ENPHASE

Technical Brief

Comparing the powerful IQ7A with IQ7+

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Introduction

PV module and inverter selection are two of important decisions when designing and planning a new PV installation. Technological breakthroughs in the photovoltaic sector, especially in PV modules and inverters markets permanently encourage to look for the best equipment in PV system design, optimizing the module and inverter pairing to ensure these new components to work smoothly together, while maximizing the PV system performance.

With a peak output power of 366 VA, the new IQ7A is the most powerful Enphase microinverter designed yet, enhancing the 60- and 72-cell microinverter family features and advantages of unique software-defined architecture, ready for the present and upcoming PV modules. With the IQ 7+ microinverter's peak output power being 295 VA, doubts can rise amongst installers about the adequacy in using each of the microinverter models depending on the PV module power rating. This document aims to address this very concern. Let's begin with introduction to the concept of DC:AC Ratio.

The DC:AC ratio is used to describe the relationship of PV module power rating, a direct current (DC) source, divided by the inverter output power rating, an alternating current source (AC). Every PV system has a DC:AC ratio regardless of architecture. Many inverters have DC:AC ratio limitations for reliability and warranty purposes. Enphase Microinverters have no DC:AC ratio limit aside from DC input voltage and current compatibility.

Deeper and further explanation about the DC:AC ratio and the importance in the PV lifetime performance, including extensive formulation and the corresponding method of calculation can be found on the Technical Brief, Why is my PV module rating larger than my inverter rating?[1].

To provide some context on DC:AC ratios and assist in the decision-making process between IQ 7A and IQ 7+, energy performance has been simulated using PVSYST[2] on different locations across Europe with dissimilar solar radiation and temperature conditions, as shown in Figure 1.

PVGIS[3] was used as the weather data source.

As PVSYST is based on the PV module parameters defined by every module manufacturer, Table 9 (please see the Appendix section) gathers the complete list of selected models ranging from 365 Wp (that means, starting from the IQ7A DC:AC ratio of 1.0), to 590 Wp. Having different degradation guarantees by each PV module manufacturer, the 25-year aggregated energy results will vary depending on each PV module parameters. Unless otherwise noted, DC circuit losses are considered 0% and soiling loss as 3%. AC circuit losses depend on each project design, hence not considered in this study. Output energy is measured at the inverter terminals. More information about the parameters used while simulating the Enphase microinverter systems can be found in the Technical Brief, Guide to Modeling Enphase Microinverter Systems with PVsyst v6[4].

The aim of this document is not to compare the energy yield among the module manufacturers, but to bring light to the right inverter model selection by analyzing the PV system performance using different PV modules. Excellent results shown by the new IQ 7A will advise the use of this model ahead of IQ 7+ for the PV projects using higher rated PV modules.

[1] Enphase Energy Inc, 2019
https://enphase.com/en-us/support/technical-brief-why-my-pv-module-rating-larger-my-inverter-rating

[2] PVsyst SA
https://www.pvsyst.com/

[3] Photovoltaic Geographical Information System, European Commission Joint Research Centre
https://ec.europa.eu/jrc/en/pvgis

[4] Enphase Energy Inc, 2015
https://enphase.com/en-us/support/guide-modeling-enphase-microinverter-systems-pvsyst-v6

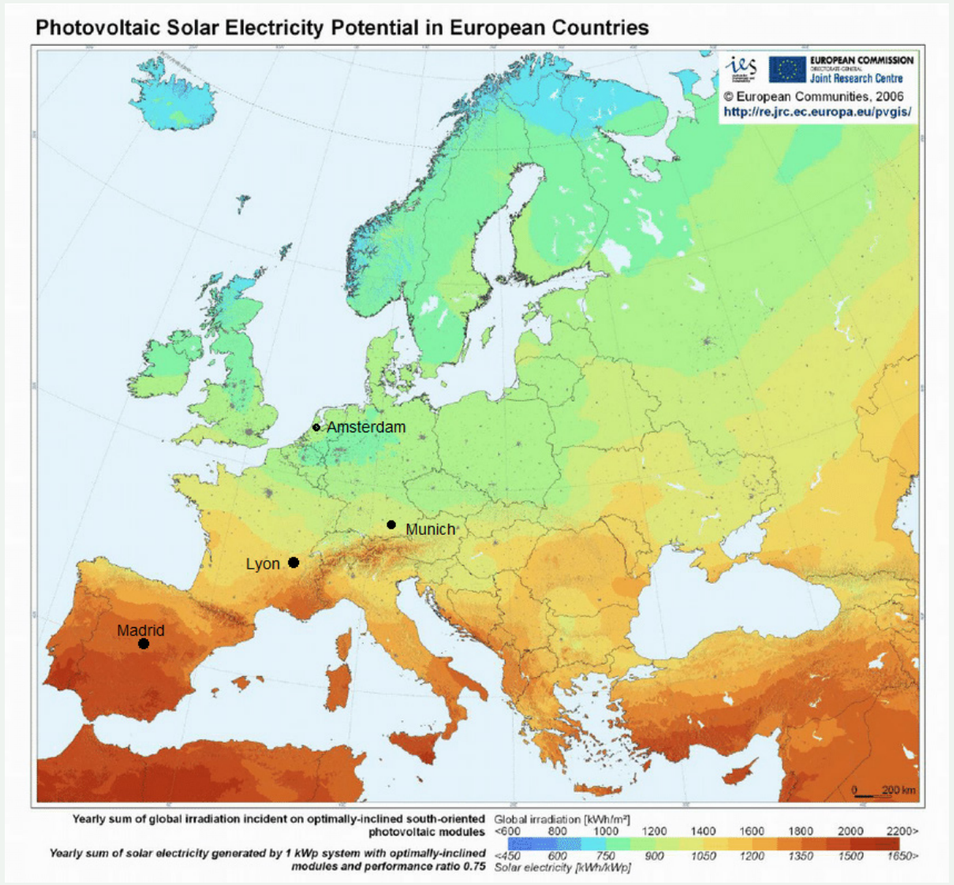

Figure 1: Yearly sum of global irradiation incident on optimally-inclined south-oriented PV modules in Europe. Source: PVGIS [5]

[5] Photovoltaic Geographical Information System, European Commission Joint Research Centre
https://ec.europa.eu/jrc/en/pvgis

Analyzing data results

Comparing energy performance between IQ 7+ and IQ 7A

Figure 2 shows the 25-year aggregated energy generated and clipping losses using the same PV module rates on both IQ7+ and IQ7A. Results highlight the lower IQ7A clipping losses compared to IQ7+, therefore implying higher net energy available and better PV system yield when using the new IQ7A. The higher the PV module rate, the wider the differences between IQ 7+ and IQ 7A performance.

It is noteworthy that clipping losses with IQ7A is almost zero until 500Wp.

Influence on location

Figure 3 shows the 25-year aggregated clipping losses over generated energy. Comparing both series of data, the IQ7A

Figure 4 compares the energy increase over 1.00 DC:AC ratio using the IQ7A microinverter during 25 years of production at different locations across Europe. The take away is: higher DC:AC ratio yields higher energy.

Looking at the increase of energy generated by the IQ 7A over the IQ 7+, Figure 5 shows results at different locations in Europe. As the southern latitudes generally produce more energy given the higher yearly irradiation shown in Figure 1, the use of IQ 7A microinverters will proportionally increase the energy generated as well.

Given the IQ7A energy generated additionally against the IQ7+ microinverter, conclusions can easily be drawn by calculating the IQ7A payback over IQ7+ based on the customer energy price per kWh and the difference of cost between both microinverter models.

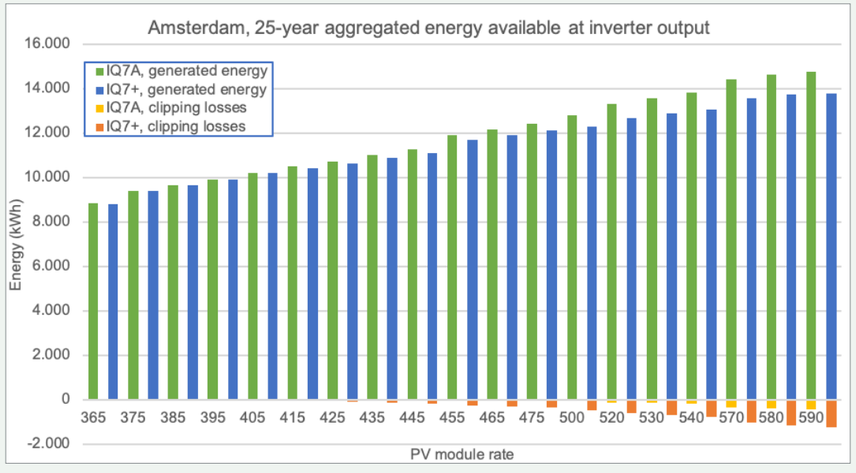

Figure 2: Amsterdam, 25° tilt, 180° azimuth, 25-year aggregated energy available at inverter input

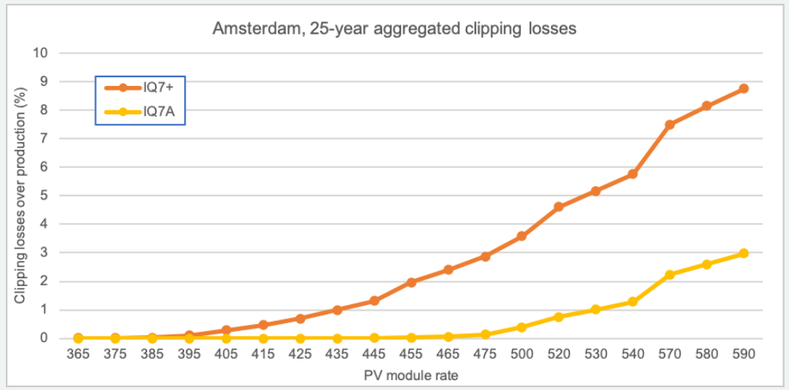

Figure 3: Amsterdam, 25° tilt, 180° azimuth, 25-year aggregated clipping losses

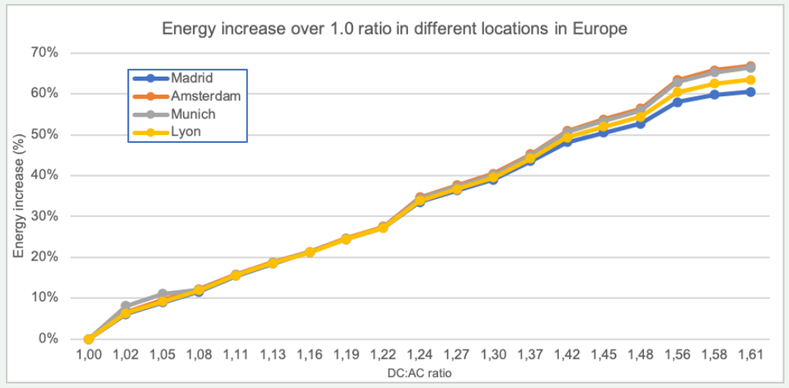

Figure 4: IQ7A, energy increase over 1.0 ratio at different locations in Europe

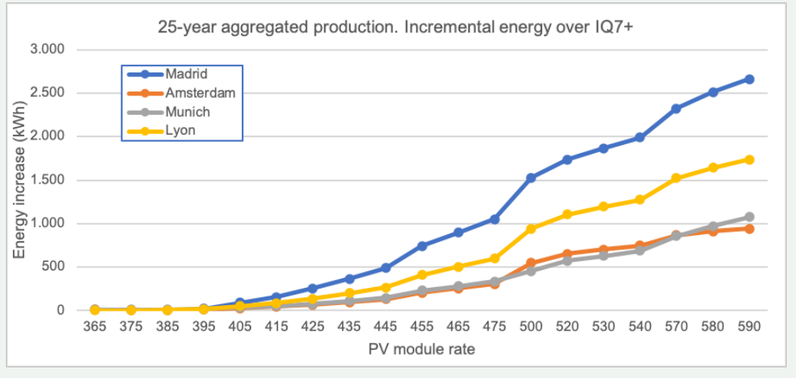

Figure 5: Additional energy generated by IQ7A when compared to IQ 7+ at different locations in Europe

IQ 7+ Simulation results

The following tables indicate example simulated single-module 25-year aggregated energy yield and clipping losses for various PV module rates on the IQ 7+ Microinverter at various locations across Europe. In this model, the module orientation is fixed at 180° azimuth, 25° tilt, and soiling loss at 3%. Many real-world PV systems do not have ideal true south orientations of 180° azimuth and ideal tilt angles, so the impact of clipping will be lower than shown in the tables below.

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 365 Wp PV module (%)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.24	8,829.6	0.00%	0.11	0.00%
375	1.27	9,417.4	6.66%	0.62	0.01%
385	1.31	9,669.6	9.51%	2.88	0.03%
395	1.34	9,911.4	12.25%	10.33	0.10%
405	1.37	10,207.7	15.61%	27.97	0.27%
415	1.41	10,457.1	18.43%	47.67	0.46%
425	1.44	10,661.0	20.74%	73.31	0.69%
435	1.47	10,922.3	23.70%	108.04	0.99%
445	1.51	11,138.4	26.15%	145.91	1.31%
455	1.54	11,702.1	32.53%	229.93	1.96%
465	1.58	11,913.0	34.92%	286.40	2.40%
475	1.61	12,119.0	37.25%	348.25	2.87%
500	1.69	12,292.3	39.22%	439.55	3.58%
520	1.76	12,693.0	43.76%	584.93	4.61%
530	1.80	12,892.4	46.01%	667.57	5.18%
540	1.83	13,084.1	48.18%	754.94	5.77%
570	1.93	13,576.6	53.76%	1,019.03	7.51%
580	1.97	13,749.7	55.72%	1,121.46	8.16%
590	2.00	13,815.5	56.47%	1,210.09	8.76%

Table 1: IQ 7+ - Amsterdam, azimuth: 180°, tilt: 25°

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 365 Wp PV module (%)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.24	9,419.3	0.00%	0.82	0.01%
375	1.27	10,188.2	8.16%	3.91	0.04%
385	1.31	10,457.7	11.02%	9.43	0.09%
395	1.34	10,561.1	12.12%	14.89	0.14%
405	1.37	10,876.3	15.47%	34.97	0.32%
415	1.41	11,141.1	18.28%	56.75	0.51%
425	1.44	11,360.6	20.61%	85.38	0.75%
435	1.47	11,636.5	23.54%	123.83	1.06%
445	1.51	11,864.9	25.96%	165.93	1.40%
455	1.54	12,448.6	32.16%	258.36	2.08%
465	1.58	12,670.0	34.51%	321.62	2.54%
475	1.61	12,885.6	36.80%	391.18	3.04%
500	1.69	13,218.2	40.33%	557.74	4.22%
520	1.76	13,632.8	44.73%	731.24	5.36%
530	1.80	13,835.7	46.89%	831.89	6.01%
540	1.83	14,029.5	48.94%	939.25	6.69%
570	1.93	14,504.7	53.99%	1,283.70	8.85%
580	1.97	14,613.9	55.15%	1,473.79	10.08%
590	2.00	14,620.8	55.22%	1,642.39	11.23%

Table 2: IQ 7+ - Munich, azimuth: 180°, tilt: 25°

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 365 Wp PV module (%)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.24	11,345.2	0.00%	1.14	0.01%
375	1.27	12,058.4	6.29%	3.40	0.03%
385	1.31	12,376.0	9.09%	9.86	0.08%
395	1.34	12,675.0	11.72%	26.31	0.21%
405	1.37	13,063.0	15.14%	64.78	0.50%
415	1.41	13,364.7	17.80%	105.60	0.79%
425	1.44	13,614.6	20.00%	158.61	1.16%
435	1.47	13,918.9	22.69%	227.66	1.64%
445	1.51	14,170.0	24.90%	302.01	2.13%
455	1.54	14,781.6	30.29%	464.33	3.14%
465	1.58	15,014.4	32.34%	573.41	3.82%
475	1.61	15,237.8	34.31%	692.36	4.54%
500	1.69	15,424.5	35.96%	872.20	5.65%
520	1.76	15,846.6	39.68%	1,142.26	7.21%
530	1.80	16,049.1	41.46%	1,296.64	8.08%
540	1.83	16,241.6	43.16%	1,458.61	8.98%
570	1.93	16,687.9	47.09%	1,982.14	11.88%
580	1.97	16,803.4	48.11%	2,218.23	13.20%
590	2.00	16,823.1	48.28%	2,421.47	14.39%

Table 3: IQ 7+ - Lyon, azimuth: 180º, tilt: 25º

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 365 Wp PV module (%)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.24	14,783.3	0.00%	2.19	0.01%
375	1.27	15,680.6	6.07%	6.55	0.04%
385	1.31	16,087.1	8.82%	18.89	0.12%
395	1.34	16,458.8	11.33%	48.63	0.30%
405	1.37	16,971.8	14.80%	123.26	0.73%
415	1.41	17,340.7	17.30%	197.55	1.14%
425	1.44	17,453.9	18.06%	234.23	1.34%
435	1.47	18,016.9	21.87%	422.39	2.34%
445	1.51	18,305.3	23.82%	556.61	3.04%
455	1.54	18,981.9	28.40%	841.19	4.43%
465	1.58	19,238.8	30.14%	1,028.87	5.35%
475	1.61	19,483.3	31.79%	1,230.12	6.31%
500	1.69	19,677.9	33.11%	1,527.64	7.76%
520	1.76	20,145.6	36.27%	1,966.91	9.76%
530	1.80	20,358.6	37.71%	2,213.12	10.87%
540	1.83	20,559.5	39.07%	2,470.74	12.02%
570	1.93	21,017.5	42.17%	3,272.99	15.57%
580	1.97	21,084.1	42.62%	3,661.85	17.37%
590	2.00	21,050.9	42.40%	4,000.76	19.01%

Table 4: IQ 7+ - Madrid, azimuth: 180º, tilt: 25º

IQ 7A Simulation results

The following tables indicate example simulated single-module 25-year aggregated energy yield and clipping losses for various PV module rates on the IQ 7A Microinverter at various locations across Europe. In this model, the module orientation is fixed at 180° azimuth, 25° tilt, and soiling loss at 3%. Many real-world PV systems do not have ideal true south orientations of 180° azimuth and ideal tilt angles, so the impact of clipping will be lower than shown in the tables below.

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 1.0 DC:AC ratio (%)	Energy increase over equivalent IQ 7+ PV system (kWh)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.00	8,841.5	0.00%	11.9	0.00	0.00%
375	1.02	9,426.4	6.62%	9.0	0.00	0.00%
385	1.05	9,678.2	9.46%	8.6	0.00	0.00%
395	1.08	9,924.3	12.25%	12.9	0.00	0.00%
405	1.11	10,236.8	15.78%	29.1	0.00	0.00%
415	1.13	10,502.1	18.78%	45.0	0.00	0.00%
425	1.16	10,727.5	21.33%	66.5	0.00	0.00%
435	1.19	11,019.5	24.63%	97.2	0.06	0.00%
445	1.22	11,269.7	27.46%	131.3	0.42	0.00%
455	1.24	11,909.6	34.70%	207.5	2.67	0.02%
465	1.27	12,168.7	37.63%	255.7	7.16	0.06%
475	1.30	12,424.4	40.52%	305.4	15.37	0.12%
500	1.37	12,841.5	45.24%	549.2	49.49	0.39%
520	1.42	13,347.2	50.96%	654.2	100.62	0.75%
530	1.45	13,594.4	53.76%	702.0	136.09	1.00%
540	1.48	13,832.1	56.45%	748.0	177.62	1.28%
570	1.56	14,442.4	63.35%	865.8	321.97	2.23%
580	1.58	14,658.9	65.80%	909.2	381.62	2.60%
590	1.61	14,758.0	66.92%	942.5	438.28	2.97%

Table 5: IQ 7A - Amsterdam, azimuth: 180°, tilt: 25°

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 1.0 DC:AC ratio (%)	Energy increase over equivalent IQ 7+ PV system (kWh)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.00	9,431.5	0.00%	12.2	0.00	0.00%
375	1.02	10,199.6	8.14%	11.4	0.00	0.00%
385	1.05	10,471.5	11.03%	13.8	0.00	0.00%
395	1.08	10,577.4	12.15%	16.3	0.00	0.00%
405	1.11	10,911.0	15.69%	34.7	0.00	0.00%
415	1.13	11,193.1	18.68%	52.0	0.02	0.00%
425	1.16	11,436.3	21.26%	75.7	0.11	0.00%
435	1.19	11,745.5	24.53%	109.0	0.55	0.00%
445	1.22	12,011.4	27.35%	146.5	1.61	0.01%
455	1.24	12,677.0	34.41%	228.4	5.63	0.04%
465	1.27	12,951.4	37.32%	281.4	11.70	0.09%
475	1.30	13,222.1	40.19%	336.5	21.54	0.16%
500	1.37	13,672.3	44.96%	454.1	60.11	0.44%
520	1.42	14,204.4	50.61%	571.6	116.12	0.82%
530	1.45	14,465.1	53.37%	629.4	155.23	1.07%
540	1.48	14,716.3	56.03%	686.8	201.20	1.37%
570	1.56	15,360.0	62.86%	855.3	362.31	2.36%
580	1.58	15,586.0	65.25%	972.1	429.22	2.75%
590	1.61	15,694.0	66.40%	1,073.2	493.51	3.14%

Table 6: IQ 7A - Munich, azimuth: 180°, tilt: 25°

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 1.0 DC:AC ratio (%)	Energy increase over equivalent IQ 7+ PV system (kWh)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.00	11,348.0	0.00%	2.8	0.00	0.00%
375	1.02	12,060.5	6.28%	2.1	0.00	0.00%
385	1.05	12,381.5	9.11%	5.5	0.00	0.00%
395	1.08	12,693.2	11.85%	18.2	0.00	0.00%
405	1.11	13,116.1	15.58%	53.1	0.00	0.00%
415	1.13	13,453.6	18.55%	88.9	0.01	0.00%
425	1.16	13,750.4	21.17%	135.8	0.14	0.00%
435	1.19	14,117.8	24.41%	198.9	0.78	0.01%
445	1.22	14,435.9	27.21%	265.9	2.57	0.02%
455	1.24	15,192.9	33.88%	411.3	9.85	0.06%
465	1.27	15,517.4	36.74%	503.0	21.11	0.14%
475	1.30	15,835.1	39.54%	597.3	39.57	0.25%
500	1.37	16,367.2	44.23%	942.7	112.15	0.69%
520	1.42	16,952.8	49.39%	1,106.2	215.43	1.27%
530	1.45	17,242.3	51.94%	1,193.2	285.43	1.66%
540	1.48	17,518.1	54.37%	1,276.5	366.58	2.09%
570	1.56	18,209.9	60.47%	1,522.0	646.79	3.55%
580	1.58	18,445.3	62.54%	1,641.9	761.54	4.13%
590	1.61	18,557.9	63.53%	1,734.8	872.00	4.70%

Table 7: IQ 7A - Lyon, azimuth: 180°, tilt: 25°

Module STC (Wdc)	DC:AC Ratio	25-year aggregated energy (kWh)	Energy yield increase over 1.0 DC:AC ratio (%)	Energy increase over equivalent IQ 7+ PV system (kWh)	25-year aggregated inverter clipping loss (kWh)	25-year aggregated inverter clipping loss (%)
365	1.00	14,768.2	0.00%	-15.1	0.00	0.00%
375	1.02	15,667.8	6.09%	-12.8	0.00	0.00%
385	1.05	16,083.8	8.91%	-3.3	0.00	0.00%
395	1.08	16,481.7	11.60%	22.9	0.00	0.00%
405	1.11	17,062.7	15.54%	90.9	0.00	0.00%
415	1.13	17,499.2	18.49%	158.5	0.04	0.00%
425	1.16	17,711.9	21.29%	258.0	0.33	0.00%
435	1.19	18,382.9	24.48%	366.0	1.66	0.01%
445	1.22	18,794.0	27.26%	488.7	5.30	0.03%
455	1.24	19,721.9	33.54%	740.0	19.90	0.10%
465	1.27	20,134.5	36.34%	895.7	42.18	0.21%
475	1.30	20,535.5	39.05%	1,052.2	77.89	0.38%
500	1.37	21,204.8	43.58%	1,526.9	212.43	1.00%
520	1.42	21,881.1	48.16%	1,735.5	400.44	1.83%
530	1.45	22,224.6	50.49%	1,866.0	527.18	2.37%
540	1.48	22,548.8	52.68%	1,989.3	673.22	2.99%
570	1.56	23,338.6	58.03%	2,321.1	1,165.18	4.99%
580	1.58	23,596.7	59.78%	2,512.6	1,361.04	5.77%
590	1.61	23,712.8	60.57%	2,661.9	1,549.46	6.53%

Table 8: IQ 7A - Madrid, azimuth: 180°, tilt: 25°

Conclusion

The primary purpose of this paper is to provide a technical framework for discussion. Some common locations in Europe and typical configurations of IQ 7+ and new IQ 7A Enphase Microinverters are simulated in PVSYST to show how the reference performance metrics are affected by DC:AC ratio variations.

Comparing the 25-year aggregated energy yield for the analyzed locations, results are influenced by local conditions of solar irradiance and temperature. Nevertheless, increasing DC:AC ratio will always increase energy yield for IQ7A and IQ7+ at every location.

The use of both microinverter models has been discussed and proved to be feasible with the current top rated PV modules, yet the IQ 7A microinverter maximizes the PV system energy yield compared to IQ 7+, especially when the DC:AC ratio is increased. Clipping losses are less than 1/100 compared to IQ 7+ in some cases.

This energy production climb, together with clipping losses drop, makes the use of IQ 7A more attractive from both energetic and economic points of view in most of the analyzed cases.

Appendix

Table 9 gathers the comprehensive list of PV modules used for the simulations carried out in PVSYST to support the current document results.

DC:AC RATIO		Rated power (Wp)	PV MODULE		Module degradation		Lifespan production warranty (years)
IQ7+	IQ7A		Manufacturer	Model	Year 0 (%)	Linear (%/year)	
1.24	1.00	**365**	Jinko Solar	365M-72-V	2.00	0.70	25
1.27	1.02	**375**	Longi	LR6-72HPH-375M	2.00	0.55	25
1.31	1.05	**385**	LongiI	LR6-72HPH-385M	2.00	0.55	25
1.34	1.08	**395**	JA Solar	JAM72S10-395/ PR	2.50	0.60	25
1.37	1.11	**405**	JA Solar	JAM72S10-405/ PR	2.50	0.60	25
1.41	1.13	**415**	JA Solar	JAM72S10-415/ PR	2.50	0.60	25
1.44	1.16	**425**	Jinko Solar	JKM425M-78H-V	2.50	0.60	25
1.47	1.19	**435**	Jinko Solar	JKM435M-78H-V	2.50	0.60	25
1.51	1.22	**445**	Jinko Solar	JKM445M-78H-V	2.50	0.60	25
1.54	1.24	**455**	Jinko Solar	JKM455M-7RL3-V	2.00	0.55	25
1.58	1.27	**465**	Jinko Solar	JKM465M-7RL3-V	2.00	0.55	25
1.61	1.30	**475**	Jinko Solar	JKM475M-7RL3-V	2.00	0.55	25
1.69	1.37	**500**	Canadian	CS3Y-500MS 1500V	2.00	0.55	25
1.76	1.42	**520**	Jinko Solar	JKM520M-7TL4-V	2.00	0.55	25
1.80	1.45	**530**	Jinko Solar	JKM530M-7TL4-V	2.00	0.55	25
1.83	1.48	**540**	Jinko Solar	JKM540M-7TL4-V	2.00	0.55	25
1.93	1.56	**570**	Jinko Solar	JKM570M-7TL4-V	2.00	0.55	25
1.97	1.58	**580**	Jinko Solar	JKM580M-7TL4-V	2.00	0.55	25
2.00	1.61	**590**	Canadian	CS6Y-590MS 1500V	2.00	0.55	25

Table 9: PV modules used for the PVSYST simulations