

# The Potential for Distributed Solar PV Systems in Riyadh

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Instant Insight

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## Context

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The country's regulator, the Electricity and Co-Generation Regulatory Authority (ECRA) has also released provisional bylaws that will govern how distributed generation (DG) would be compensated within the Kingdom. Many governmental organizations mandated to support local industries and energy efficiency measures are assessing the potential business and employment opportunities that could result from renewable energy deployment. This analysis provides a timely insight that can help shape the discussion around DG as the Kingdom moves forward with its renewable energy plans.

Solar photovoltaic (PV) systems can be broadly categorized as residential (2 kilowatts [kW] – 10kW), commercial (20kW – 200kW), or utility-scale systems (1 megawatt [MW] and above). Residential and commercial systems are classified as DG systems – those installed within the distribution network or near the load. DG systems are mostly installed on rooftops, but they can also be ground-mounted if the area is available. However, utility-scale systems are always ground-mounted and require large land areas for deployment.

DG solar systems are seen as important components of future sustainable cities. Deploying DG systems has technical, financial, policy, and market implications for utilities, governments, and businesses. As such, forecasting the number of DG systems that could be deployed in a certain jurisdiction helps inform the decision-making process for all stakeholders. This insight draws on research that estimated the upper limit of rooftop PV systems that could be deployed in the Saudi capital, Riyadh.

## Contrasting utility-scale and DG solar PV

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DG and utility-scale PV have respective strengths and weaknesses. Utility-scale solar farms, for example, benefit from economies of scale and are easier to manage from a central planning perspective. However, land availability makes utility-scale deployment difficult within cities, and even more so in city centers.

DG systems meanwhile do not require significant land area and can provide direct economic and non-economic benefits to individuals and businesses. Homeowners or businesses can reduce their utility bills by consuming the electricity produced by their DG systems. Furthermore, DG owners can even turn a profit if they sell energy back to the grid, becoming so-called 'prosumers' (producers and consumers simultaneously). This is particularly appealing when electricity prices are high. However, DG systems could also destabilize the distribution network. They therefore necessitate careful regulation by the authorities and new operating procedures by utility companies.

## How to quantify DG potential in an urban setting?

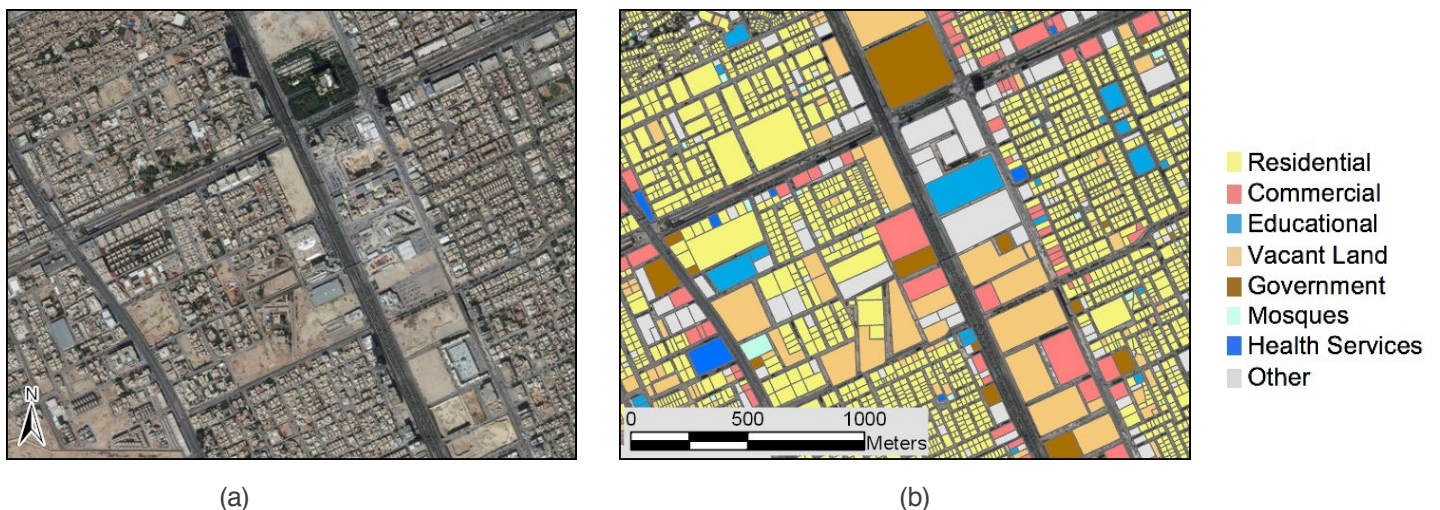
Assessing the feasibility of DG deployment involves considering several factors, including spatial analysis. Many research papers on the topic rely heavily on geographic information systems (GIS) analysis. Using GIS analysis is not restricted to DG penetration; it is also used to guide utility-scale PV siting efforts. However, there is greater need for GIS analysis in DG deployment.

The study from which this insight is drawn uses land lot data, also referred to as land parcel data, taken from land-use and zoning datasets. A land parcel, or land lot, is a piece of land that would be used for a specific purpose depending on the governmental and/or municipal zoning. Land parcel designations can include, but are not restricted to, residential, commercial, industrial and governmental uses.

The study obtained a GIS layer representing land parcels and their designation for Riyadh from the Riyadh Development Authority (<http://rda.gov.sa>).<sup>1</sup> This layer is a static snapshot of land use codes in 2016. It includes a spatial representation (i.e., location and shape) of every land parcel in the city. The dataset included approximately 1 million parcels. Each land parcel is given a land-use code based on the city's zoning regulation and is also assigned a building type, if a building exists.

Figure 1 shows a snapshot of this data. Image (a) shows a satellite picture of a neighborhood in Riyadh, and image (b) shows the corresponding zoning categorization. Note how each land parcel is color-coded for ease of identification.

**Figure 1:** A sample of the geographical data available for a neighborhood in northern Riyadh.



Source: Riyadh Development Authority.

Note: (a) This figure shows the neighborhood as it appears in satellite imagery using the ArcGIS software base-map; (b) Displays the same neighborhood as (a) but identifies land parcels. Each land parcel is color-coded based on its zonal designation: yellow parcels represent residential land lots, while a light-blue parcel represents a lot designated as an educational institution, for example.

<sup>1</sup>The Riyadh Development Authority has now become the Royal Commission of Riyadh.

Buildings that reside within a certain parcel will not fully occupy the area of that parcel. Buildings and/or structures need to be a minimum distance away from streets, fences, and/or the parcel boundary. This minimum distance is referred to as the land use setback. Local municipalities and/or governments specify the value of the setback through building codes, depending on the parcel type. Although setback values differ across countries, their implementation ensures, among other things, architectural uniformity within the same neighborhood, access around the building, access to sunlight, and the availability of space for landscaping.

Using the same reasoning, building codes also specify the maximum allowable area that can be built (MAAB) within a land parcel. While the setback is mostly concerned with the distance that separates the building from the parcel boundaries, the MAAB sets an upper limit to the overall area that can be built in a specific land lot. Akin to the setback, the MAAB varies across categories. For the purposes of this insight, the MAAB represents a realistic estimate of the maximum possible rooftop area that can exist in any parcel.

A PV system cannot always fully cover the rooftop. The rooftop may not be flat or may be covered with shingles that prevent PV modules being mounted. Parts of the roof can also be occupied by satellite dishes, water tanks, air conditioners, ducts, or other service units – all reducing the potential area that can be used for PV installation. Parts of the roof may also be shaded by a balustrade or by adjacent buildings, rendering these parts of the roof unsuitable for PV installation. Of course, such granular information does not exist for every building. Hence, we have to make an assumption of available roof space, and a sensitivity analysis can account for the variation that exists between buildings.

The potential PV capacity of a land parcel can be calculated using the area of the land parcel and its MAAB, and the assumption of the area that can be used for solar modules.

## Results and implications for the government and utility

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The rooftop space suitable for PV deployment was quantified using land lot data and the maximum allowable area that could be built within a certain lot using prevailing building codes. The analysis was restricted to residential, mosque, shopping mall, and healthcare building rooftops. The upper limit of rooftop solar PV capacity that can be deployed in the city of Riyadh was found to be 4.34 GW. This capacity represents nearly 22% of the peak load and can satisfy approximately 9% of the energy requirement in Saudi Arabia's central region, the region in which Riyadh resides.

It is important not to confuse this potential upper limit of PV deployment with the practical limit; the latter is governed by a number of constraints including, for example:

- Infrastructure preparedness, i.e., whether the utility can accommodate the unpredictable nature of distributed generation.
- Household finances: a 5 kW residential PV system for example, at 5 Saudi riyals (SAR) per Watt (W), would cost SAR 25,000 – a prohibitive sum for some households.

- Tenants: Some households may not own the property in which they reside. This segment would most likely not invest in rooftop PV since their presence is governed by short-term circumstances, and they would not be able to reap the financial benefits of the investment.
- Esthetics: Homeowners may opt not to install rooftop PV due to esthetic reasons, i.e., if the architectural beauty of the building will be compromised.

If 5% of this upper limit were deployed (i.e., around 200 MW), the Saudi Electricity Company would forego revenue of around 62 million SAR, assuming an electricity price of 0.18 SAR per kilowatthour. However, this revenue adjustment does not include the savings to the utility from avoided generation. A dedicated study is needed to determine whether the foregone revenues exceed the avoided costs or vice versa.

The government would need to allocate 200 million SAR if it wanted to subsidize the deployment of 200 MW with an investment credit mechanism at 1 SAR/W. The capital costs of DG systems currently range from 3.75 SAR/W – 5.5 SAR/W (1\$/W – 1.5 \$/W).

## Acknowledgement

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## References

Elshurafa, Amro M. and Abdelrahman Muhsen. 2019. "The Upper Limit of Distributed Solar PV Capacity in Riyadh: A GIS-Assisted Study." *Sustainability* (11), 4301.



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