*234,721*	*149%*
Increased demand	*308,689*	*304,221*	*291,583*	*319,133*	*360,379*	*17%*
New and emerging	*107,787*	*113,151*	*119,874*	*145,897*	*172,364*	*60%*
Total green	**510,921**	**530,772**	**554,796**	**658,377**	**767,465**	**50%**
Other	1,398,429	1,412,304	1,430,123	1,590,121	1,806,143	29%
Total jobs	**1,909,350**	**1,943,076**	**1,984,919**	**2,248,498**	**2,573,608**	**35%**
% Green jobs	26.8%	27.3%	28.0%	29.3%	29.8%	

Source: Author's calculations based on GOSI data provided by the National Labor Observatory (NLO).

Figure 4. Saudi private sector employment in 2022 by occupation, category, and gender.

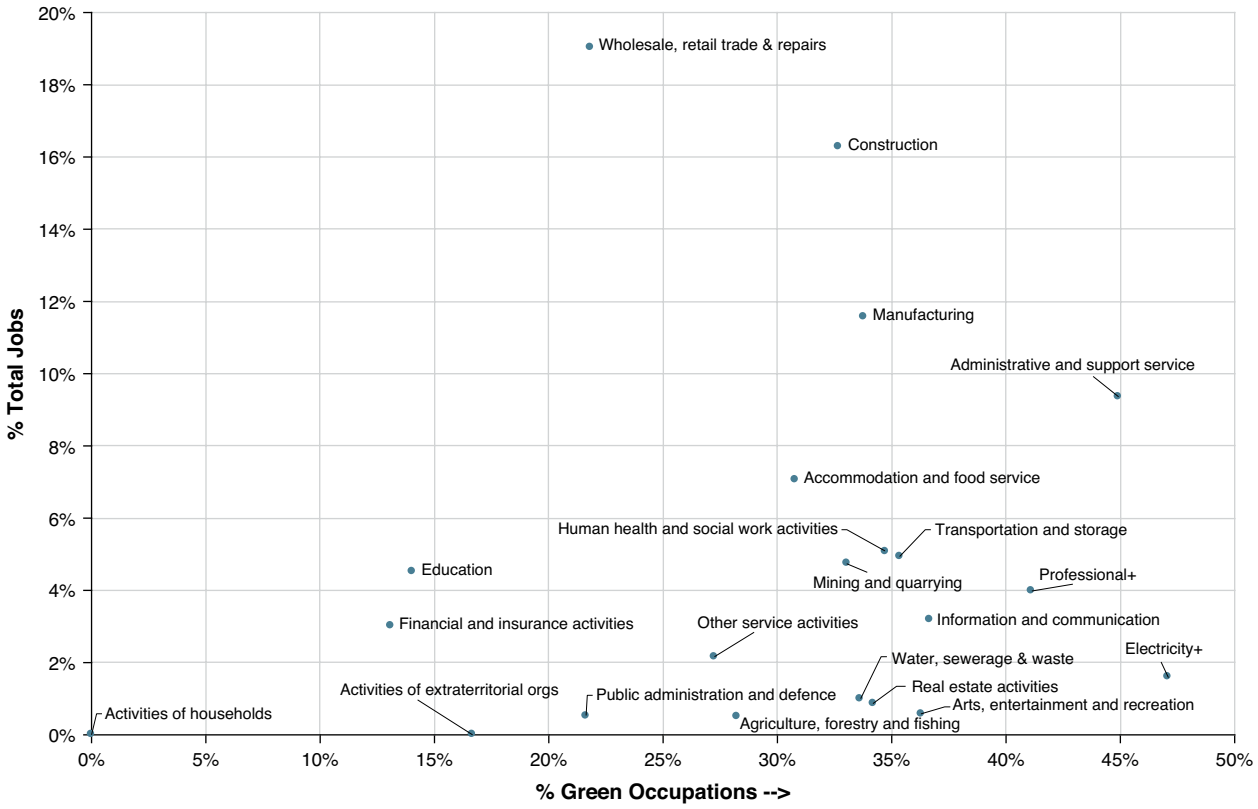


Source: Author's calculations based on GOSI data provided by the NLO.

4.1 Sector

The sectoral composition of green occupations is entirely consistent with the overall structure of employment by ISIC4 economic activity: 56% of all Saudis in the private sector are employed in four sectors, namely, construction, administrative and support services, manufacturing and wholesale, and retail trade and repairs. These same four activities command 57% of all green jobs. Within these economic activities, 47% of all those employed in electricity, water, and waste can be considered green workers, albeit in a sector with just a 1.6% share of total employment. Almost 45% of administrative and support service workers are classified as being in green occupations, with this sector employing 9.4% of Saudis covered.

Figure 5. Green jobs in ISIC4 major groups, Saudi nationals, 2022.

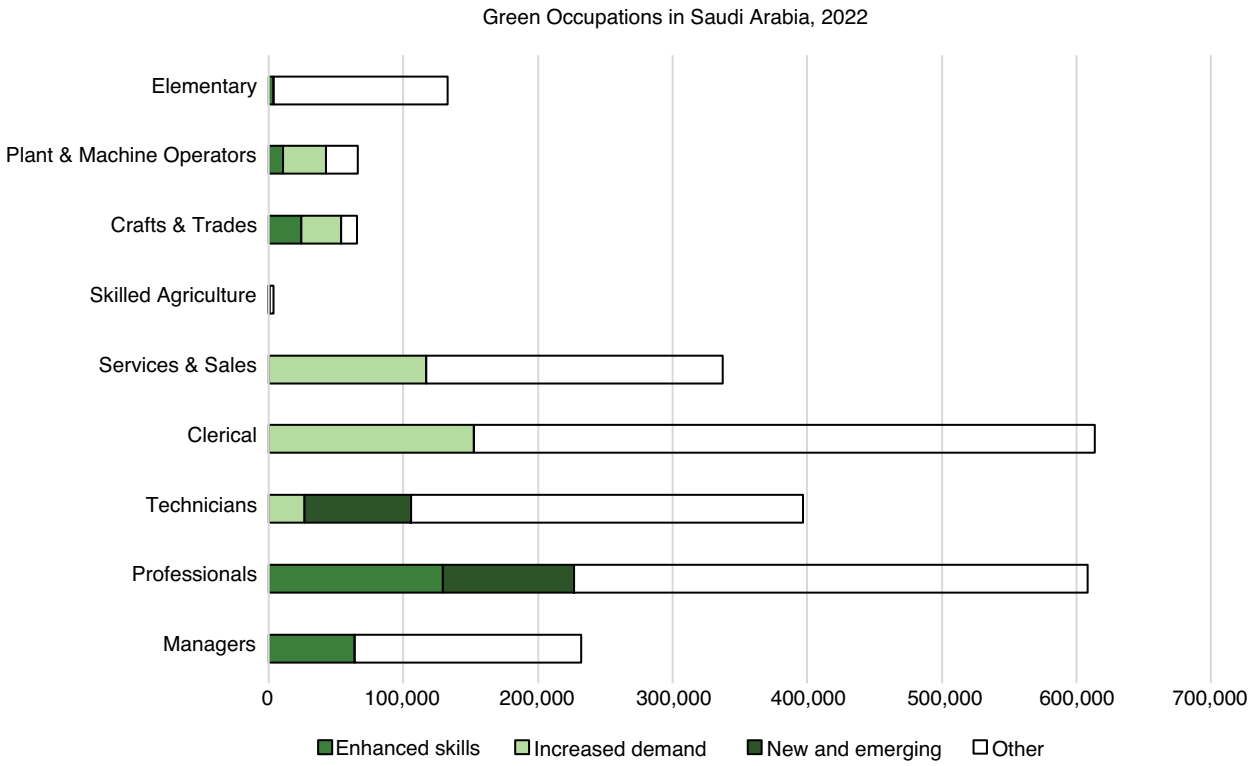


Source: Author's calculations based on GOSI (2022).

4.2 Occupations

We saw in Figure 3 that one of the most popular SSCO major groups for Saudi workers was professional occupations. Almost 30% of green occupations were in this category, and 37.3% of all workers within this category were designated as green. Also of note is the green composition of administrative occupations – comprising almost 25% of employment, and 20% of all green employment. Overall, 52% of Saudi green jobs are in the SSCO major groups 1, 2, and 3, indicating high skill requirements. This result reflects Saudi occupational preferences in general and a high-skilled and highly educated Saudi labor force.

Figure 6. Green jobs in Saudi Arabia by SSCO group, 2022.



Source: Author's calculations based on GOSI data provided by the NLO.

4.2.1 New and Emerging Occupations

Zooming into the three-digit (minor) SSCO group allows for a more detailed analysis of the green occupations. Starting with NEOs, we can see in Table 7 the types of occupations that are contributing to the uptake in these jobs. NEOs offer the possibility not just of job creation but also the creation of new occupations in the coming years as the green economy transforms the world of work. In the original green skills assessment by O*Net, the authors approximated that these would be higher-skilled occupations mostly requiring science, technology, engineering, and mathematics (STEM) skills (Dierdorff et al. 2009). In Saudi Arabia between 2018-2022, all NEO minor groups achieved strong growth, particularly "social and religious professionals" and "government regulatory associate professionals."

Table 7. New and emerging green occupations in Saudi Arabia (Saudi nationals).

SSCO 3-digit	NEO	2018	2019	2020	2021	2022
214	Engineering professionals (excluding electrotechnology)	31,837	35,087	38,611	44,752	49,457
251	Software and applications developers and analysts	16,110	17,248	18,762	21,841	24,209
263	Social and religious professionals	7,739	8,280	8,784	19,223	23,885
311	Physical and engineering science technicians	49,331	49,685	50,281	56,483	65,638
333	*Business services agents*	*973*	*981*	*1,280*	*1,613*	*2,195*
335	Government regulatory associate professionals	1,797	1,870	2,156	1,985	6,980
	Total	**107,787**	**113,151**	**119,874**	**145,897**	**172,364**

Note: "Business service agents" qualifies in all three green occupation categories. To reflect this, and to also avoid double counting, their results are split evenly between ESOs, IDOs, and NEOs.

Source: Author's calculations based on GOSI data provided by the NLO.

4.2.2 Enhanced Skills Occupations

Table 8 shows that the most significant increases in the ESO category were in the "finance professionals" minor group, indicating that finance is experiencing strong employment growth. In 2018, it accounted for less than 7,000 GOSI subscribers but grew to over 100,000 by 2022. The influence of sustainability and green investment concerns undoubtedly became a theme in the finance industry during that period (Yilmaz et al. 2023), justifying its inclusion due to the extra skills demanded to complement the energy transition.[6]

"Legal professionals" and "life science professionals" also tracked strongly. All minor groups within the ESO category recorded increases, apart from two ("sales, marketing and development managers" and "food and related products machine operators"). Recalling Table 5, ESOs experienced the most growth in the period.

[6] *The O*NET analysis lists 18 tasks that define this occupation, with six defined as green tasks (Dierdorff et al. 2009).*

Table 8. Enhanced skills green occupations in Saudi Arabia (Saudi nationals).

SSCO three-digit code	Enhanced skills occupation	2018	2019	2020	2021	2022
112	Managing Directors and Chief Executives	23,270	24,554	28,464	31,827	47,841
122	Sales, marketing and development managers	17,152	16,723	16,921	17,024	16,194
211	Physical and earth science professionals	1,452	1,605	1,740	1,925	2,348
212	Mathematicians, actuaries, and statisticians	945	918	907	944	2,710
213	Life science professionals	1,223	1,407	1,673	2,066	4,671
241	Finance professionals	6,645	22,837	48,739	86,888	103,029
261	Legal professionals	5,946	7,030	8,484	12,620	16,396
333	*Business services agents*	*973*	*981*	*1,280*	*1,613*	*2,195*
612	Animal producers	157	135	139	157	180
712	Building finishers and related trades workers	3,230	3,246	2,738	2,997	3,944
722	Blacksmiths, toolmakers, and related trades workers	4,469	4,631	4,164	5,128	4,657
723	Machinery mechanics and repairers	15,840	15,868	15,521	16,668	15,745
811	Mining and mineral processing plant operators	6,182	6,675	6,305	6,028	7,362
816	Food and related products machine operators	662	625	605	686	645
818	Other stationary plant and machine operators	2,980	2,685	2,704	2,889	3,181
961	Refuse workers	3,320	3,480	2,956	3,888	3,623
	Total	**94,446**	**113,400**	**143,340**	**193,348**	**234,721**

Note: "Business service agents" qualifies in all three green occupation categories. To reflect this, and to also avoid double counting, their results are split evenly between ESOs, IDOs and NEOs.

Source: Author's calculations based on GOSI data provided by the NLO.

4.2.3 Increased Demand Occupations

Recalling Table 6, IDOs are the largest category of green occupations in Saudi Arabia, and at the minor level (Table 9) we can see that two minor groups in particular are responsible for this: client information workers (this includes various tourism-related roles) and protective services workers (such as coastguards and natural reserve security officers). These workers constitute 68% of all Saudi workers in IDOs. In general, this category experienced inconsistent growth in the period, with many minor groups declining. It is notable that IDOs do not contain any of the more skilled/educated SSCO major group 1 (managers) and group 2 (professionals), implying wages may be lower in this category of green occupations. This may be a reason for the inconsistent growth in this category, as we have seen already that Saudis are concentrated in the higher-skilled major occupational groups.

Table 9. Increased demand green occupations in Saudi Arabia (Saudi nationals).

SSCO 3-digit		2018	2019	2020	2021	2022
314	Life science technicians and related associate professionals	671	710	796	967	1,211
333	*Business services agents*	*973*	*981*	*1,280*	*1,613*	*2,195*
343	Artistic, cultural, and culinary associate professionals	5,141	5,258	5,771	6,386	5,519
351	Information and communications technology operations and user support technicians	12,159	13,193	15,091	18,653	20,090
422	Client information workers	99,539	100,222	91,862	103,330	126,547
432	Material recording and transport clerks	21,938	21,674	21,255	24,441	25,881
541	Protective services workers	106,421	103,050	100,469	105,507	116,967
621	Forestry and related workers	133	138	141	142	156
711	Building frame and related trades workers	3,327	2,989	2,683	2,873	3,612
721	Sheet and structural metal workers, moulders and welders, and related workers	9,039	8,483	7,196	7,097	6,953
741	Electrical equipment installers and repairers	21,256	20,350	19,109	19,790	19,168
813	Chemical and photographic products plant and machine operators	2,002	1,838	1,844	1,780	2,081
814	Rubber, plastic, and paper products machine operators	1,211	1,170	1,261	1,273	1,366

(*continued*)

Table 9. (continued)

SSCO 3-digit		2018	2019	2020	2021	2022
821	Assemblers	3,192	3,049	3,158	3,449	6,355
831	Locomotive engine drivers and related workers				5	84
833	Heavy truck and bus drivers	17,332	16,747	15,359	16,877	16,571
834	Mobile plant operators	4,355	4,369	4,308	4,950	5,623
	Total	**308,689**	**304,221**	**291,583**	**319,133**	**360,379**

Note: "Business service agents" qualifies in all three green occupation categories. To reflect this, and to also avoid double counting, their results are split evenly between ESOs, IDOs and NEOs.

Source: Author's calculations based on GOSI data provided by the National Labor Observatory (NLO).

4.3 A Word on Wages

A common talking point on the benefits of green jobs is the higher wages green workers receive, the so-called green wage premium (Bluedorn et al. 2022). Preliminary evidence from Saudi Arabia is inconsistent. In the years 2018-2020, wages were higher for those in green occupations, but this was not true for 2021 and 2022 (Table 10). Delving deeper into the green occupation categories reveals that, indeed, EDOs and NEOs earn more, on average, than non-green workers. However, IDO workers earn significantly less than non-green workers. As IDOs are the largest category of green workers in Saudi Arabia, it appears that they are driving down the average wages of green workers. NEOs, in particular, enjoy an average wage 36% higher than non-green workers. These results are consistent with the type of occupations within each category: both IDOs and NEOs consist largely of higher skilled occupation groups (SSCO groups 1, 2 and 3), while IDOs consist mostly of the lower educated groups. These figures represent an elementary investigation of the green wage premium in Saudi Arabia, and empirical analysis is necessary to disaggregate the exact green premium from the individual human capital characteristics of workers that may affect wage formation.

Table 10. Comparison of nominal average monthly wages (SAR) by category of occupation.

	2018	2019	2020	2021	2022
Other	6,840	7,064	7,352	7,417	7,395
Green	7,305	7,467	7,581	7,372	7,337
Raw green premium	6.8%	5.7%	3.1%	-0.6%	-0.8%
GREEN OCCUPATION CATEGORY*					
ESO	*9,490*	*9,270*	*8,774*	*8,160*	*8,266*
IDO	*5,417*	*5,469*	*5,544*	*5,518*	*5,441*
NEO	*10,856*	*11,089*	*11,132*	*10,398*	*10,064*

**Note: As the group "Business service agents" is categorized in all three groups, it is excluded from the category-level wage analysis. SAR= Saudi Arabian Riyal.*

Source: Author's calculations based on GOSI data provided by the National Labor Observatory (NLO).

5. Discussion

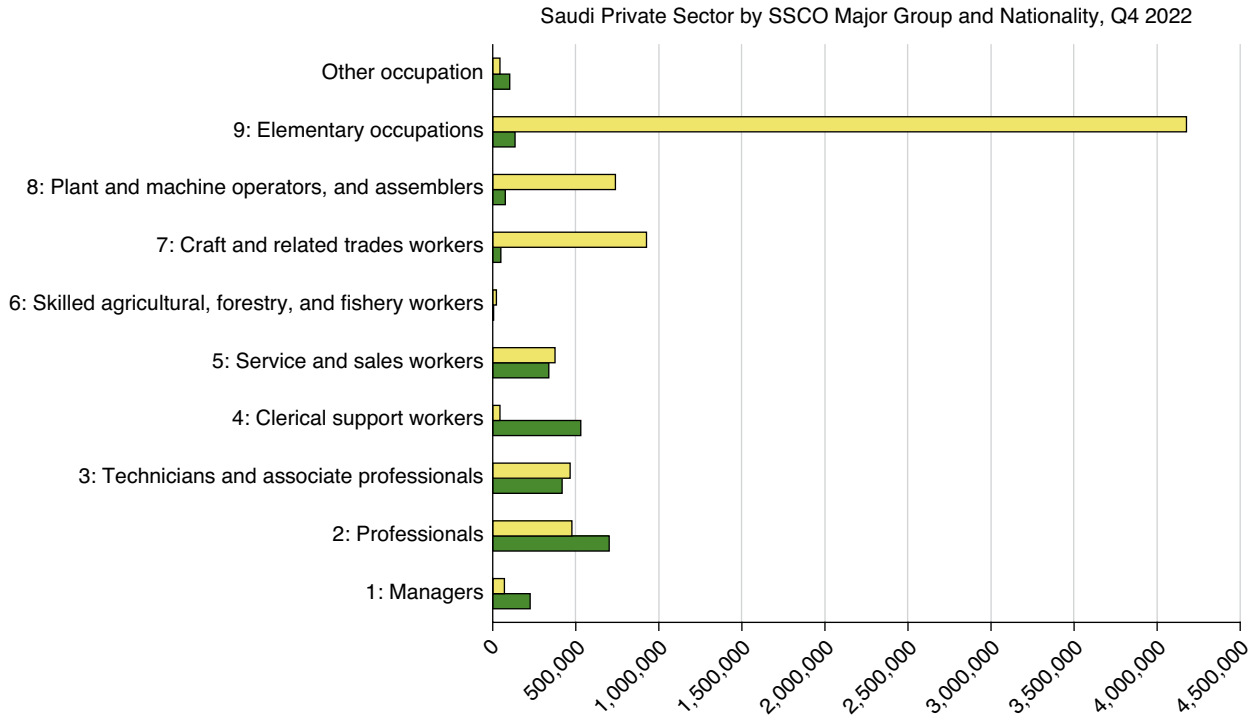
5.1 Scratching the Surface

This study offered a methodology for approximating green employment in Saudi Arabia and produced the first estimates of green jobs in the country. However, all that this analysis can really claim is that there were at least 767,465 green workers in the Saudi labor market in 2022. Including workers covered under civil insurance would be an addition to the analysis. However, the main limitation of these results is the absence of data on expatriate workers, who made up 75% of Saudi Arabia's private sector in 2022. Although the results published here are relevant to policymakers in that they provide a detailed account of Saudi nationals' green employment in the private sector, a more comprehensive sample of the labor market would show that we are just scratching the surface of the true number of green jobs in Saudi Arabia.

While the structure of the Saudi labor market is interesting in itself, what makes the inclusion of expatriates even more significant in this analysis is that Saudis and non-Saudis differ greatly in occupational choice. As illustrated in Figure 7, Saudis are clustered in major groups 1-5. Although these groups also contain a significant number of non-Saudis due to the large number of expatriate workers in the labor market, groups 7-9 contain a large share of not only expatriates but all employment in the private sector and, therefore, the entire labor market.

The analysis did show many Saudis work in green occupations in major groups 7, 8, and 9. However, including expatriates in the study may have revealed millions more in just these three groups. Almost half of all potential ESOs and 56% of all potential IDOs are in these three groups (Table 3), meaning much of the green employment has yet to be revealed. This paper provides the necessary instructions for those with this data to expand the coverage.

Figure 7. Saudi private sector by SSCO major group and nationality, Q4 2022.



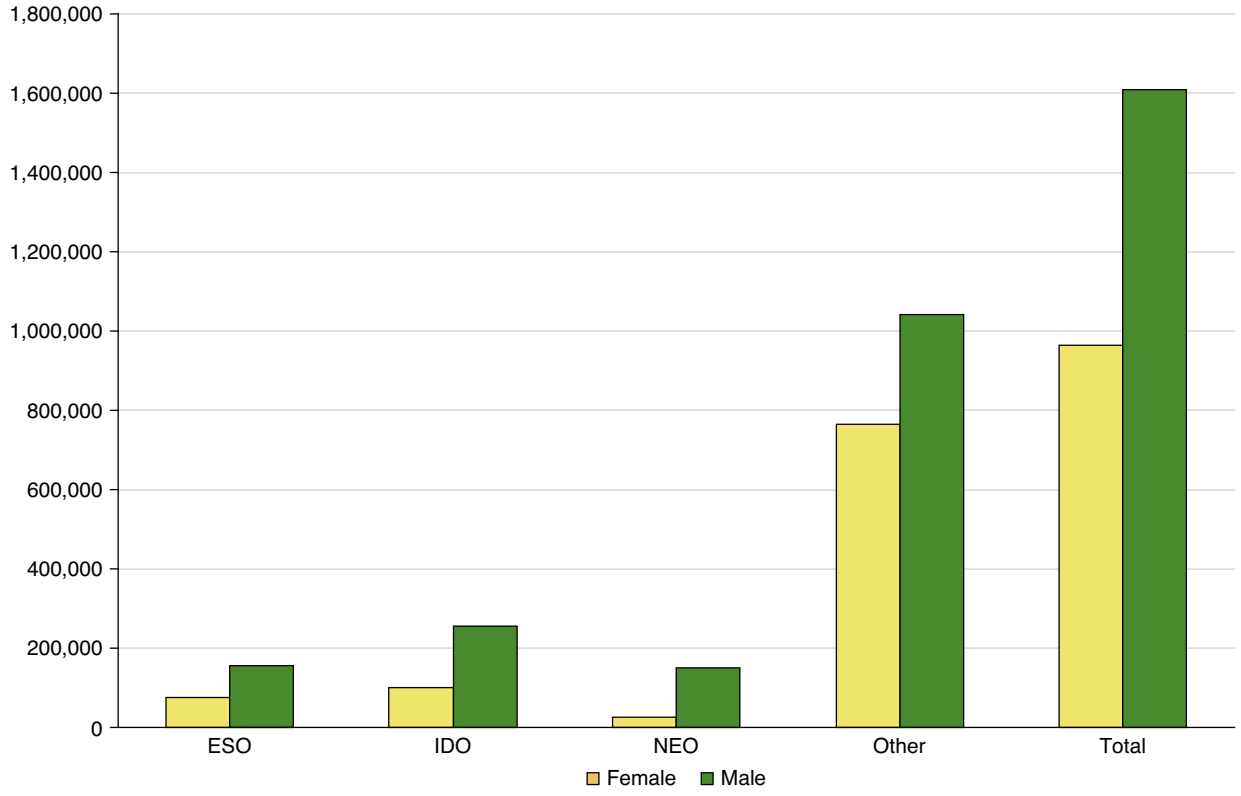
Source: Author's calculations based on the Saudi Labor Force Survey.

5.2 Women in NEOs

One of the major labor market success stories of the twenty-first century has been Saudi Arabia's bid to increase female labor force participation (LFP). Starting from very low levels in the early 2010s and supercharged by Vision 2030, Saudi women reached their 2030 target of 30% LFP almost a decade ahead of the Vision 2030 target, in Q2 2020. The increased participation of women in the labor force has transferred into increased representation, and at the end of 2022, almost 38% of GOSI-registered employed Saudis were women .In the results section here, however, it should be noted that women are falling behind in the uptake of green occupations, at 21% compared to 35% for Saudi men. This may seem like a trivial statistic, but going deeper into this result can offer some insight.

Analyzing the gender shares within each category shows, overall, that women comprise 32% of ESOs, 28% of IDOs, but only 14% of NEOs (Figure 8). In the brief discussion about wages in the previous section, we can recall that that NEOs have the highest wages and skill requirements of all green occupations, and it seems that this result is worthy of further inspection. Looking at the NEO minor occupation groups, women are falling behind in two of these green occupations in particular: "engineering professionals" and "physical and engineering science technicians" (Table 11). Of note is that the engineering professionals' group has the highest average wage of not only all green occupations but also of any occupation group in the labor market, and 95% of this group is male.

Figure 8. Gender differences in green occupation categories, 2022.



Source: Author's calculations based on GOSI data provided by the NLO.

The focus on NEOs is not arbitrary, as it is important to remember that these are the new occupations being created by the energy transition, and they are predicted to see the most growth in the coming decades (Kochar 2020). Identifying a gender gap such as this at the early stages of both the energy transition and female employment in the country offers a chance for appropriate labor market interventions to remedy any potential suboptimal outcome. These high-paying NEO jobs are mostly engineering and technology jobs – meaning policymakers can focus on encouraging Saudi women to work in STEM occupations. The key word here is "work" in STEM. It is apparent that Saudi women have strong participation in third-level education, often in STEM subjects, but it needs to be investigated whether these studies and qualifications lead to employment in STEM occupations. The analysis here that reveals the gender gap in the engineering fields of NEOs implies otherwise, and policy intervention may be required to rectify this.

While many reasons may exist for the separation of men and women into different occupations, these situations can quickly become entrenched and path dependent. It is important to track this, particularly in such high-paying jobs, as strong growth in these areas may exclude women and therefore widen the overall gender pay gap in Saudi Arabia. Further, STEM occupations are important for other aspects of the future of work that will incorporate artificial intelligence (Saurabh et al. 2023), which implies that this issue goes beyond the green economy.

Table 11. Saudi women in new and emerging green occupations, with average monthly wages - 2022.

SSCO code	SSCO minor group	Female	Male	Total	% Female	Wages (SAR)
214	Engineering professionals (excluding electrotechnology)	2,329	47,128	49,457	5%	14,185
251	Software and applications developers and analysts	9,684	14,525	24,209	40%	12,643
263	Social and religious professionals	6,445	17,440	23,885	27%	6,587
311	Physical and engineering science technicians	2,720	62,918	65,638	4%	7,768
335	Government regulatory associate professionals	1,866	5,114	6,980	27%	5,406
	Total	**23,044**	**147,125**	**170,169**	**14%**	**10,064**

Source: Author's Calculations based on GOSI data provided by the NLO.

Note: SAR= Saudi Arabian riyal.

5.3 Limitations

Outlined throughout the discussion herein are the many limitations of the green occupations methodology in accurately disaggregating green employment. The first among these limitations is the broad definition of green occupations, particularly when grouped at the three-digit SSCO level, which includes many occupations that perhaps are not relevant and may distort the level of green employment. Further refinement is necessary to narrow the occupations to at least a four-digit level in order to alleviate this concern.

A second limitation is the categorization of "green" and "other" employment. While it is common in the green jobs literature to categorize employment into "green" and "brown" employment, the green occupations method assumes that there is not such a clear distinction in this categorization, and is thus undiscering about the occupations not counted as green. The focus on categorizing tasks within occupations – rather than an industry or sector – can lead to a surprising and counterintuitive designation of certain occupations. In the oil industry, for example, many workers are involved in energy efficiency initiatives and sustainability efforts, and therefore many occupations contain green tasks and count toward green occupations. The O*NET methodology requires one task within an occupation to be designated as green in order to be classified as a "green" occupation. Perhaps a weighting is needed to balance the contribution of green tasks against possible "brown" tasks that are currently ignored once the disaggregation occurs. It is clear that a spectrum of green employment exists between green and brown, and more precision is needed to clarify this. While criticism of the specificity of the green occupations when counted at the three-digit level is valid, the disaggregation acts as a first step in estimating green employment using the available data.

6. Conclusion

This study has applied a simple methodology for tracking employment in green occupations to quantify the number of green jobs in Saudi Arabia using readily available data from the country's statistical agencies. The data used for this analysis was provided under a new policy of increased data transparency from these agencies. However, there are no guarantees that further granular datasets will be provided in the future to track green jobs in Saudi Arabia. Should this data not be available, the agencies could consider applying this methodology themselves and releasing aggregated results on a regular basis to monitor the progress of green employment in the country. It would merely be a case of organizing data into the appropriate three-digit SSCO codes already collected by the agencies, and this paper provides all the information on how to do this.

The energy transition requires a transformation of our entire economic system, necessitating a more sustainable version of every aspect of the economy so that these aspects contribute toward climate mitigation and adaptation. This includes a greening of the labor market, which will have large consequences for the world of work. Some sectors may be prioritized over others, causing increased demand for occupations in these sectors. Some occupations may suddenly require extra skills due to the energy transition. Innovation as a result of the energy transition may create entirely new occupations. All of these scenarios are relevant to employment and education policy, and monitoring the trends in this aspect of the labor market is the first step in providing a response that prepares the labor force for the future of work. The analysis here has shown that these occupations are growing faster than others, indicating that this is not just relevant for the future of work but also for work right now. Tracking and publicizing these trends shows the public that the socioeconomic benefits of the energy transition are not just a vague promise of jobs in the future but are, in fact, something that is already here and that many are already benefitting from.

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Appendix 1: Clarification of Terms

Term	Definition	Example
Job	A set of tasks and duties intended to be performed by one person for an employer (can be self).	Employee in finance industry.
Occupation	A set of jobs whose main tasks and duties are characterized by a high degree of similarity.	Credit specialist.
Task	A specific responsibility or duty of the worker. A bundle of tasks defines a discrete occupation.	Determine the financial needs, return requirements and level of risk taking.
Skill	A competency that contributes toward the performance of a task. Can be formal education, on the job training, or work experience.	Certificate in financial forecasting.

Sources: GaStat (2023); author.

Appendix 2: Green Occupations

SSCO three-digit code	Minor group name	Green occupation category
112	Managing directors and chief executives	Enhanced skills
122	Sales, marketing and development managers	Enhanced skills
211	Physical and earth science professionals	Enhanced skills
212	Mathematicians, actuaries and statisticians	Enhanced skills
213	Life science professionals	Enhanced skills
214	Engineering professionals (excluding electrotechnology)	New and emerging
241	Finance professionals	Enhanced skills
251	Software and applications developers and analysts	New and emerging
261	Legal professionals	Enhanced skills
263	Social and religious professionals	New and emerging
311	Physical and engineering science technicians	New and emerging
314	Life science technicians and related associate professionals	Increased demand
333	Business services agents	ESO/IDO/NEO
335	Government regulatory associate professionals	New and emerging
343	Artistic, cultural, and culinary associate professionals	Increased demand
351	Information and communications technology operations and user support technicians	Increased demand
422	Client information workers	Increased demand
432	Material recording and transport clerks	Increased demand
541	Protective services workers	Increased demand

SSCO three-digit code	Minor group name	Green occupation category
612	Animal producers	Enhanced skills
621	Forestry and related workers	Increased demand
711	Building frame and related trades workers	Increased demand
712	Building finishers and related trades workers	Enhanced skills
721	Sheet and structural metal workers, moulders and welders, and related workers	Increased demand
722	Blacksmiths, toolmakers, and related trades workers	Enhanced skills
723	Machinery mechanics and repairers	Enhanced skills
741	Electrical equipment installers and repairers	Increased semand
811	Mining and mineral processing plant operators	Enhanced skills
813	Chemical and photographic products plant and machine operators	Increased demand
814	Rubber, plastic, and paper products machine operators	Increased demand
816	Food and related products machine operators	Enhanced skills
818	Other stationary plant and machine operators	Enhanced skills
821	Assemblers	Increased demand
831	Locomotive engine drivers and related workers	Increased demand
833	Heavy truck and bus drivers	Increased demand
834	Mobile plant operators	Increased demand
961	Refuse workers	Enhanced skills

Source: GaStat (2023).

About the Author

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Cian has been a member of the KAPSARC Energy Macro- and Microeconomics team since March 2018. Focusing on analyzing the employment benefits of the energy transition, he has authored a series of studies that shed light on issues relevant to the modern Saudi labor market in light of Saudi Vision 2030. His recent research interests include analysis of green jobs in Saudi Arabia, Saudi female labor force participation, and optimizing local content policy design. He has presented research at multiple international conferences and worked and studied in the Netherlands, the United Kingdom, Spain, Italy, Germany, Austria, and Taiwan, as well as his native country of Ireland.

About the Project

Although the energy sector has long been known to be more capital than labor intensive — particularly in more traditional industries like oil, gas and coal — the transition to new energy technologies provides an opportunity to reconsider the relationship between energy and employment. While the economic literature heralds the potential of renewable energy to create employment, many systemic constraints hamper the Saudi labor force from exploiting these "green" job opportunities. This project investigates these issues and contributes to the policy discussion on the employment aspects of the energy transition.

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