**Derivation of Supply Curve of PV ~**

**Impact of Setback regulation ~**

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**Abstract**

This is an abstract.

**Keywords:** Keword1, Keword-2, Keyword-3

1. Introduction

전세계 속에서 우리나라 특성 온실가스, (신재생)에너지 등

우리나라에서 경기도 특성: 온실가스, (신재생)에너지

신재생 도입을 방해하는 요소: 1.2.3….Setback

Setback에 대한 전세계 현황

Setback에 대한 우리나라 현황: Setback 규제가 생겨난 이유, Setback의 종류 등등

Objective:

1) explore suitable sites for PV deployment. (GIS-based approach)

2) scenario analysis (No Setback vs. Setback)

3) Supply curve

Comparison of PV energy potential

4) Compare supply curve of PV (LCOE assumption)

4)

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텍스트, 전자제품, 스크린샷, 웹사이트이(가) 표시된 사진

자동 생성된 설명

Fig. 1. Study Design

1. Methodology
   1. GIS-based approaches

Land-use types are categorized.

# 9가지 유형별 대표 사진

|  |  |  |
| --- | --- | --- |
| 스크린샷, 태양광 발전, 태양 에너지, 태양 전지 패널이(가) 표시된 사진  자동 생성된 설명 | 스크린샷, 태양광 발전, 태양 에너지, 태양 전지 패널이(가) 표시된 사진  자동 생성된 설명 | 스크린샷, 태양광 발전, 태양 에너지, 태양 전지 패널이(가) 표시된 사진  자동 생성된 설명 |
| 스크린샷, 태양광 발전, 태양 에너지, 태양 전지 패널이(가) 표시된 사진  자동 생성된 설명 | 스크린샷, 태양광 발전, 태양 에너지, 태양 전지 패널이(가) 표시된 사진  자동 생성된 설명 | 스크린샷, 태양광 발전, 태양 에너지, 태양 전지 패널이(가) 표시된 사진  자동 생성된 설명 |
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Fig. 2. Representative examples of PV installation across nine land-use types.

* + 1. Industrial complex

- 산업단지 정의 및 유형 설명.

- 산업단지를 골라낸 방법

* + 1. Logistics complex

- 물류단지 정의 및 유형 설명.

- 물류단지를 골라낸 방법

* + 1. Residential complex
    2. Public buildings
    3. Mountainous area
    4. Farmland
    5. Parking lot
    6. Roadside land
    7. Water

Table. 1. Summary of land-use types

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

* + 1. Geographical constraint

법적, 지형적 규제를 검토한 사항들에 대한 설명.

- (농지) 농업보호구역, 농업진흥지역

- (산지) 보전산지, 경사 15도.

- (전체) 이격거리

* 1. Calculation of PV potential

Annual theoretical potential generation of PV in the given area ( in m2) is calculated as the global horizontal irradiation ( in kW/m2) as followings.

The theoretical potential is limited to deliver meaningful information to policy makers. Geographical and technical constraints would be taken into account when we try to find more realistic estimation for the PV potential. The geographical and technical potential would be calculated as followings.

Here, (in kWh/m2) is geographical and technical generation potential under geographical (ex. protected area) and technical constraints (ex. PV module efficiency). (unitless) is generator-to-system area ratio, which is the ratio of the area occupied by the PV generator (including PV arrays and the spaces between them) to the total suitable area available for the PV system. It indicates how efficiently the available area is utilized for placing PV systems. (unitless) is the packing factor, the ratio of the total PV array area to the land area PV arrays occupy. It measures how densely the PV arrays are packed within the occupied space. (unitless) is the performance ratio, the ratio of the actual generation achievable in practice to the ideal generation under no-losses conditions. Regardless of module efficiency and shading effect, it measures PV system losses from array temperature, surface soiling, panel degradation etc.[[2]](#footnote-3) is the module efficiency. is the shading factor.

In this study, instead, the reduced formula is applied as followings.

Here, (in kWh/year) is geographical and technical potential at an individual site (), located within a city& county (), classified as land-use type () and PV technology type (). (m2) is the area of the individual site. (m2/kW) is the land coverage ratio, which represents the ratio of land covered by a PV system. (unitless) is the land-use ratio, which represents the ratio of the land area used for a PV system. (unitless) is the capacity factor of a PV system, defined by the ratio of the actual power generation to theoretical power generation if the PV system has generated at its maximum power output during same period [1,2]. The differences between the formula in the previous studies and the formula in this study are i) measurement of PV installation size (PV module area in m2 vs. PV capacity in kW), and ii) measurement of PV efficiency (disaggregation into performance ratio, module efficiency, and shading effect vs. capacity factor as integrated efficiency). In previous studies [sources], solar radiation that could be utilized by a PV system is measured in the unit of kW/m2 (), while in this study, PV capacity that could be installed in the suitable area is measured in the unit of kW/m2 (). And in previous studies, energy losses associated with solar-to-electric power conversion, including shading losses are represented into three parts (), while in this study, the capacity factor (), the definition-based parameter, includes technical efficiency, shading effects, surface soiling etc.

* + 1. Total area

In this study, total area represents

* + 1. Total area to PV area

Fig. 3 (c) shows the graphical concept of ‘total area to PV area’. Since facilities that are nothing to do with PV operation or unsuitable terrain to install PV in its shape and size or other reasons may be included in the field practice, the 100% of the total area cannot be utilized for PV system installation. Such surrounding environment varies in all shapes for each individual site, making it unfeasible to investigate every sites. Previous studies assumes that 70% of the total area could be utilized for PV system installation, which called generator to system ratio (GSR), or area factor [3–5].

* + 1. PV area to PV size
    2. PV size to PV generation

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Fig. 3

GSR : (Agen/As)

Martin-chivelet (2016) generator to system ratio(GSR) : 0.7 ~ 0.85

Saraswat et al (2021): Area factor, maximum land area covered by the PV panels with the minimum shading effect : 70% (based on previous studies)

Dhunny et al. (2019): Area factor which indicates the fraction of calculated area that can be filled with solar panels.: 70%

Ratio of Land Coverage

PF (Apv/Agen)

Ground Cover Ratio or (Spacing factor): Elkadeem et al. (2022) : the ratio of total land requirements compared to the actual surface area of PV panels: 20%

Ouchani et al. (2021): Ground Coverage Ratio: 20%

IRENA (2014): Ground Coverage Ratio: 20%

Land Occupancy Factor (LOF) : 1.4: Yushcenko et al. (2018) : ratio of total land requirements to the surface of PV panels.

()

Vyas et al. (2022), Land Cover Ratio (LCR) : 13.16(m2/kW) : Land Coverage Ratio, which is the ratio of land area occupied by the structures (which becomes unusable for any other purpose) to the total land area available at the project site(area occupied by structure/foundation of SPV tree can be seen in graphical representation in Fig3.))

would be called Land occupancy factor

Elkadeem et al. (2022): spacing factor

는 나랑 똑같이 2개 (Ratio, Coef)로 나누어서 했네.

Where (kWh/year) is generation potential of PV in Gyeonggi province. is an individual site, is a city& county, is a type of PV technology, is a type of land-use. (kWh/year) is generation potential at an individual site. (m2) is the area of the individual site. (unitless) is the land-use ratio, which represents the ratio of the land area used for a PV system. (m2/kW) is the land coverage ratio, which represents the ratio of land covered by a PV system. (unitless) is the capacity factor of a PV system.

Data for the area of individual site is obtained from GIS-based approach as previous section describes. XX% (XXm2) of the total Gyeonggi province area (XXm2) is explored which counts totally 100,000 individual sites. Data for the land-use ratio is calculated using actual PV installation cases data, or in some cases, are assumed, depending on the land-use types. As a rooftop PV case, 54.5% of the individual site area is utilized for a PV system on average in industrial complex, logistics complex, residential complex, and public buildings. The land-use ratio for the mountainous area and farmland are assumed to be 40% and 5% respectively. In parking lot and roadside land, 18.9% and 28.4 % of the individual site area is utilized for a PV system respectively. Data for the land coverage ratio is calculated using the actual PV installation cases data as well. Unlike the land-use ratio, land coverage ratio is applied depending on the PV technology types. For the case of roof-top PV, 7.23m2 is required for a PV system of 1kW capacity. For the one of ground-mounted PV, 11.50m2 is required for a PV system of 1kW capacity. Data for capacity factor is obtained from XX, which is calculated based on the actual power market data. The capacity factor is applied differently depending on the city& county where the individual sites are located.

While the land-use ratio for the roof-top PV cases is applied as the average on the four land-use types, the one for the ground-mounted PV cases are applied differently depending on each land-use type. The land-use ratio for the mountainous area and farmland are assumed to be 40% and 5% respectively.

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오명찬 (PhDThesis) Table5.2

태양 전지, 태양광 발전, 태양 에너지, 태양의이(가) 표시된 사진

자동 생성된 설명

텍스트, 스크린샷, 폰트, 디자인이(가) 표시된 사진

자동 생성된 설명

* 1. Assumption of LCOE

LCOE assumption from KEEI. Draw a graph.

* 1. Scenario

지도, 텍스트, 아틀라스이(가) 표시된 사진

자동 생성된 설명

|  |  |
| --- | --- |
| Scenario | Description |
| No Setback | PV generation potential without Setback regulation |
| Setback | PV generation potential under Setback regulation |

Coefficient >> LCR (Land Coverage Ratio)

Power-based direct land use : Martin-Chivelet (2016)

Ground Cover Ratio or (Spacing factor): Elkadeem et al. (2022) :20%: the ratio of total land requirements compared to the actual surface area of PV panels.

Ratio >> ELR이라고 명명하자. (Effective Land Ratio)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Explored suitable sites for PV | | | Applied parameters | | | | LCOE |
| Land-use type | Area (m2) | Number of sites | PV type | Ratio (%) | Coefficient (m2/kW) | Capacity factor |
| Industrial complex | 25,293,157 | 25,128 | Roof-top PV | 54.5 | 7.23 | Applied geographically\* | Applied geographically\* |
| Logistics complex | 5,450,717 | 1,848 |
| Residential complex | 44,657,356 | 132,000 |
| Public buildings | 5,618,738 | 12,810 |
| Mountainous area |  |  | Ground-mounted PV | 40 | 11.50 | Applied geographically\* |
| Farmland |  |  | 5 |
| Parking lot |  |  | 18.9 |
| Roadside land |  |  | 28.4 |
| Water | 56,372,992 | 446 | Floating PV |  |  |

\* It is applied differently depending on the city & county where the individual site is located.

1. Results
   1. Geographical potential of PV

GIS

s

|  |  |
| --- | --- |
| No Setback | Setback |
| Total | Total |
| 텍스트, 지도, 도표, 폰트이(가) 표시된 사진  자동 생성된 설명 |  |
| 지도, 텍스트, 아틀라스, 폰트이(가) 표시된 사진  자동 생성된 설명 |  |
| Industrial complex |  |
| Logistic complex |  |
| Residential complex |  |
| Public buildings |  |
| Parking lot |  |
| Roadside |  |
| Water |  |

Fig. 4. Geographical potential of PV generation

* 1. Supply curve of PV

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자동 생성된 설명

* 1. CO2 mitigation potential of PV

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1. Conclusions

Electrification

**CRediT authorship contribution statement**

**Seungho Jeon:** ABC. **Gildong Hong:** ABC. **Gyeonggi Do:** AB

**Declaration of competing interest**

The authors declare that they have no know competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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2. Definition of PR depends on researchers. [↑](#footnote-ref-3)