**Derivation of Supply Curve of PV**

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# Supplementary Materials

# Note 1: Korean Administrative

South Korea has three-tier local governance systems: Tier 1 (province-level or state-level) includes 8 provinces and 7 metropolitan cities, including Seoul. Tier 2 (county-level) includes 226 counties and cities affiliated with the Tier 1 governments, and 2 autonomous jurisdictions (Sejong city and Jeju Island). Lastly, Tier 3 (town-level) governments are affiliated with the Tier 2 governments. Even if Gyeonggi-do, a province in tier 1, consists of 31 cities and counties, both cities and counties will be collectively referred to as ‘cities’. (KO, 2023)

# Note 2: Ratio (Area covered by PV to the total area, %)

- South Korea consists of a total of 17 provinces, each of which encompasses cities & counties, as indicated in the following table. In this paper, the administrative category at high-level is consistently referred to as 'province', while at low-level it is expressed as 'city & county'.

# Note 3: Coefficient (Required area to install PV, m2/kW)

- In the standard version of GCAM, there are two systems: the model engine (GCAM-core) and the model interface for querying scenario output. In contrast, GCAM-EML combines a model engine with a model interface. The model engine of GCAM-EML is written in C#, and the model interface is developed using Windows Presentation Foundation (WPF). The requirements for the GCAM-EML are as follows.

|  |  |  |
| --- | --- | --- |
| Land-use type | Description | Data source |
| Industrial complex |  |  |
| Logistics complex |  |  |
| Residential complex |  |  |
| Public buildings |  |  |
| Mountainous area |  |  |
| Farmland |  |  |
| Parking lot |  |  |
| Roadside land |  |  |
| Water |  |  |

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Fig. . Area covered by PV to total area of individual site. (Total area vs. PV installation area)

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Fig. . Required area for PV installation (capacity(kW) vs. area(m2))

# Note 2: Projection of population and GRDP at 229 citiy level

- (Population) Each province has projected its future population at the city level by 2040. To extend the data for the next ten years (2040-2050), the Auto-Regressive Integrated Moving Average (ARIMA) method has been applied. The augmented data is then converted to represent each city & county’s share of the national population over the entire period (2020-2050). The city & county’s population share is applied to the midpath of the national population by 2050. Ultimately, the future population pathways of all 229 city & counties are projected.

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# Note 3: Electricity consumption of electric vehicle

- (Number of BEVs) The complete set of registered BEVs data is not universally accessible across all 229 cities & counties. Table SM 4 serves as a summary of the most comprehensive BEV data we were able to compile. This table includes information on provincial populations (KOSIS, 2023), the number of BEVs (KSGA, 2023), their proportions in South Korea, and the count of cities & counties within each province. The data on registered BEVs is sourced from various provinces and cities & counties. Provinces in Group A provide fully available data, encompassing cities & counties, time horizons, and vehicle type information. Group B provinces do not distinguish between vehicle types in their data. Group C provinces lack vehicle type information for the year 2020, even though they possess BEV data organized by cities & counties. In the case of Group D, GJ province, BEV data is available for three out of the five cities & counties, categorized by vehicle types in 2022, while the remaining two cities & counties lack any data. Group E provinces do not possess any BEV data at the city & county level. For provinces from Group B to E, missing BEV data was estimated as follows. Assumptions are made to estimate the number of registered BEVs in 2020 by cities & counties and vehicle type. Firstly, in cases where the number of EVs per city & county is unavailable for a given province, it is assumed that the distribution of total vehicles by city & county reflects the distribution of EVs across cities & counties. Secondly, in the absence of data for 2020, the growth rate of the total BEVs for the entire province is calculated from 2020 to the available data year. This growth rate is then applied to estimate the number of BEVs in 2020. Thirdly, if the data does not specify the number of BEVs by vehicle type and only provides the total count, the vehicle type distribution in the province for 2020 is uniformly applied to each city & county.

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