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Photovoltaic Land Area Converted into Aviation Fuel and Passenger Flight Performance

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Abstract

Purpose – Show with three simple example calculations the effect that photovoltaic (PV) energy production can have on commercial flight operations. Considered is rooftop PV, normal ground-mounted PV, and ground-mounted PV at airports.
Methodology – Calculations are based on first principles, common parameters, and statistics.
Findings – The result highlights the extremely high energy needs of commercial aviation relative to the renewable-energy yield of land by means of PV. The conclusion is not that airport-associated PV is unimportant. On the contrary, PV can contribute meaningfully to airport energy supply and synthetic-fuel production for aircraft operation. However: The calculation shows that even comparatively large PV areas that airports could offer correspond to only a small fraction (e.g. 1%) of the fuel demand created by commercial flight operations at the airport.

Table of Contents

1 Objective and System Boundary 3
2 Basic Conversion Factors 4
2.1 Energy Content of Aviation Kerosene 4
2.2 Power-to-Liquid Efficiency 4
2.3 Photovoltaic Electricity Yield 5
2.4 Aircraft Fuel Consumption 6
2.5 Combined Conversion Factor 6
3 Example 1: Rooftop PV Installation with 15.8 m² Module Area 7
4 Example 2: One Hectare of Land for Ground-Mounted PV 9
5 Example 3: Airport-Associated PV Area of 100 ha 12
5.1 Available PV Area 12
5.2 Annual PV Electricity and PtL Fuel Production 13
5.3 Illustrative Airport Traffic Model 14
5.4 Fuel Demand per Departure 15
5.5 Comparison with Hamburg Airport 15
5.6 Annual Airport Fuel Demand 16
5.7 Share Supplied by 100 ha PV 16
5.8 Real-World Check Using Fuel Uplift at Hamburg Airport 17
5.9 Interpretation of the 100 ha PV Area 19
5.10 Example of External Renewable-Energy Land: Hamburg and Kaltenkirchen 21
6 Summary of the Three Examples 23
7 Conclusions 25

1 Objective and System Boundary

This report provides an order-of-magnitude conversion between available area, photovoltaic (PV) electricity, Power-to-Liquid (PtL) kerosene, and passenger-aircraft transport performance. The conversion chain considered is:

available area → PV electricity → PtL kerosene → passenger-km

The objective is not to design a specific PV or PtL production facility. Instead, the calculations provide transparent conversion factors that allow the impact of available areas to be estimated. The considered system boundary starts with electricity available for PtL production. The PtL efficiency includes:

- hydrogen production by electrolysis,
- synthesis gas preparation,
- Fischer–Tropsch conversion,
- fuel upgrading.

The following aspects are not included separately:

- electricity storage,
- grid transport losses,
- direct-air-capture energy,
- airport infrastructure energy,
- aircraft manufacturing.

Therefore, the results represent an optimistic but technically plausible energy conversion estimate.

The aviation system boundary is the fuel consumed by aircraft. This should not be confused with claims of a "CO_2-neutral airport", which usually refer to airport-controlled activities such as buildings, vehicles, and purchased electricity. Aircraft fuel burned during flight operations is normally excluded from such airport carbon-neutrality claims.

2 Basic Conversion Factors

2.1 Energy Content of Aviation Kerosene

Jet fuel has a lower heating value of approximately

$H_u = 42.8\ \mathrm{MJ/kg}$ (ICAO value).
Using

$$1\ \mathrm{kWh} = 3.6\ \mathrm{MJ}$$

this corresponds to

$$H_u = \frac{42.8}{3.6} = 11.9\ \mathrm{kWh/kg}$$

For the present order-of-magnitude calculations:

$$\boxed{H_u = 12\ \mathrm{kWh/kg}}$$

is used.

Source: https://doi.org/10.1016/j.ccst.2024.100263

2.2 Power-to-Liquid Efficiency

A PtL process converts electrical energy into synthetic liquid hydrocarbons through several steps:

$$\text{electricity} \rightarrow \mathrm{H_2} \rightarrow \text{syngas} \rightarrow \text{FT fuel}$$

For a conservative present-day estimate, the overall electricity-to-liquid-fuel efficiency is assumed as:

$$\boxed{\eta_{\mathrm{PtL}} = 0.44}$$

This means 44% of the electrical energy input appears as chemical energy in the produced liquid fuel. For the internal decomposition, hydrogen production is assumed with:

$$\eta_{\mathrm{H_2}} = 0.65$$

The remaining conversion chain is therefore:

$$\eta_{\mathrm{FT,eff}} = \frac{\eta_{\mathrm{PtL}}}{\eta_{\mathrm{H_2}}}$$

or

$$\eta_{\mathrm{FT,eff}} = \frac{0.44}{0.65} = 0.68$$

Thus:

$$0.65 \cdot 0.68 \approx 0.44$$

The value 0.68 represents the effective efficiency of syngas preparation, Fischer–Tropsch synthesis, and fuel upgrading combined.

Sources:

- DLR PtL analysis:
  https://elib.dlr.de/109641
- U.S. Department of Energy PEM electrolysis targets:
  https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis

2.3 Photovoltaic Electricity Yield

The starting point is solar irradiation. For northern Germany, a typical annual solar irradiation is approximately:

$$1000\ \mathrm{kWh/(m^2\ a)}$$

A PV module converts part of this radiation into electricity. For a conservative estimate, a net module-area yield of:

$$\boxed{E_{\mathrm{PV}} = 200\ \mathrm{kWh/(m^2\ a)}}$$

is used. The area refers to **PV module area**, not land area.

Source: https://globalsolaratlas.info

2.4 Aircraft Fuel Consumption

The passenger aircraft fuel consumption is assumed as:

$$3\ \mathrm{kg/(100\ passenger\ -\ km)}$$

or:

$$\boxed{c_f = 0.03\ \mathrm{kg/(passenger\ -\ km)}}$$

This represents a modern passenger aircraft with good utilization.

2.5 Combined Conversion Factor

The annual PtL fuel production from one square meter of PV module area is:

$$m_f = \frac{E_{\mathrm{PV}} \cdot \eta_{\mathrm{PtL}}}{H_u}$$

With the adopted values:

$$m_f = \frac{200 \cdot 0.44}{12}$$

resulting in:

$$\boxed{m_f = 7.3\ \mathrm{kg/(m^2\ a)}}$$

The equivalent passenger transport performance is:

$$s_{\mathrm{pax}} = \frac{m_f}{c_f}$$

Therefore:

$$s_{\mathrm{pax}} = \frac{7.3}{0.03}$$

and:

$$\boxed{s_{\mathrm{pax}} = 244\ \mathrm{passenger\ -\ km/(m^2\ a)}}$$

The basic conversion used throughout this report is therefore:

$$\boxed{1\ \mathrm{m^2\ PV\ module} \rightarrow 7.3\ \mathrm{kg\ PtL/a} \rightarrow 244\ \mathrm{passenger\ -\ km/a}}$$

3 Example 1: Rooftop PV Installation with 15.8 m² Module Area

The first example considers a rooftop photovoltaic installation (Figure 3.1) with a module area of

$$A_{\mathrm{PV}} = 15.8\ \mathrm{m}^2 \quad .$$

Figure 3.1 This rooftop photovoltaic installation is considered in this example.

Because this is the actual PV module area, no correction for land use is necessary. The annual electrical energy production is

$$E_{\mathrm{el}} = A_{\mathrm{PV}} \cdot E_{\mathrm{PV}}$$

Thus,

$$E_{\mathrm{el}} = 15.8 \cdot 200$$

and therefore

$$\boxed{E_{\mathrm{el}} = 3160\ \mathrm{kWh/a}}$$

The corresponding chemical energy contained in the produced PtL fuel is

$$E_{\mathrm{fuel}} = E_{\mathrm{el}} \cdot \eta_{\mathrm{PtL}}$$

Hence,

$$E_{\mathrm{fuel}} = 3160 \cdot 0.44$$

which gives

$$\boxed{E_{\mathrm{fuel}} = 1390\ \mathrm{kWh/a}} \quad .$$

The annual PtL kerosene mass is

$$m_f = \frac{E_{\text{fuel}}}{H_u}$$

Thus,

$$m_f = \frac{1390}{12}$$

and therefore

$$\boxed{m_f = 116 \text{ kg/a}}$$

The corresponding passenger transport performance is

$$s_{\text{pax}} = \frac{m_f}{c_f}$$

Hence,

$$s_{\text{pax}} = \frac{116}{0.03}$$

which results in

$$\boxed{s_{\text{pax}} = 3860 \text{ passenger} - \text{km/a}}$$

The result can therefore be summarized as

$$\boxed{15.8 \text{ m}^2 \text{ rooftop PV} \rightarrow 116 \text{ kg PtL/a} \rightarrow 3860 \text{ passenger} - \text{km/a}} \quad .$$

This means that the annual output corresponds approximately to transporting one passenger

$$\boxed{3900 \text{ km}}$$

or, equivalently, 100 passengers (one smaller passenger aircraft) approximately

$$\boxed{39 \text{ km}}$$

4 Example 2: One Hectare of Land for Ground-Mounted PV

For a ground-mounted PV installation, the land area cannot generally be treated as identical to the PV module area (Figure 4.1). The available land area is

$$A_{\text{land}} = 1\ \text{ha} = 10\,000\ \text{m}^2$$

For this illustrative calculation, an effective module-area fraction of 50% is assumed:

$$f_A = 0.50 \quad .$$

Thus, the effective PV module area becomes

$$A_{\text{PV}} = f_A \cdot A_{\text{land}}$$

or

$$A_{\text{PV}} = 0.50 \cdot 10\,000$$

giving

$$\boxed{A_{\text{PV}} = 5000\ \text{m}^2}$$

The annual PV electricity production is therefore

$$E_{\text{el}} = A_{\text{PV}} \cdot E_{\text{PV}}$$

Thus,

$$E_{\text{el}} = 5000 \cdot 200$$

and consequently

$$\boxed{E_{\text{el}} = 1\,000\,000\ \text{kWh/a} = 1.0\ \text{GWh/a}}$$

The annual PtL kerosene production is

$$m_f = \frac{E_{\text{el}} \cdot \eta_{\text{PtL}}}{H_u}$$

Hence,

$$m_f = \frac{1\,000\,000 \cdot 0.44}{12}$$

which results in

$$\boxed{m_f = 36\,700 \text{ kg/a} = 36.7 \text{ t/a}}$$

The corresponding passenger transport performance is

$$s_{\text{pax}} = \frac{m_f}{c_f}$$

Thus,

$$s_{\text{pax}} = \frac{36\,700}{0.03}$$

and therefore

$$\boxed{s_{\text{pax}} = 1.22 \times 10^6 \text{ passenger} - \text{km/a}} \quad .$$

The result can be summarized as

$$\boxed{1 \text{ ha PV land} \rightarrow 36.7 \text{ t PtL/a} \rightarrow 1.22 \text{ million passenger} - \text{km/a}}$$

Frankfurt–New York Interpretation:

The great-circle distance between Frankfurt and New York is approximately

$$s_{\text{FRA-NYC}} \approx 6200 \text{ km} \quad .$$

The number of passengers who can be transported one-way from Frankfurt to New York with the annual PtL production of one hectare is

$$N_{\text{pax}} = \frac{s_{\text{pax}}}{s_{\text{FRA-NYC}}}$$

Thus,

$$N_{\text{pax}} = \frac{1.22 \times 10^6}{6200}$$

which gives

$$\boxed{N_{\text{pax}} \approx 197}$$

or, rounded,

$$\boxed{\text{approximately 200 passengers one-way from Frankfurt to New York}} \quad .$$

For a return journey, the corresponding number of passengers is approximately

$$N_{\text{pax,RT}} = \frac{197}{2}$$

and therefore

$$\boxed{N_{\mathrm{pax,RT}} \approx 100} \quad .$$

Thus, one hectare of land used for PV can be interpreted approximately as the annual energy-equivalent PtL production required to transport

$$\boxed{\text{200 passengers FRA} \rightarrow \text{NYC}}$$

or

$$\boxed{\text{100 passengers FRA} \rightarrow \text{NYC} \rightarrow \text{FRA}}$$

per year (or one smaller passenger aircraft).

This is an energy-equivalent interpretation. It does not imply that a specific aircraft is operated exclusively with fuel produced from that one hectare.

Figure 4.1 Aerial view of a ground-mounted photovoltaic installation near Mead, Nebraska, USA. Photo: AllTheUsernamesAreInUse, Wikimedia Commons, CC0 1.0. Source: Wikimedia Commons. Available from: https://commons.wikimedia.org/wiki/File:Mead,_Nebraska_solar_farm_aerial_2026_(cropped).jpg

5 Example 3: Airport-Associated PV Area of 100 ha

The third example considers an airport operator making available an area of

$$A_{\text{land}} = 100 \text{ ha}$$

for photovoltaic electricity generation. This corresponds to

$$A_{\text{land}} = 1\,000\,000 \text{ m}^2$$

and is approximately comparable to a strip of

$$3000 \text{ m} \times 333 \text{ m}$$

alongside a runway of about 3 km length. The 100 ha value is used as an illustrative benchmark. It does **not** imply that such an area can always be installed inside an active airport perimeter. The practical availability of PV areas depends on:

- obstacle limitation requirements,
- runway protection areas,
- navigation and communication equipment,
- access roads and drainage,
- ecological constraints,
- glare assessment.

Furthermore, an airport operator does not necessarily need to use land inside the airport boundary. Suitable land can also be acquired or leased outside the airport perimeter.

5.1 Available PV Area

As in the previous example, only part of the land area is assumed to be occupied by PV modules. Using the same land-to-module factor:

$$f_A = 0.50$$

the effective PV module area is

$$A_{\text{PV}} = f_A \cdot A_{\text{land}}$$

Thus,

$$A_{\mathrm{PV}} = 0.50 \cdot 1\,000\,000$$

and therefore

$$\boxed{A_{\mathrm{PV}} = 500\,000\ \mathrm{m}^2}$$

5.2 Annual PV Electricity and PtL Fuel Production

The annual electrical energy production is

$$E_{\mathrm{el}} = A_{\mathrm{PV}} \cdot E_{\mathrm{PV}}$$

Using

$$E_{\mathrm{PV}} = 200\ \mathrm{kWh/(m^2\ a)}$$

gives

$$E_{\mathrm{el}} = 500\,000 \cdot 200$$

and therefore

$$\boxed{E_{\mathrm{el}} = 100\,000\,000\ \mathrm{kWh/a}}$$

or

$$\boxed{E_{\mathrm{el}} = 100\ \mathrm{GWh/a}}$$

The corresponding annual PtL kerosene production is

$$m_f = \frac{E_{\mathrm{el}} \cdot \eta_{\mathrm{PtL}}}{H_u}$$

Thus,

$$m_f = \frac{100\,000\,000 \cdot 0.44}{12}$$

which results in

$$\boxed{m_f = 3\,667\,000\ \mathrm{kg/a}}$$

or

$$\boxed{m_f = 3667\ \mathrm{t/a}}$$

Therefore:

$$\boxed{100\ \mathrm{ha\ PV\ land} \rightarrow 3667\ \mathrm{t\ PtL/a}}$$

5.3 Illustrative Airport Traffic Model

The purpose of this section is not to model a specific airport. Instead, a representative medium-sized international airport is defined. The assumed airport has:

- one runway of approximately 3 km length,
- 17 h of daily operation,
- one aircraft movement every 3 min on average.

A **movement** is defined as either one landing or one take-off. The assumed movement rate is therefore:

$$n_{\mathrm{mov}} = \frac{60}{3}$$

which gives

$$\boxed{n_{\mathrm{mov}} = 20 \text{ movements/h}}$$

The annual number of movements is:

$$N_{\mathrm{mov}} = 20 \cdot 17 \cdot 365$$

and therefore

$$\boxed{N_{\mathrm{mov}} = 124\,100 \text{ movements/a}}$$

Assuming approximately equal numbers of arrivals and departures:

$$N_{\mathrm{dep}} = \frac{N_{\mathrm{mov}}}{2}$$

Thus,

$$N_{\mathrm{dep}} = \frac{124\,100}{2}$$

and

$$\boxed{N_{\mathrm{dep}} = 62\,050 \text{ departures/a}}$$

Equivalently, this corresponds to approximately one departure every 6 min during the assumed operating period. This traffic assumption should not be interpreted as the maximum capacity of a single runway. It is simply an average annual traffic rate chosen for an illustrative medium-sized airport.

5.4 Fuel Demand per Departure

A first estimate is obtained from passenger transport demand. The following assumptions are used:

$$N_{\text{pax}} = 120 \text{ passengers/flight}$$

and

$$s_{\text{flight}} = 1500 \text{ km}$$

representing a typical medium-range international flight. The fuel required per departure is:

$$m_{\text{fuel,dep}} = c_f \cdot N_{\text{pax}} \cdot s_{\text{flight}}$$

Substituting:

$$m_{\text{fuel,dep}} = 0.03 \cdot 120 \cdot 1500$$

gives

$$\boxed{m_{\text{fuel,dep}} = 5400 \text{ kg}}$$

or

$$\boxed{m_{\text{fuel,dep}} \approx 5.4 \text{ t/departure}}$$

For the following airport calculation, this is rounded to:

$$\boxed{m_{\text{fuel,dep}} = 5 \text{ t/departure}}$$

5.5 Comparison with Hamburg Airport

Hamburg Airport is used only as a **reality check**, not as the definition of the illustrative airport. Hamburg has a different runway configuration, with two intersecting runways. Therefore, the comparison concerns only the order of magnitude of annual traffic and fuel consumption. Hamburg Airport reported approximately **127 000** aircraft movements in 2024.

Source: https://perma.cc/UVZ3-8U8M

This is close to the illustrative value of **124 100** movements/a. The agreement confirms that the assumed traffic level is representative of a medium-sized international airport, although the runway concepts are different.

Hamburg's scheduled operating period of approximately 06:00–23:00 also supports the use of

$$17\ \mathrm{h/day}$$

as an illustrative assumption.

Source: https://perma.cc/3HT9-VF2Y

5.6 Annual Airport Fuel Demand

Using the rounded fuel demand:

$$m_{\mathrm{fuel,dep}} = 5\ \mathrm{t/departure}$$

the annual aircraft fuel demand is:

$$m_{\mathrm{airport}} = N_{\mathrm{dep}} \cdot m_{\mathrm{fuel,dep}}$$

Therefore:

$$m_{\mathrm{airport}} = 62\,050 \cdot 5$$

resulting in:

$$\boxed{m_{\mathrm{airport}} = 310\,250\ \mathrm{t/a}}$$

5.7 Share Supplied by 100 ha PV

The annual PtL production from the PV area is:

$$m_{\mathrm{PtL}} = 3667\ \mathrm{t/a}$$

The fraction of airport fuel demand supplied is:

$$f_{\mathrm{PV}} = \frac{m_{\mathrm{PtL}}}{m_{\mathrm{airport}}} \cdot 100$$

Thus:

$$f_{\mathrm{PV}} = \frac{3667}{310\,250} \cdot 100$$

and therefore:

$$\boxed{f_{\mathrm{PV}} = 1.18\%}$$

Rounded:

$$\boxed{\text{100 ha PV supplies approximately 1.2\% of annual aircraft fuel demand}}$$

An alternative interpretation is the number of departures that could be supplied:

$$N_{\mathrm{dep,PtL}} = \frac{3667\ \mathrm{t/a}}{5\ \mathrm{t/departure}}$$

giving:

$$\boxed{N_{\mathrm{dep,PtL}} \approx 730\ \mathrm{departures/a}}$$

Compared with:

$$62\ 050\ \mathrm{departures/a}$$

this again gives approximately:

$$\boxed{1.2\%}$$

Key result:

$$\boxed{\text{100 ha of PV land} \rightarrow 3667\ \mathrm{t\ PtL/a} \rightarrow \approx 730\ \mathrm{departures/a}}$$

for an airport requiring approximately:

$$\boxed{62\ 000\ \mathrm{departures/a}}$$

under the assumed operating conditions.

5.8 Real-World Check Using Fuel Uplift at Hamburg Airport

The previous calculation used a deliberately simple model based on:

$$120\ \mathrm{passengers/flight}$$
$$1500\ \mathrm{km/flight}$$

and

$$3\ \mathrm{kg/(100\ passenger\ -\ km)}$$

which resulted in approximately:

$$5.4\ \mathrm{t/departure}$$

A useful independent check is available from actual fuel-uplift data for Hamburg Airport. For 2024, the amount of kerosene supplied at Hamburg Airport was reported as:

$$V_f = 368\,997\ \mathrm{m^3/a} \quad .$$

Source: https://perma.cc/6CDM-FLE6

Using an approximate Jet A-1 density of:

$$\rho_f = 0.80\ \mathrm{t/m^3}$$

the corresponding annual fuel mass is:

$$m_f = V_f \cdot \rho_f$$

Thus:

$$m_f = 368\,997 \cdot 0.80$$

giving:

$$\boxed{m_f \approx 295\,000\ \mathrm{t/a}}$$

Hamburg Airport reported approximately 63 600 departures in 2024.

Source: https://perma.cc/ES78-D26N

The average fuel uplift per departure is therefore:

$$m_{\mathrm{fuel,dep}} = \frac{295\,000}{63\,600}$$

which gives approximately:

$$\boxed{m_{\mathrm{fuel,dep}} \approx 4.6\ \mathrm{t/departure}}$$

This value is close to the simplified model result of:

$$5.4\ \mathrm{t/departure}$$

The difference is entirely plausible because actual fuel uplift depends on operational factors such as:

- residual fuel on arrival,
- tankering,
- route length,
- aircraft type,
- alternate and reserve fuel requirements,
- refuelling strategy.

The comparison supports the use of the rounded value:

$$\boxed{m_{\mathrm{fuel,dep}} = 5\ \mathrm{t/departure}}$$

for the illustrative airport calculation.

5.9 Interpretation of the 100 ha PV Area

The use of 100 ha should be understood as an illustrative land-resource assumption. It is not necessary to assume that all 100 ha are located directly adjacent to the runway or even inside the airport boundary. This is important because airport land is subject to operational restrictions, including:

- obstacle limitation surfaces,
- navigation-system protection zones,
- runway and taxiway safety areas,
- access requirements,
- drainage,
- environmental restrictions,
- possible glare effects.

As a result, the practically usable PV area inside an airport boundary may be much smaller than the total open area visible on an airport map (Figure 5.1 and 5.2). However, airport operators may also:

- use terminal and hangar roofs,
- use parking structures,
- use peripheral airport land,
- lease suitable external sites,
- acquire land specifically for renewable-energy production.

Figure 5.1 Hamburg Airport with its intersecting runway system. Much land, but little available for PV. Photo: Oliver Sorg / Hamburg Airport. Available from: https://www.hamburg-airport.de/de/unternehmen/die-politische-kommunikation-am-hamburg-airport-35804, https://perma.cc/4AVC-9XRM.

Figure 5.2 Northwest Runway at Frankfurt Airport. Much land, but little available for PV. Photo: Fraport AG. Source: Fraport AG, https://www.fraport.com/en/newsroom/press-releases/2021/q2-2021/frankfurt-airport-to-reopen-northwest-runway-from-june-1.html, https://perma.cc/2ZVP-HBFE.

This broadens the relevant question from:

How much PV can physically be installed inside the airport perimeter?

to:

How much land can an airport operator make available for photovoltaic electricity production?

For the energy calculation presented here, this distinction is important because only the total productive PV area matters.

5.10 Example of External Renewable-Energy Land: Hamburg and Kaltenkirchen

Hamburg Airport provides a useful example of the principle that renewable-energy land does not need to be located directly at the airport. Hamburg Airport owns land near Kaltenkirchen,

where once a replacement airport was planned and land had been purchased. Today, Hamburg Airport is using this broader land portfolio as part of its renewable-energy strategy.

The significance for the present report is not the airport's carbon-neutrality claim itself, but the land-use concept:

airport-related renewable-energy land can be geographically separate from the airport

This makes the 100 ha benchmark more meaningful. It can be interpreted as land controlled, leased, or acquired by the airport operator, rather than land that must necessarily be found between runways and taxiways.

Source: https://perma.cc/C7R6-9JRE

6 Summary of the Three Examples

The three examples can now be compared directly.

Example 1: Rooftop PV

$$15.8\ \mathrm{m}^2$$

of PV module area produce approximately:

$$\boxed{116\ \mathrm{kg\ PtL/a}}$$

corresponding to:

$$\boxed{3860\ \mathrm{passenger-km/a}}$$

Example 2: One hectare of PV land

$$1\ \mathrm{ha}$$

with 50% effective PV module coverage produces approximately:

$$\boxed{36.7\ \mathrm{t\ PtL/a}}$$

corresponding to:

$$\boxed{1.22\ \mathrm{million\ passenger-km/a}}$$

This is approximately sufficient for:

$$\boxed{200\ \mathrm{passengers\ FRA \rightarrow NYC}}$$

or:

$$\boxed{100\ \mathrm{passengers\ FRA \rightarrow NYC \rightarrow FRA}}$$

per year.

Example 3: Airport-associated PV area

$$100\ \mathrm{ha}$$

with the same 50% effective PV module coverage produce approximately:

$$\boxed{3667\ \mathrm{t\ PtL/a}}$$

For the illustrative airport:

$$62\,050 \text{ departures/a}$$

with:

$$5 \text{ t/departure}$$

result in:

$$\boxed{310\,250 \text{ t/a}}$$

of annual aircraft fuel demand.

The PV-derived PtL therefore supplies:

$$\boxed{1.18\% \approx 1.2\%}$$

of the annual aircraft fuel demand.

Equivalently, it supplies fuel for approximately:

$$\boxed{730 \text{ departures/a}}$$

out of:

$$\boxed{62\,000 \text{ departures/a}}$$

Table 6.1 Compact Summary Table of three examples using photovoltaics for aviation.

Case	Area	PtL fuel per year	Aviation interpretation
1.) Rooftop PV	15.8 m² module area	116 kg/a	3860 passenger-km/a
2.) PV field	1 ha land	36.7 t/a	1.22 million passenger-km/a ≈ 200 passengers FRA–NYC one-way
3.) Airport-associated PV	100 ha land	3667 t/a	≈ 730 departures/a
Illustrative airport demand	—	310,250 t/a	62,050 departures/a
PV share of airport demand	—	—	≈ 1.2%

7 Conclusions

The area-to-flight conversion can be summarized by the following chain:

$$\boxed{1\ \mathrm{m}^2\ \mathrm{PV\ module} \rightarrow 7.3\ \mathrm{kg\ PtL/a} \rightarrow 244\ \mathrm{passenger} - \mathrm{km/a}}$$

For ground-mounted PV with 50% effective module coverage:

$$\boxed{1\ \mathrm{ha\ land} \rightarrow 36.7\ \mathrm{t\ PtL/a}}$$

and:

$$\boxed{100\ \mathrm{ha\ land} \rightarrow 3667\ \mathrm{t\ PtL/a}}$$

The most striking result is the airport comparison:

$$\boxed{100\ \mathrm{ha\ of\ PV\ land} \rightarrow \mathrm{only\ about\ 1.2\%\ of\ annual\ aircraft\ fuel\ demand}}$$

for the illustrative medium-sized international airport considered here.

This result highlights the extremely high energy needs of commercial aviation relative to the renewable-energy yield of land.

The conclusion is not that airport-associated PV is unimportant. On the contrary, PV can contribute meaningfully to airport energy supply and synthetic-fuel production. However:

The calculation shows that even comparatively large PV areas correspond to only a small fraction of the fuel demand created by commercial flight operations at the airport.