

Technical Note

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Powering the Cities: Technical Potential of Rooftop Solar for Public and Commercial Buildings in Two Metropolitan Cities in Indonesia

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Background

Indonesia has committed to reduce its fossil fuel dependence by aiming to increase renewable energy use in the national energy mix. Indonesia's National Energy Policy (NEP) is very clear, Indonesia must increase its renewable energy share with from only 8% in 2013 to 23% by 2025. This target, however, has yet to be executed effectively, as renewable energy deployment in Indonesia is moving slowly since the target was set in 2014. For the past three years, the share of renewables in Indonesia's power system is stable at 11 – 13%. Renewables growth reached only 3.6% each year¹, dominated by large-scale renewables: hydropower and geothermal. Other renewables, including solar energy and wind, contributed to less than 1% of total renewable installed capacity in 2018. This sluggish deployment is not in agreement with NEP, with 23% target by 2025, Indonesia must add 5 – 6 GW of renewables power plants each year. It means increasing its current renewables deployment rate by 6- to 8-fold.

Indonesia is often called a country with massive, untapped solar energy potential. Indonesia's average global horizontal irradiation² is 4.8 kWh/m², meaning a significant amount of electricity per year could be generated, as high as 1,534 kWh/year for each

¹ IESR, 2018, *Laporan Status Energi Bersih Indonesia 2018*

² Solargis, <https://solargis.com/maps-and-gis-data/download/indonesia>

installed kWp of solar panels². According to MEMR, Indonesia's technical potential of photovoltaic electricity generation is 559 GWp, calculated with panel efficiency of 15%³. In contrast to this high potential, cumulative solar power generation in Indonesia is still below 100 MW, lagging behind neighboring countries such as Thailand (over 2.7 GW of solar power), The Philippines (886 MW), and Singapore (150 MW)⁴.

In order to achieve NEP's target, through General Planning for National Energy (GPNE), government has regulated the mandatory use of rooftop solar for government and public buildings, of which a minimum of 30% of roof space area must be allocated for rooftop solar. The implementation of this mandatory clause, however, is currently not in place. Several government offices, such as The National Palace, The Office of the Vice President, and Secretariat General Office of MEMR have installed a certain amount of rooftop solar; but the move has not been followed by other ministries, government offices, and local government buildings. One of the challenges for local government is their limited understanding on procurements and the lack of certified vendors in their respective area.

MEMR has also issued Ministerial Regulation No. 49/2018 on rooftop solar PV, aiming to boost rooftop solar use by households, commercial buildings, and industries. While based on content there are several issues to address, such as its

low credit scheme of 1:0.65 ratio (compared to previous PLN's Directors' regulation issued in 2013), the regulation could be very attractive for commercial buildings as they tend to consider its electricity savings (own use). This is a window of opportunity for government and local government to encourage commercial buildings to use rooftop solar, since most metropolitan cities in Indonesia has several (if not many) large complex malls and department stores. AEON Mall in East Jakarta has just commenced the operation of their 507 kWp rooftop solar in April 2019⁵. It means malls and department stores can play a significant role in accelerating the use of rooftop solar in Indonesia, as their roof space area are large enough for at least hundreds kWp of rooftop solar.

With these reasons, Institute for Essential Services Reform (IESR) calculated technical potential of rooftop solar for public buildings and commercial buildings in Jakarta and Surabaya. With this data of technical potential, it is expected that the government, both national and local, can set up an ambitious target to increase renewable energy share and start transitioning to a low-carbon energy system.

Methodology

To simplify the calculation, we divided targeted buildings as follows:

Table 1. Building categories and details used in this study

Category	Details	Remarks
Government buildings	National government offices	for Jakarta only (national capital)
	Provincial government offices	
	City government offices	
	State and military hospitals	
	Prominent universities and colleges	
Commercial buildings	Prominent high schools	For Surabaya only
	Malls and department stores	
	Large private hospitals	For Surabaya only
	Large hotels	For Surabaya only

3 Ministry of Energy and Mineral Resources, 2014, P3TKEBT

4 IRENA, 2019, *Renewable Energy Statistics 2019*

5 <https://www.beritasatu.com/ekonomi/550757/plts-atap-berkapasitas-507-kwp-mulai-beroperasi>

We listed all the buildings based on information from government's official websites⁶, pinned their location on Google Maps, and then performed rooftop solar technical potential calculation for each building. We used a web-based photovoltaic design software⁷, in which a user is allowed to specify location, design (module model, racking geometry and layout, inverter model, electrical wiring characteristics, optimizer), and scenario (weather data, soiling, temperature variability, far and near shading) to determine technically feasible rooftop solar capacity. The version we used includes a web interface supporting overlay of Google Maps satellite images to ease the calculation. We picked default design and scenario from the software and only changed parallel formation of the panels on the roof (horizontally or vertically stacked, to optimize roof area).

We listed as the buildings measured and software setting (design and scenario) in the annex.

Result

In total, Surabaya has rooftop solar potential of 35.6 MWp, while Jakarta has 22.2 MWp of rooftop solar potential. The number could be significantly higher as we considered many government buildings but less on commercial buildings. In many metropolitan cities, commercial buildings and business complexes are abundant. They are often large in size, located in prime areas, and consume high amount of energy; making them a potential target for rooftop solar use.

Among the buildings we assessed in Surabaya, the highest two are prominent state universities, i.e. Airlangga University and Sepuluh Nopember Institute of Technology (ITS). They both occupy massive land complexes

which corresponds to their megawatt-order of rooftop solar potential. With most activities conducted during daylight time, both universities can benefit significantly from rooftop solar use, as their electricity consumption will certainly be reduced by utilizing solar energy. In the Top 10, 5 large malls in Surabaya each also has over 1 MW of rooftop solar potential (Table 2).

Table 2. Top 10 buildings with highest rooftop solar potential in Surabaya

No	Building	Capacity (kWp)
1	Airlangga University (Campus A & B)	3785.3
2	Institut Teknologi Sepuluh November	3629.1
3	Pakuwon Mall and Supermall Surabaya	3117.1
4	RSUD Dr. Soetomo Surabaya	2951.4
5	RS Angkatan Laut Dr. Ramelan	1734.7
6	Mall Tunjungan Plaza Surabaya	1567.4
7	Mall Grand City Mall Surabaya	1516.8
8	Mall Galaxy Mall Surabaya	1422.1
9	Mall City of Tomorrow Surabaya	1369.3
10	Hotel Ascott Waterplace Surabaya	1245.1

Similarly, malls in Jakarta also have high technical potential of rooftop solar (Table 3). In many big cities in Indonesia, malls and department stores are often huge in size. The growing ones also tend to expand, Galaxy Mall in Surabaya for example, has just opened its third building. With current ministerial regulation on rooftop solar, commercial buildings can take several benefits: they are allowed to install rooftop solar, they can use the solar energy (reducing their electricity bill), and in case of excess energy, they can export their electricity to PLN grid. Commercial buildings are not required to pay for parallel charge if they generate their own power, which is also a plus.

6 East Java Province (<http://jatimprov.go.id/read/profil/perangkat-daerah->), City of Surabaya (<https://www.surabaya.go.id/id/page/0/8060/daftar-nama-&-alamat-kepala-dinas-kota-surabaya>), City of Jakarta (<http://alamat-kantor-pemerintah.com/provinsi/alamat/11/DKI>), ministries building and malls in Jakarta are listed manually.

7 www.helioscope.com

Table 3. Top 10 buildings with highest rooftop solar potential in Jakarta

No	Building	Capacity (kWp)
1	Mall Kelapa Gading	2288.3
2	Jakarta State University	1664.6
3	Grand Indonesia	1614.7
4	Rumah Sakit Umum Pusat Fatmawati	1571.2
5	Rumah Sakit Cipto Mangunkusumo (RSCM)	1524.8
6	University of Indonesia Salemba	1431.4
7	Pondok Indah Mall	1308.8
8	RS Pusat Angkatan Darat (RSPAD) Gatot Soebroto	1133.8
9	Mall Central Park	989.8
10	Kementerian Pekerjaan Umum	617.3

Both cities also have state and military hospitals with high technical potential of rooftop solar, while other government offices are somewhat smaller in size. Over time, cities grow in size and their landscape also changes. However, buildings utilized for essential public services (e.g. health and education) are often maintained and preserved. Jakarta and Surabaya are similar in this instance, and thus it is also important to promote the use of rooftop solar for large complex state buildings such as hospitals.

We also listed Top 10 for each building category in Table 4 and 5.

The number of buildings we assessed in Jakarta is higher than in Surabaya (75 versus 69 buildings), but Surabaya has higher technical potential of rooftop solar. Due to land scarcity and high population density in Jakarta, many government offices are high-rise buildings with limited roof space area. On top of that, the roof area is often used for HVAC system (heating,

Table 4. Top 10 buildings with highest rooftop solar potential for each building category in Surabaya

No	Government Offices	Hospitals	Universities and Schools	Commercials
1	Dinas Pekerjaan Umum Bina Marga Jatim	RSUD Dr. Soetomo Surabaya	Universitas Airlangga Surabaya (Kampus A&B)	Pakuwon Mall dan Supermall Surabaya
2	Dinas Sosial Provinsi Jatim	RS Angkatan Laut Dr. Ramelan	Institut Teknologi Sepuluh November	Tunjungan Plaza Surabaya
3	Kantor Gubernur Jawa Timur	Rumah Sakit Jiwa Menur Surabaya	Universitas Kristen Petra	Grand City Mall Surabaya
4	Bappeda Jawa Timur	RSUD Haji Surabaya	SMA Negeri 2 Surabaya	Galaxy Mall Surabaya
5	DPRD Jawa Timur	RS Premier Surabaya	SMA Negeri 5 Surabaya	City of Tomorrow Surabaya
6	Dinas Pendidikan Provinsi Jatim	RS Adi Husada Undaan	SMA Negeri 6 Surabaya	Ascott Waterplace Surabaya
7	Dinas Perhubungan Provinsi Jatim	RS Husada Utama Surabaya	SMA Negeri 21 Surabaya	Surabaya Town Square
8	Dinas Pertanian dan Ketahanan Pangan Jatim	RS Adi Husada Kapasari		Ciputra World Surabaya
9	Dinas Kominfo dan Lingkungan Hidup Surabaya	RS Siloam Surabaya		Hotel Majapahit Surabaya
10	Dinas Perindustrian dan Perdagangan Jatim			Marvell City Mall

Table 5. Top 10 buildings with highest rooftop solar potential for each building category in Jakarta

No	Government Offices	Hospitals	Universities	Commercials
1	Kementerian Pekerjaan Umum	Rumah Sakit Umum Pusat Fatmawati	Universitas Negeri Jakarta	Mall Kelapa Gading
2	Kementerian Pertanian	Rumah Sakit Cipto Mangunkusumo (RSCM)	Universitas Indonesia Salemba	Grand Indonesia
3	Kementerian Pendidikan dan Kebudayaan	RS Pusat Angkatan Darat (RSPAD) Gatot Soebroto		Pondok Indah Mall
4	Kantor Gubernur dan Balaikota	RSUD Cengkareng		Mall Central Park
5	Kementerian Lingkungan Hidup dan Kehutanan	RSUD Budhi Asih		Senayan City
6	Kementerian Keuangan	RSUD Pasar Rebo		
7	Kementerian Tenaga Kerja dan Transmigrasi	RSUD Kebayoran Lama		
8	Kementerian Kesehatan	RSUD Tebet		
9	Kementerian Pertahanan	RSUD Cipayung		
10	Kementerian Koordinator Pembangunan Manusia dan Kebudayaan	RSUD Kemayoran		

ventilation, and air conditioning); thus, decreasing roof space available to install rooftop solar. With this early assessment, we also recommend the use of government offices' parking lot to install rooftop solar, in addition to the office building itself. However so, with the high number of government offices in both cities, mandatory implementation of General Planning for National Energy (GPNE) can boost rooftop solar deployment in Indonesia. Government itself should be an early adopter of rooftop solar, procuring rooftop solar in a large number and bringing down the cost. The government should procure in bulk to obtain lower price for rooftop solar, and consequently, it will grow the market size. With this step, we

expect the price of rooftop solar installation to be more affordable for homeowners, as they consider price as important key factor to install rooftop solar⁸.

Remarks

Powering the Cities (*Energi Surya untuk Kota*) is IESR's publication series discussing the use of renewable energy to provide energy for cities. This technical note is an early study and will be expanded to include more buildings and city spaces.

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⁸ Based on market survey performed in Greater Jakarta (2018) and Surabaya (2019)

Annex

Annex A1 - DKI Jakarta

No	Location	Building category	Capacity (kWp)
1	Kantor Gubernur dan Balaikota	Government office	474
2	Badan Pajak dan Retribusi Daerah & Dinas Pelayanan Pajak	Government office	67.5
3	Dinas Lingkungan Hidup DKI Jakarta	Government office	113
4	Dinas Pendidikan DKI Jakarta	Government office	61
5	Dinas Sosial Provinsi DKI Jakarta	Government office	31.4
6	Dinas Ketahanan Pangan, Kelautan dan Pertanian Provinsi DKI Jakarta	Government office	47
7	Badan Pengembangan Sumber Daya Manusia (BPSDM) DKI Jakarta	Government office	27.2
8	Dinas Pemberdayaan, Perlindungan Anak, dan Pengendalian Penduduk DKI Jakarta	Government office	87
9	Dinas Pariwisata dan Budaya DKI Jakarta	Government office	55
10	Dinas Penanaman Modal dan Pelayanan Terpadu Satu Pintu (DPMTSP) Jakarta	Government office	49.6
11	Dinas Lingkungan Hidup DKI Jakarta	Government office	115
12	Dinas Koperasi, Usaha Mikro, Kecil dan Menengah, Serta Perdagangan	Government office	95
13	Dinas Olahraga dan Pemuda Provinsi DKI Jakarta	Government office	40
14	Dinas Kependudukan dan Pencatatan Sipil DKI Jakarta	Government office	6.7
15	Dinas Perumahan dan Gedung Pemerintah Daerah, PU	Government office	15.4
16	Dinas Kesehatan DKI Jakarta	Government office	81
17	Kantor Wilayah Kementerian Hukum dan HAM DKI Jakarta	Government office	79
18	Dinas Perhubungan dan Bina Marga DKI Jakarta	Government office	133
19	Dinas Tenaga Kerja dan Transmigrasi Provinsi DKI Jakarta	Government office	53.1
20	Kementerian Koordinator Bidang Politik, Hukum, dan Keamanan	Ministries office	85.1
21	Kementerian Koordinator Bidang Perekonomian	Ministries office	87.4
22	Kementerian Koordinator Pembangunan Manusia dan Kebudayaan	Ministries office	232
23	Kementerian Dalam Negeri	Ministries office	119.7
24	Kementerian Luar Negeri	Ministries office	76.8
25	Kementerian Pertahanan	Ministries office	250
26	Kementerian Hukum dan Hak Asasi Manusia	Ministries office	12
27	Kementerian Keuangan	Ministries office	430
28	Kementerian Energi dan Sumber Daya Mineral	Ministries office	148
29	Kementerian Perindustrian	Ministries office	106
30	Kementerian Perdagangan	Ministries office	45
31	Kementerian Pertanian	Ministries office	587.5
32	Kementerian Lingkungan Hidup dan Kehutanan	Ministries office	433
33	Kementerian Perhubungan	Ministries office	17.6
34	Kementerian Kelautan dan Perikanan	Ministries office	61

35	Kementerian Tenaga Kerja dan Transmigrasi	Ministries office	330.9
36	Kementerian Pekerjaan Umum	Ministries office	617.3
37	Kementerian Kesehatan	Ministries office	321.6
38	Kementerian Pendidikan dan Kebudayaan	Ministries office	524.8
39	Kementerian Sosial	Ministries office	85
40	Kementerian Agama	Ministries office	151
41	Kementerian Kebudayaan dan Pariwisata	Ministries office	55
42	Kementerian Komunikasi dan Informatika	Ministries office	130
43	Kementerian Riset dan Teknologi	Ministries office	56
44	Kementerian Koperasi dan Usaha Kecil dan Menengah	Ministries office	160
45	Kementerian Pemberdayaan Perempuan dan Perlindungan Anak	Ministries office	195
46	Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi	Ministries office	66.2
47	Kementerian Pembangunan Daerah Tertinggal	Ministries office	146
48	Kementerian Perencanaan Pembangunan Nasional	Ministries office	92
49	Kementerian Badan Usaha Milik Negara	Ministries office	87
50	Kementerian Perumahan Rakyat	Ministries office	169
51	Kementerian Pemuda dan Olah Raga	Ministries office	120
52	Mall Central Park	Mall	989.8
53	Senayan City	Mall	539.2
54	Pondok Indah Mall	Mall	1308.8
55	Mall Kelapa Gading	Mall	2288.3
56	Grand Indonesia	Mall	1614.7
57	RSUD Koja	Hospital	23
58	RSUD Kemayoran	Hospital	28.8
59	RSUD Cipayung	Hospital	29.8
60	RSUD Budhi Asih	Hospital	77
61	RSUD Pasar Rebo	Hospital	38.4
62	RSUD Tebet	Hospital	30.7
63	RSUD Sawah Besar	Hospital	5.4
64	RSUD Tarakan	Hospital	22.4
65	RSUD Cengkareng	Hospital	169
66	RSUD Jatipadang	Hospital	4.8
67	RSUD Kebayoran Baru	Hospital	13.8
68	RSUD Kebayoran Lama	Hospital	33.6
69	RSUD Taman Sari	Hospital	12.5
70	RSUD Tanah Abang	Hospital	19.5
71	Hospital Cipto Mangunkusumo (RSCM)	Hospital	1524.8
72	RS Pusat Angkatan Darat (RSPAD) Gatot Soebroto	Hospital	1133.8
73	Hospital Umum Pusat Fatmawati	Hospital	1571.2
74	Universitas Indonesia Salemba	University	1431.4
75	Universitas Negeri Jakarta	University	1664.6

Annex A2 - Surabaya

No	Location	Building category	Capacity (kWp)
1	Kantor Gubernur Jawa Timur	Government office	331.5
2	Bappeda Jawa Timur	Government office	314
3	Sekretariat Daerah Jawa Timur	Government office	95
4	DPRD Jawa Timur	Government office	261
5	Dinas Kesehatan Provinsi Jawa Timur	Government office	84
6	Dinas Sosial Provinsi Jatim	Government office	336
7	Dinas Pendidikan Provinsi Jatim	Government office	231
8	Dinas Perhubungan Provinsi Jatim	Government office	216
9	Dinas Komunikasi dan Informatika Jatim	Government office	112
10	Dinas Tenaga Kerja dan Transmigrasi Jatim	Government office	130
11	Dinas Kebudayaan dan Pariwisata Jatim	Government office	164
12	Dinas Koperasi dan Usaha, Mikro, Kecil, Menengah(UMKM) Jatim	Government office	112
13	Dinas Kepemudaan dan Olahraga Jatim	Government office	95
14	Dinas Pekerjaan Umum Binamarga Jatim	Government office	553
15	Dinas Pekerjaan Umum Sumber Daya Air Jatim	Government office	53
16	Dinas Perumahan Rakyat, Kawasan Pemukiman dan Cipta Karya Jatim	Government office	34
17	Dinas Pertanian dan Ketahanan Pangan Jatim	Government office	209
18	Dinas Perkebunan Jatim	Government office	67
19	Dinas Peternakan Jatim	Government office	66
20	Dinas Kelautan dan Perikanan Jatim	Government office	135
21	Dinas Perindustrian dan Perdagangan Jatim	Government office	182
22	Dinas ESDM Jatim	Government office	95
23	Dinas Lingkungan Hidup Jatim	Government office	55
24	Dinas Perpustakaan dan Kearsipan Jatim	Government office	104
25	Dinas Pemberdayaan Masyarakat Jatim	Government office	46
26	Badan Kepegawaian Daerah Jatim	Government office	67
27	Badan Pengelola Keuangan dan Aset Daerah Jatim	Government office	81
28	Kantor Walikota Surabaya	Government office	125.4
29	Dinas Perumahan Rakyat dan Kawasan Permukiman, Cipta Karya dan Tata Ruang Surabaya	Government office	29
30	Dinas Kesehatan Surabaya	Government office	57
31	Dinas Pendidikan Surabaya	Government office	83.2
32	Dinas Kebersihan dan Ruang Terbuka Hijau Surabaya	Government office	23.7
33	Dinas Pemadam Kebakaran Surabaya	Government office	35
34	Dinas Kependudukan dan Capil & Dinas Perdagangan & Dinas Kebudayaan dan Pariwisata Surabaya	Government office	152.3
35	Dinas Kominfo dan Lingkungan Hidup Surabaya	Government office	196.2
36	Dinas Ketahanan Pangan dan Pertanian Surabaya	Government office	69.8
37	Dinas Perhubungan Surabaya	Government office	57.9

38	Dinas Pengelolaan Bangunan dan Tanah	Government office	16
39	Satpol Pamong Praja	Government office	38
40	Hotel Majapahit Surabaya	Hotel	453.8
41	JW Marriott Hotel Surabaya	Hotel	83.8
42	Sheraton Surabaya Hotels & Towers	Hotel	410.6
43	Bumi Surabaya City Resort	Hotel	81.9
44	Hotel Shangri-La Surabaya	Hotel	262.1
45	Ascott Waterplace Surabaya	Hotel	1245.1
46	Hotel Ciputra World Surabaya	Hotel	311.4
47	Tunjungan Plaza Surabaya	Mall	1567.4
48	Pakuwon Mall dan Supermall Surabaya	Mall	3117.1
49	Galaxy Mall Surabaya	Mall	1422.1
50	Ciputra World Surabaya	Mall	523.5
51	Marvell City Mall	Mall	436.5
52	City of Tomorrow Surabaya	Mall	1369.3
53	Grand City Mall Surabaya	Mall	1516.8
54	Surabaya Town Square	Mall	1026.6
55	RSUD Dr. Soetomo Surabaya	Hospital	2951.4
56	RSUD Haji Surabaya	Hospital	1032
57	Hospital Jiwa Menur Surabaya	Hospital	1162.2
58	RS Adi Husada Kapasari	Hospital	87.7
59	RS Adi Husada Undaan	Hospital	341.8
60	RS Angkatan Laut Dr. Ramelan	Hospital	1734.7
61	RS Siloam Surabaya	Hospital	80
62	RS Husada Utama Surabaya	Hospital	265
63	RS Premier Surabaya	Hospital	508.5
64	SMA Negeri 5 Surabaya	School	292.8
65	SMA Negeri 2 Surabaya	School	371.2
66	SMA Negeri 6 Surabaya	School	246.4
67	SMA Negeri 21 Surabaya	School	151
68	Institut Teknologi Sepuluh November	University	3629.1
69	Airlangga University (A & B)	University	3785.3

Annex A3 - Technical Parameter

Solar panel

Manufacturer	Trina Solar
Power	320.0 W
V _{mp}	37.1V
V _{oc}	45.8V
I _{sc}	9.1A
I _{mp}	8.63A
Technology	Si-Poly (72 cells)
Dimensions	0.992m x 1.956m
Temp Coefficient P _{max}	-0.41%/°C
Temp Coefficient V _{oc}	-0.32%/°C
Temp Coefficient I _{sc}	0.05%/°C

Inverter

Name	Sunny Tripower 24000TL-US
Manufacturer	SMA
Max Power	24.1 KW
Min Power	0
Max Voltage	1,000V
Max MPPT Voltage	800V
Min MPPT Voltage	150V
Min Voltage	150V
Source	CEC
Last Update	

Orientation of the modules

Set automatically to face the edge of the building

Tilt

Flush Mount Racking, which means tilt will follow the slope of the roof.

Row Spacing, Module Spacing, and Frame Spacing

Default from the software

Snapshot (example of panel arrangement on top of Dinas Kesehatan DKI Jakarta building)



