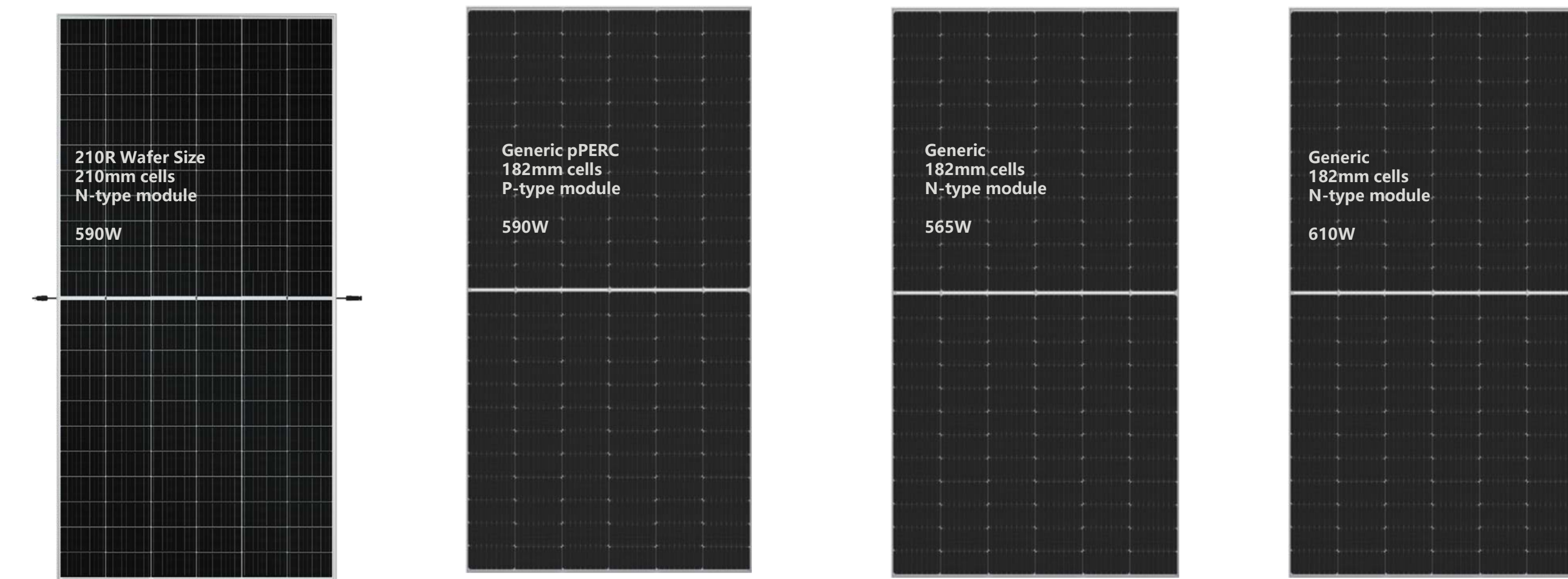


LCOE Assessment of TOPCon N-type Panels that utilize 210mm cells

Introduction

Module manufacturers in the utility market are investigating ways to optimize energy production of modules by incorporating larger cells of lower voltage ratings and higher efficiency. One of the main concerns of having panels with larger cells is the impacts of additional cost considerations due to heavier mechanical loads and structural considerations. Additionally, the future generation of solar panels also need to have compatibility with existing and future inverter and tracker technologies. This study assesses how 210mm N-type cell technology can mitigate the cost involved with structural considerations, especially as they compare to PERC conventional modules that are rated 600W+ and other modules that utilize the 182mm cell. The analysis was performed to show the potential impact that the following modules may have on solar project LCOE:

- Generic, N-type, 182mm cell module – 610W
- Generic, pPERC, 182mm cell module – 590W
- TOPCon N-type, 210mm cell module – 590W
- Generic, N-type, 182mm cell module – 565W

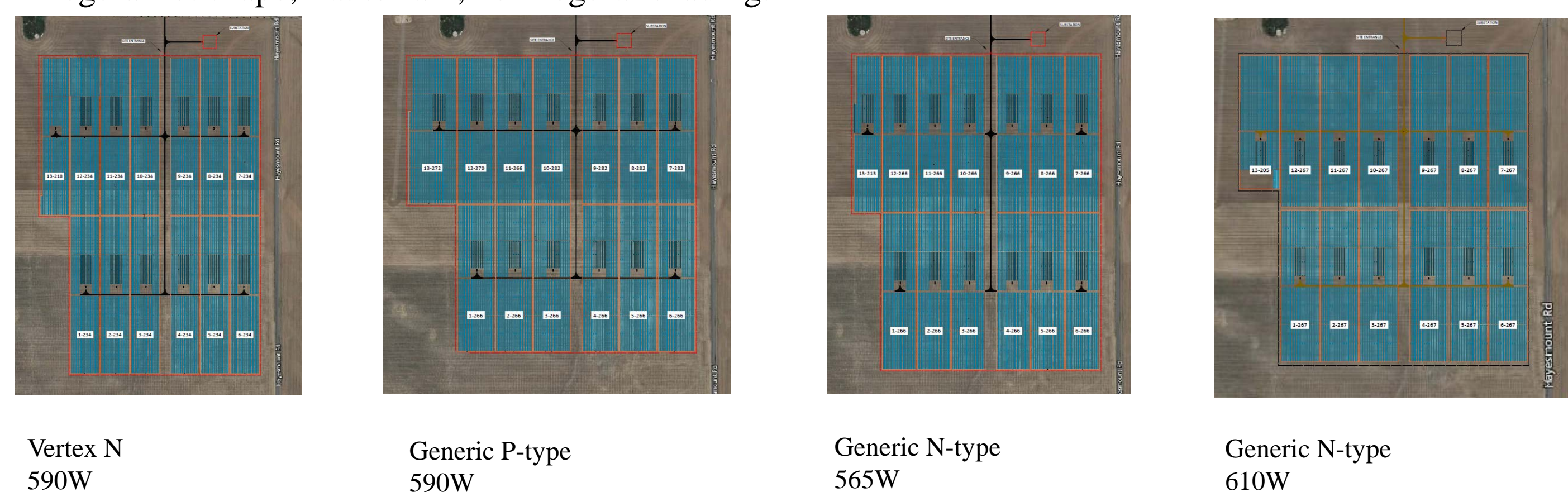


The strategies to realizing low LCOE at the module level involve improving technology that will harness the advantages of higher power, higher efficiency, higher power generation and higher reliability. Traditional P-type module development has reached its optimal point due to the process cost reduction, and the efficiency of P-type mass production cells has been closely approaching its bottleneck of efficiency. In addition, 182mm cells have its own limitation on the power rating and density that can be assembled in a single PV module. It is anticipated that with the combination of the N-type TOPCon module technology over conventional pPERC, in addition to having more power that results from a larger 210mm cell, that the N-type 210mm module would have the lowest LCOE and advantages in CAPEX savings, compared to the other conventional technologies.

Assessment Methodology

Four different projects scenarios were created for a hypothetical jobsite using the above-mentioned modules. Using standard industry methods and current market conditions, initial construction costs (civil, electrical, soft costs, labor) were considered for each scenario, and land space was compared. Each system was modeled using PVSYST for the production estimates and the results were obtained for a 30-year operating life of the plant. The site and plant design characteristics are as follows:

- Project site : Denver, Colorado, US Latitude: 39.92° Longitude: -104.65°
- Annual GHI: 1,745.2 kWh/m² Average temperature: 10.09°C
- Project size : 50MWdc, 39.6MWac (at POI)
- Project Life: 30 years
- NX 1P single axis tracker
- Central Inverter: Sungrow SG3600UD-MV
- Ground coverage ratio (GCR): 0.35, DC/AC ratio: 1.26
- Regular lot shape, flat terrain, no irregular shading.



To calculate the LCOE, the Net Present value (NPV) of the project costs were divided by the NPV of the project's generation over the life of the facility, as shown below:

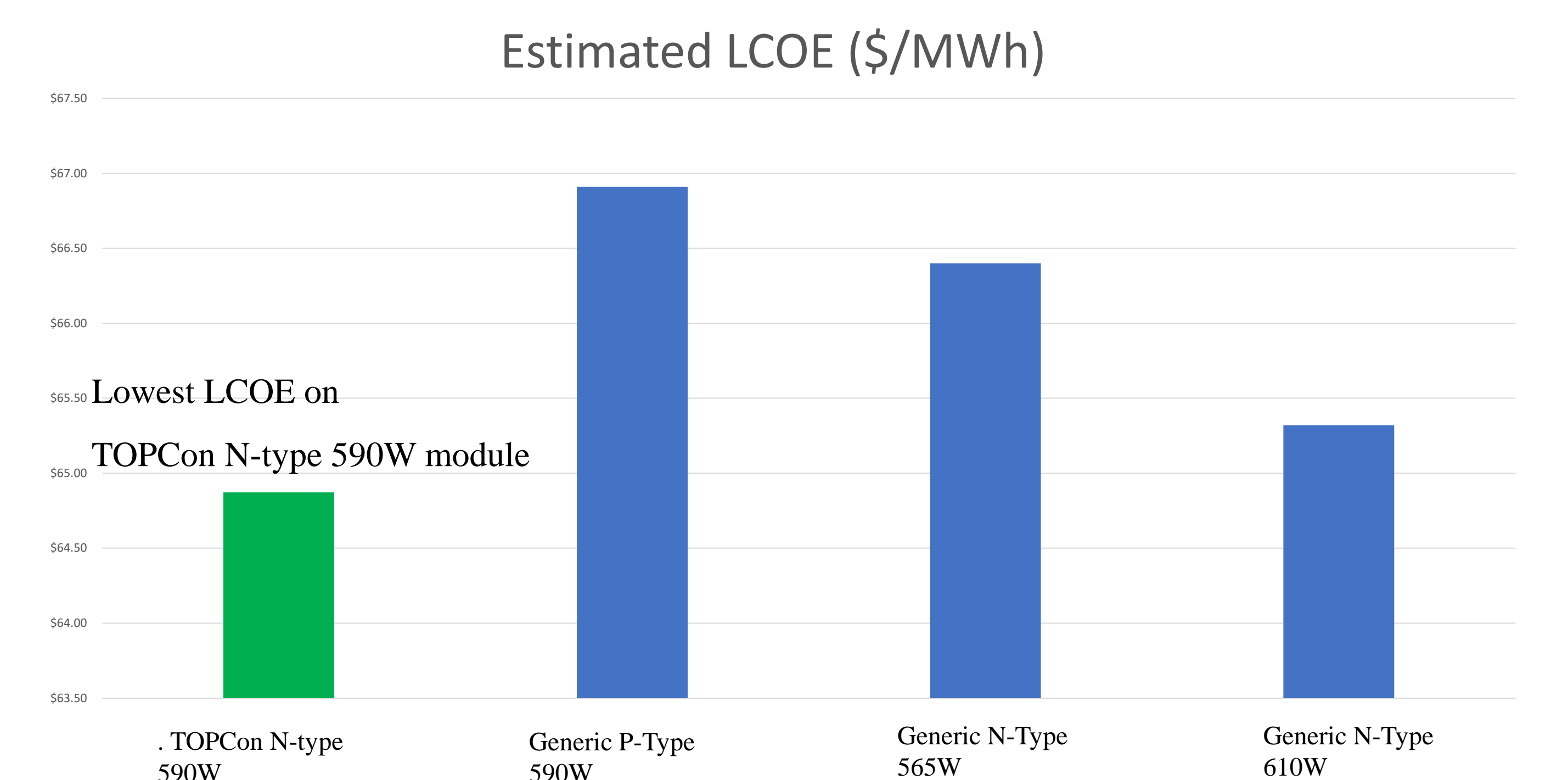
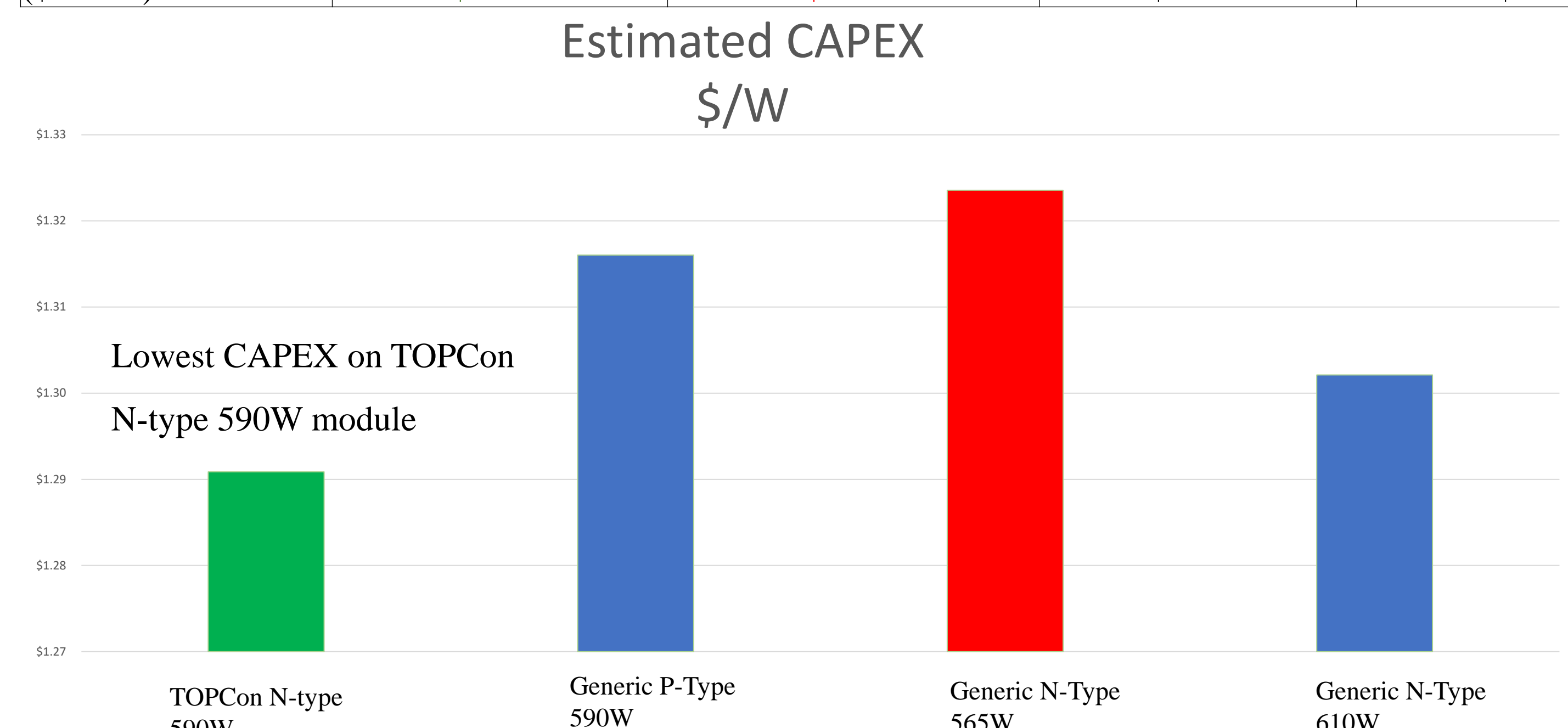
$$LCOE = \frac{\sum NPV(Construction + Financing + Lease + O\&M + Insurance + Asset Management)}{\sum [Lifetime MWh Output (1 - Degradation)^t]}$$

Key Findings

System Design Parameter	TOPCon N-type, 210mm cell 590W	Generic, pPERC, 182mm cell 590W	Generic, N-type, 182mm cell 565W	Generic, N-type, 182mm cell 610W
System DC Capacity (kWp)	50,023	50,013	50,019	50,010
String DC Voltage			1500	
Modules per String	28	24	26	24
Number of Modules	84,784	84,768	88,530	81,984
Y1 Annual Energy Production [MWh]	100,871	99,562	100,790	100,762
Annual Specific Yield [kWh/yr/kWp]	2,019	1,994	2,018	2,017
Performance Ratio	82.20%	81.20%	82.00%	82.20%

- The performance ratio of TOPCon N-type 590W closely matches with that of the 182mm N-type 610W module. This result supports previous results that the 210mm cell has a positive advantage over 182mm cells
- The TOPCon N-type 590W module production versus P-type 590W module resulted in a 1,309 MWh difference, which supports the hypothesis that the N-type technology has higher energy yield per Watt (currently +3% versus PERC)
- The TOPCon N-type 590W panels allows for the longest series string length which resulted in the most savings in DC wiring and eBOS cost
- Despite highest rated module of 610W, this module gave the smallest system DC capacity. This was because the 610W panel was also the largest dimensioned panel and required the furthest spacing between racks

	TOPCon N-type 590W	Generic P-Type 590W	Generic N-Type 565W	Generic N-Type 610W
Estimated CAPEX (\$/W)	\$1.29	\$1.32	\$1.32	\$1.30
Estimated LCOE (\$/MWh)	\$64.87	\$66.91	\$66.40	\$65.32



Observations and Conclusions

- Cost savings benefits for the N-Type 590W versus P-Type 590W:
 - Rack & Post Install and Construction ~ \$875K
 - Civil Costs: ~ \$122K
 - Total initial cost CAPEX savings: ~ \$1.25M
- Cost savings benefits for the N-Type 590W versus N-Type 610W:
 - Rack & Post Install and Construction ~ \$531K
 - Civil Costs: ~ \$49K
 - Total initial cost CAPEX savings: ~ \$547K
- Cost savings benefits for the N-Type 590W versus N-Type 565W:
 - Rack & Post Install and Construction ~ \$1.17M
 - Total initial cost CAPEX savings: ~ \$1.63M

The Trina NEG19RC.20 590W module results in the lowest calculated LCOE of the four modules and is \$0.45 less than the next lowest Generic 610W module.

For more information on this study, please contact bobby.naimool@trinasolar.com