The effect of the solar cell band gap on power yield

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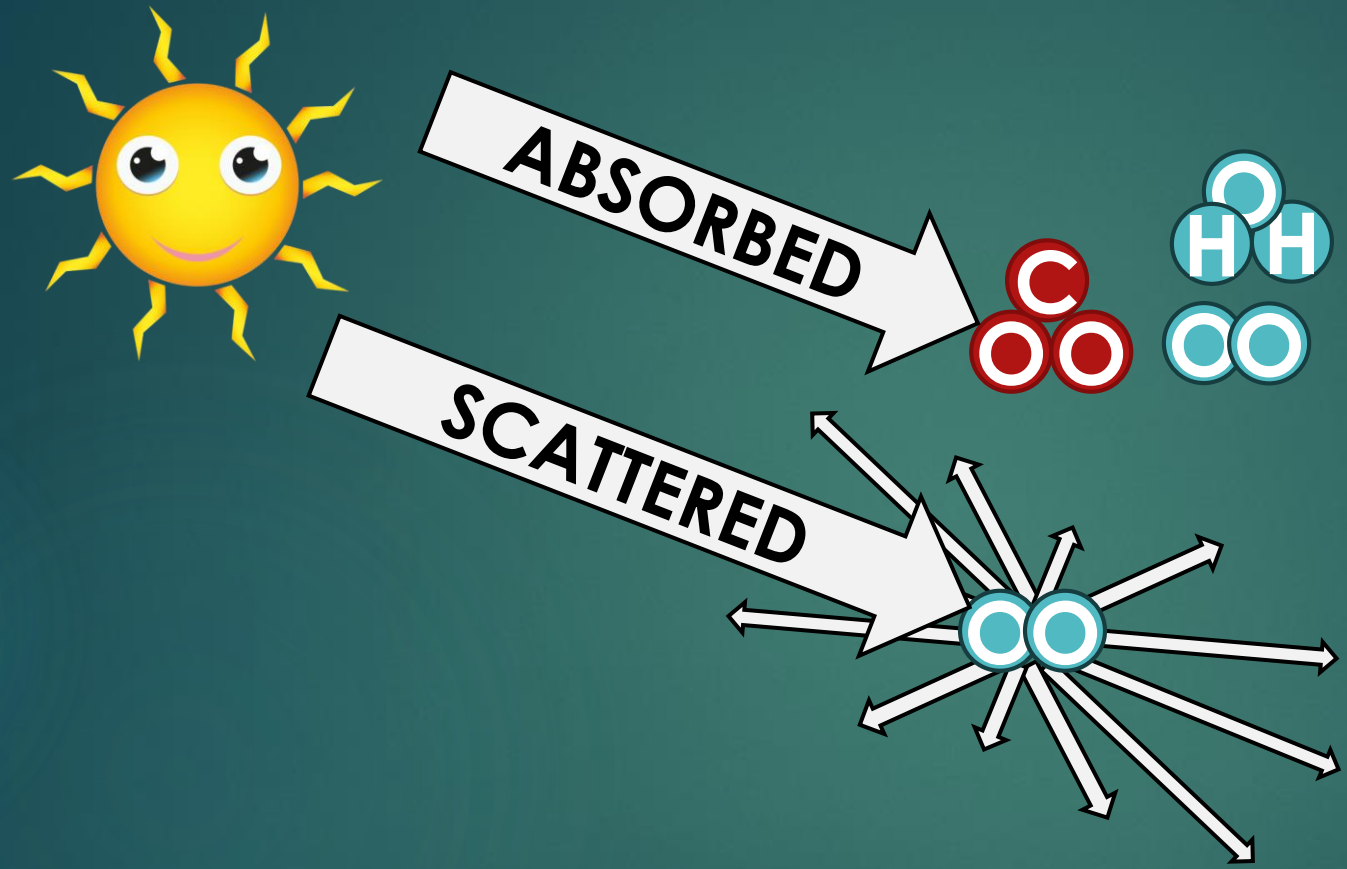
Content

- Solar irradiance calculations
  - Theoretical efficiency limit for single p-n junction solar cell
  - Radiative recombination
- What is the Shockley-Queisser limit
- Why this paper
- Results
- Conclusion
- Questions

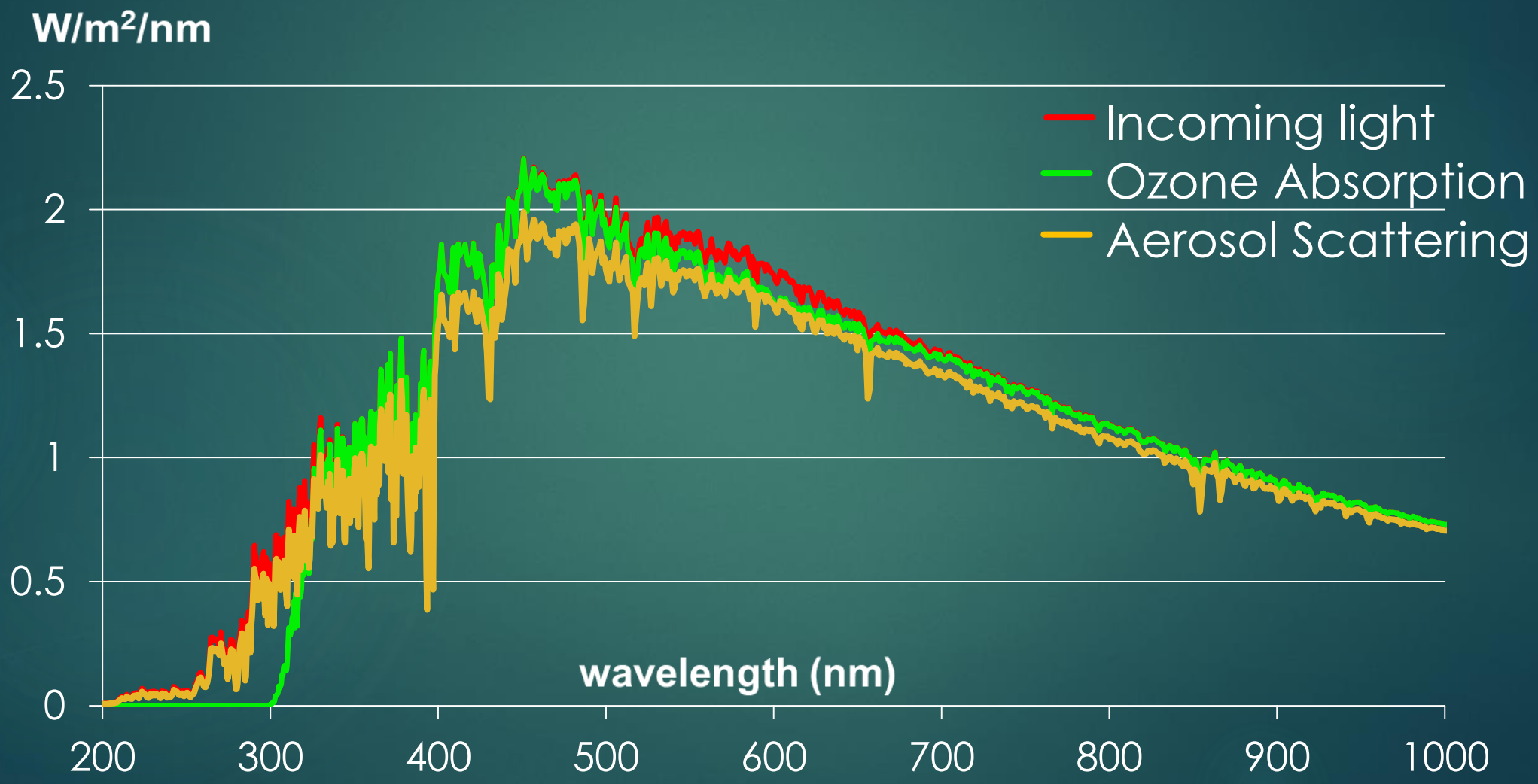
Extinction of the solar irradiance



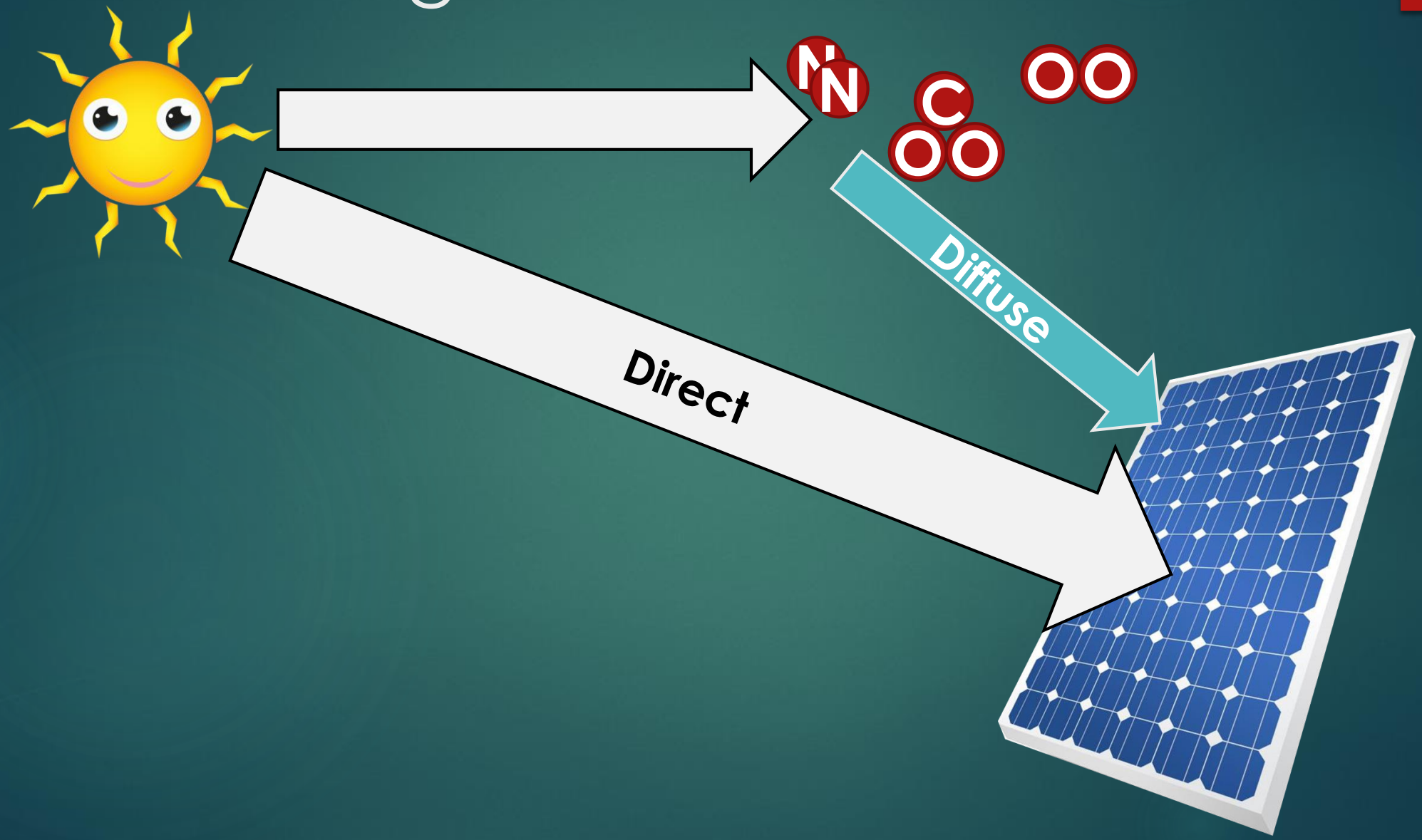
- O_2
- CO_2
- O_3
- H_2O

- Rayleigh Scattering
- Mie Scattering

Extinction examples

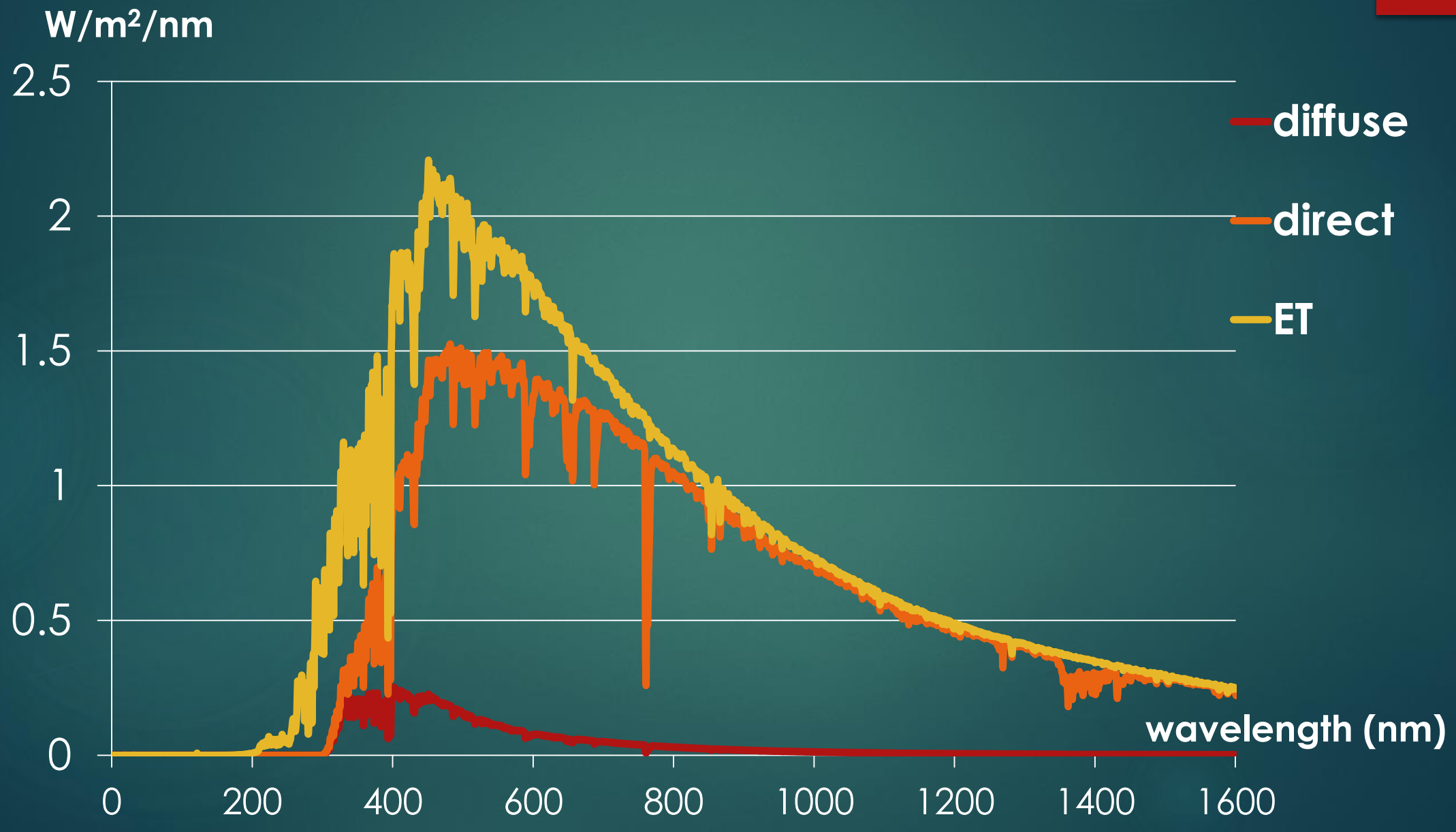


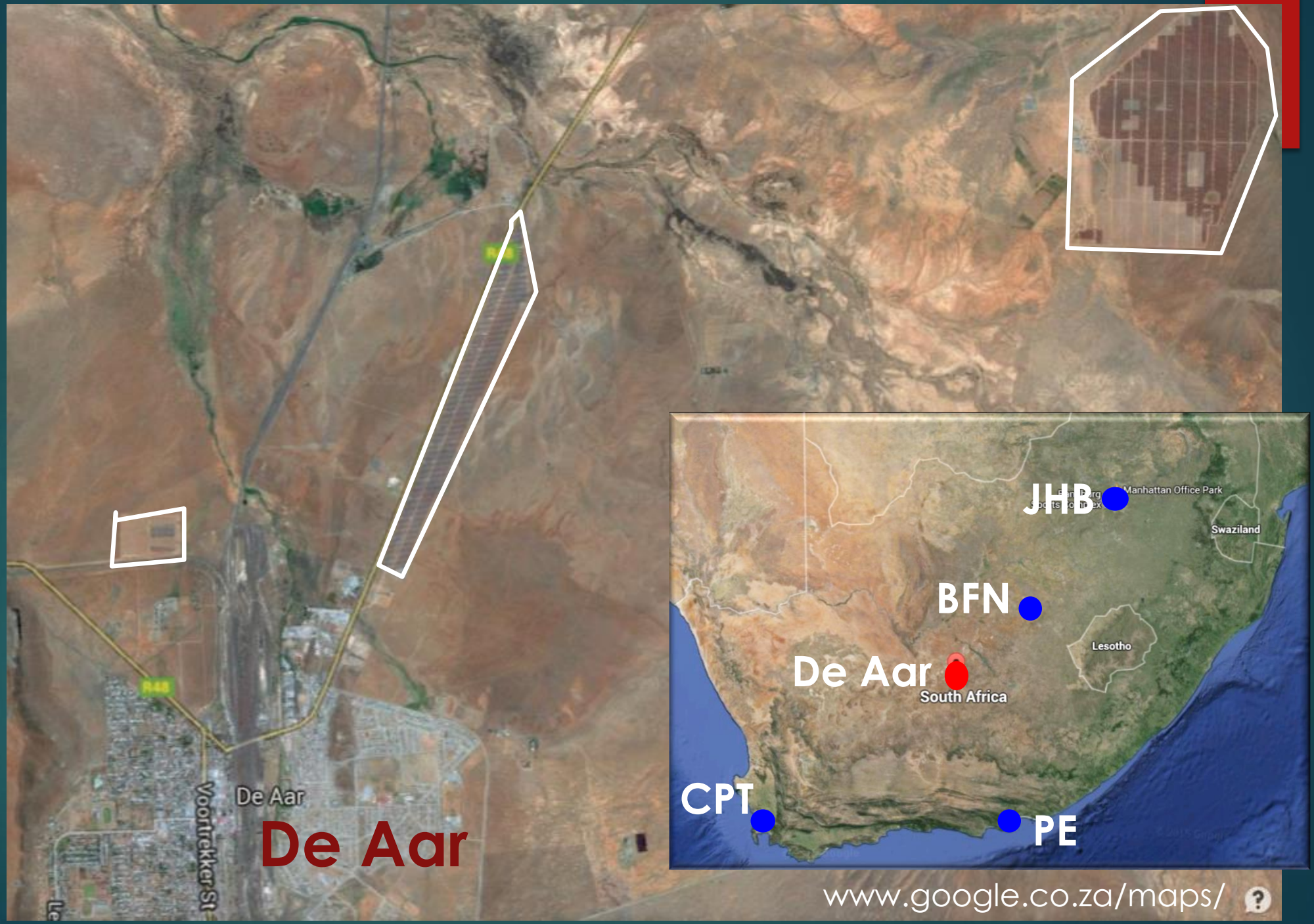
Calculating the solar irradiance



Sunlight Spectral Shift

Sunlight irradiance components

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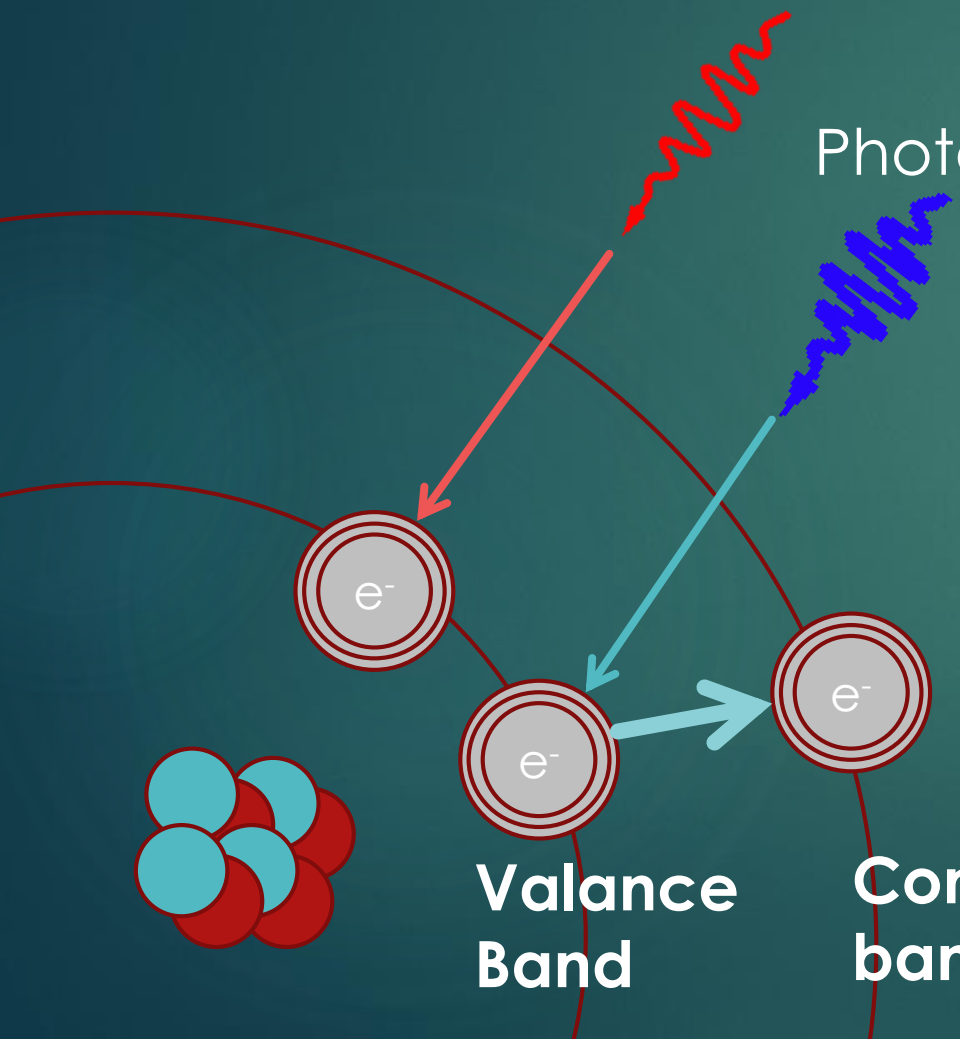
Photovoltaic cell

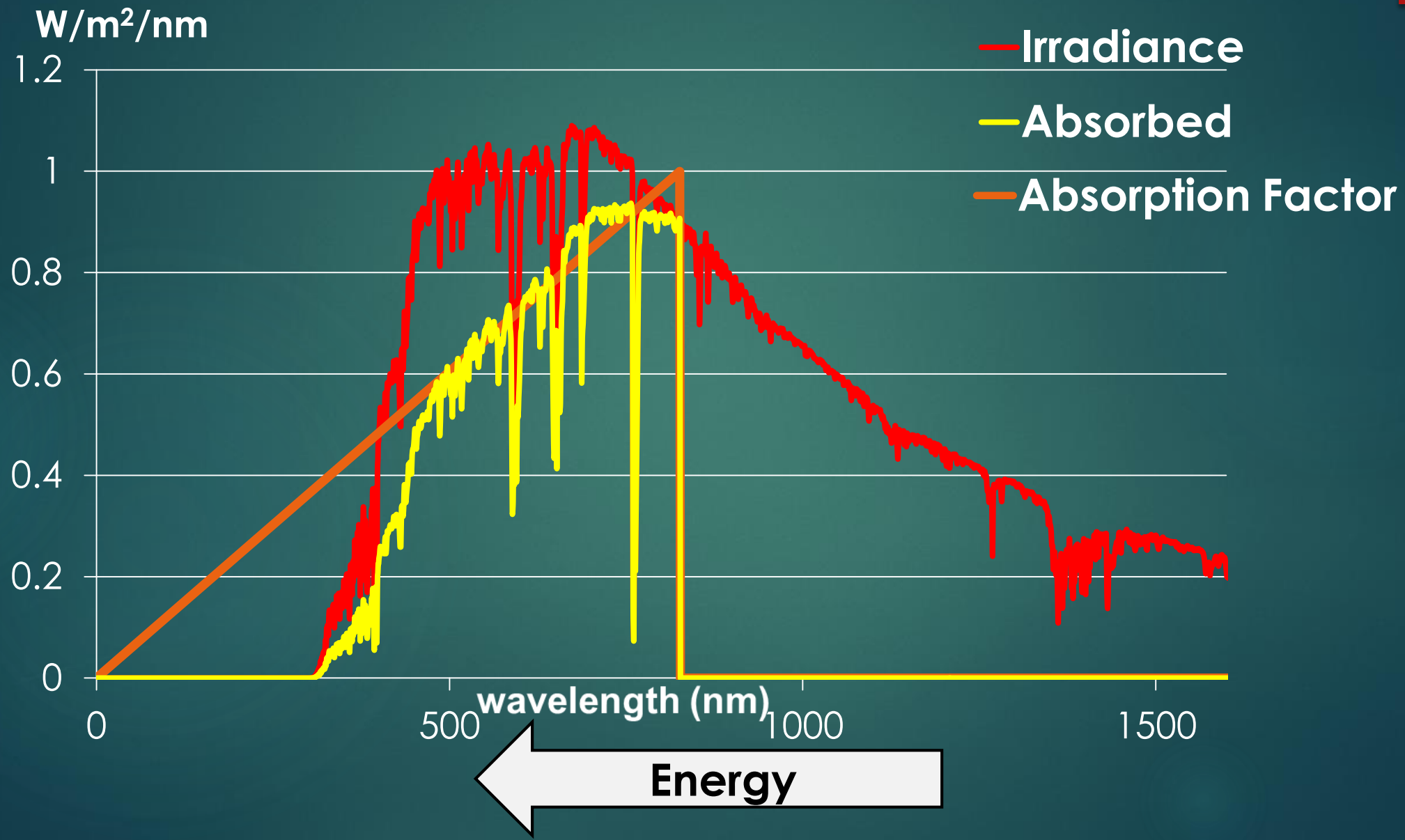
Photon with energy less than the band gap

Photon with energy greater than the band gap



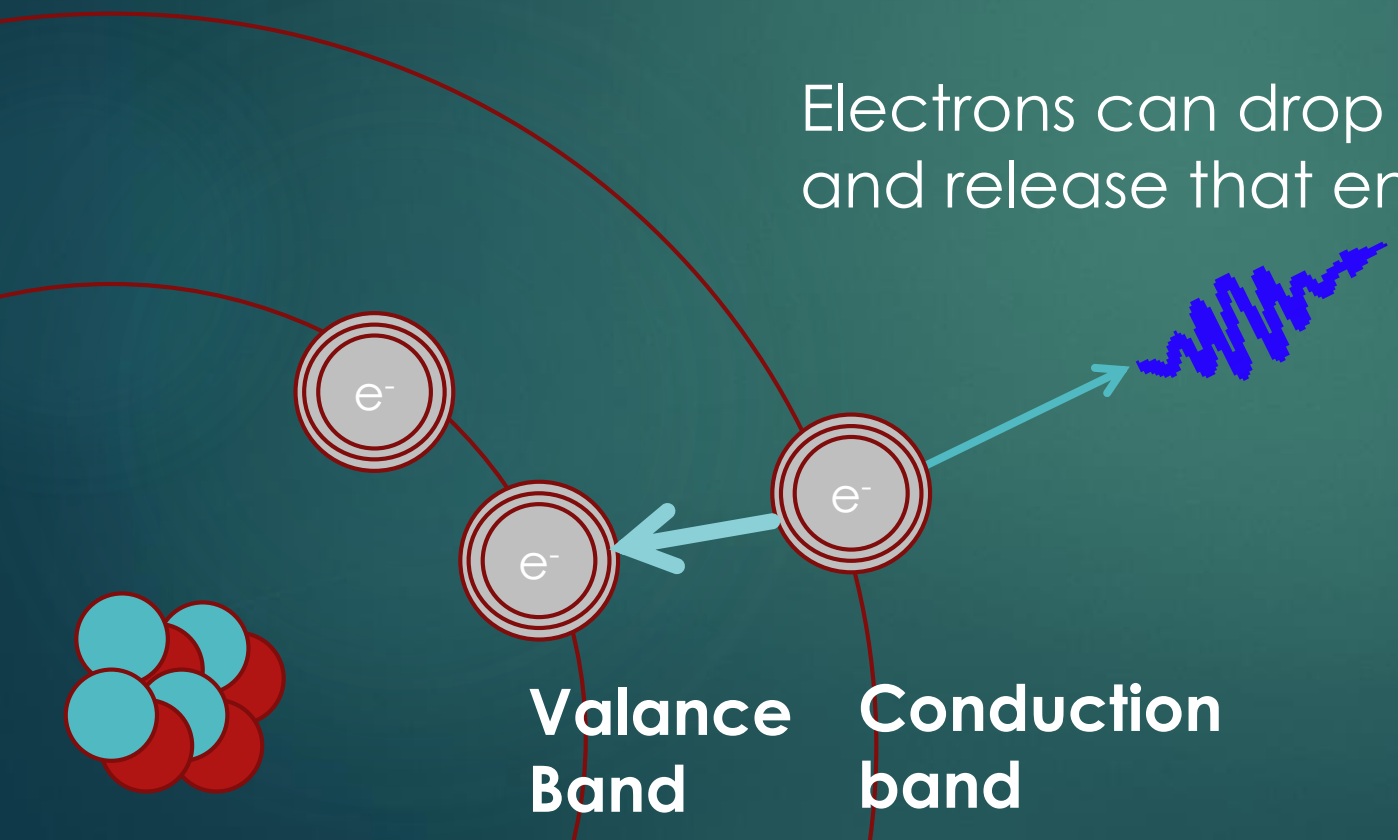
Not to scale

Absorbed = Irradiance x Response



Radiative recombination

Electrons can drop back into the Valance band and release that energy as light

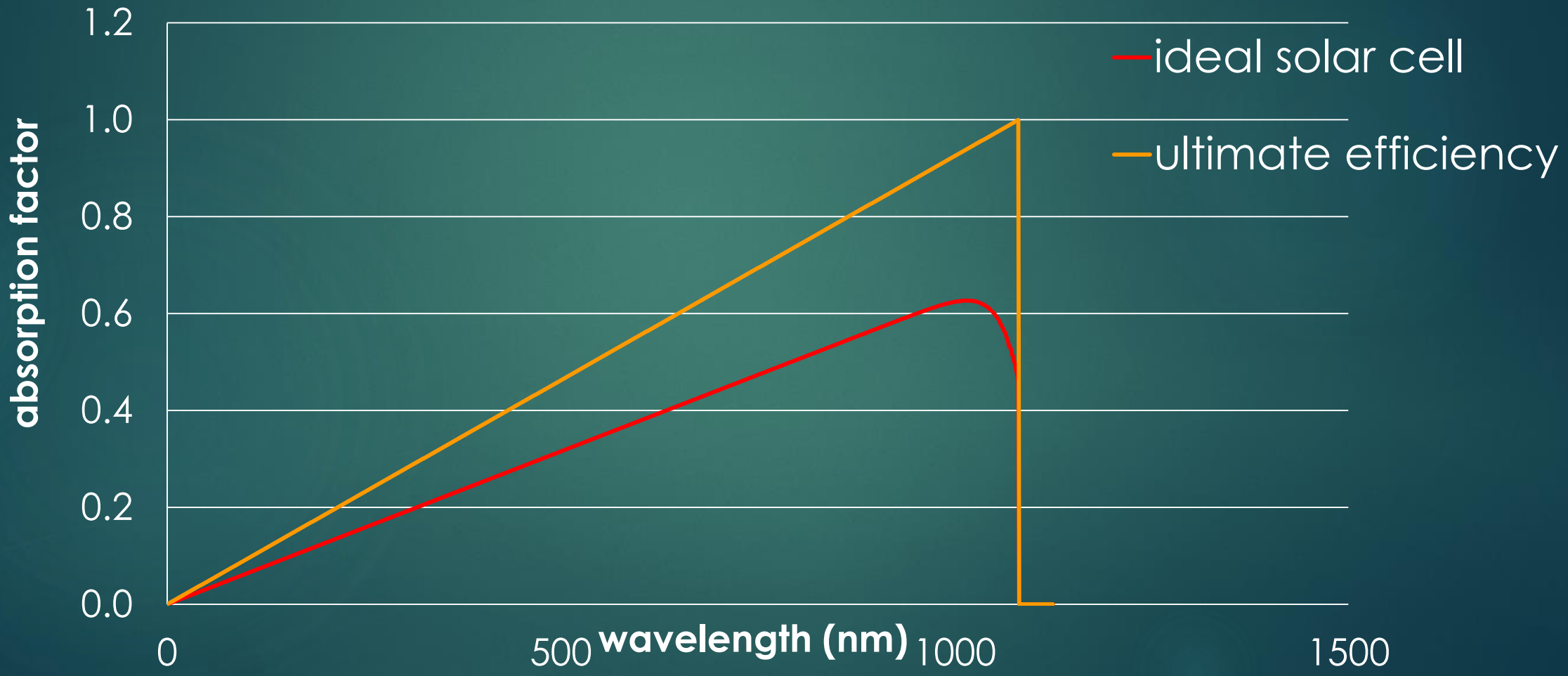


Valance Band

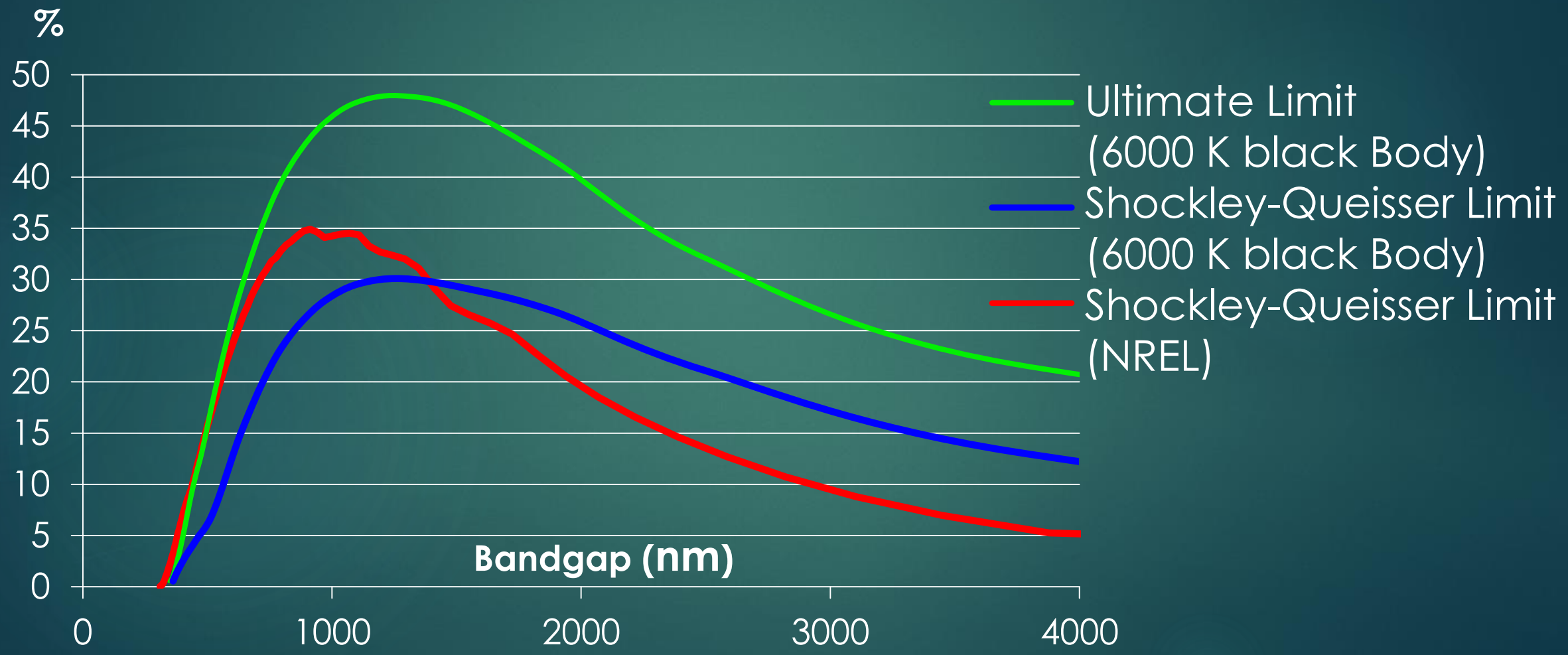
Conduction band

Not to scale

Effect of radiative recombination on absorption factor



Noteworthy Calculations of Bandgap vs. Efficiency

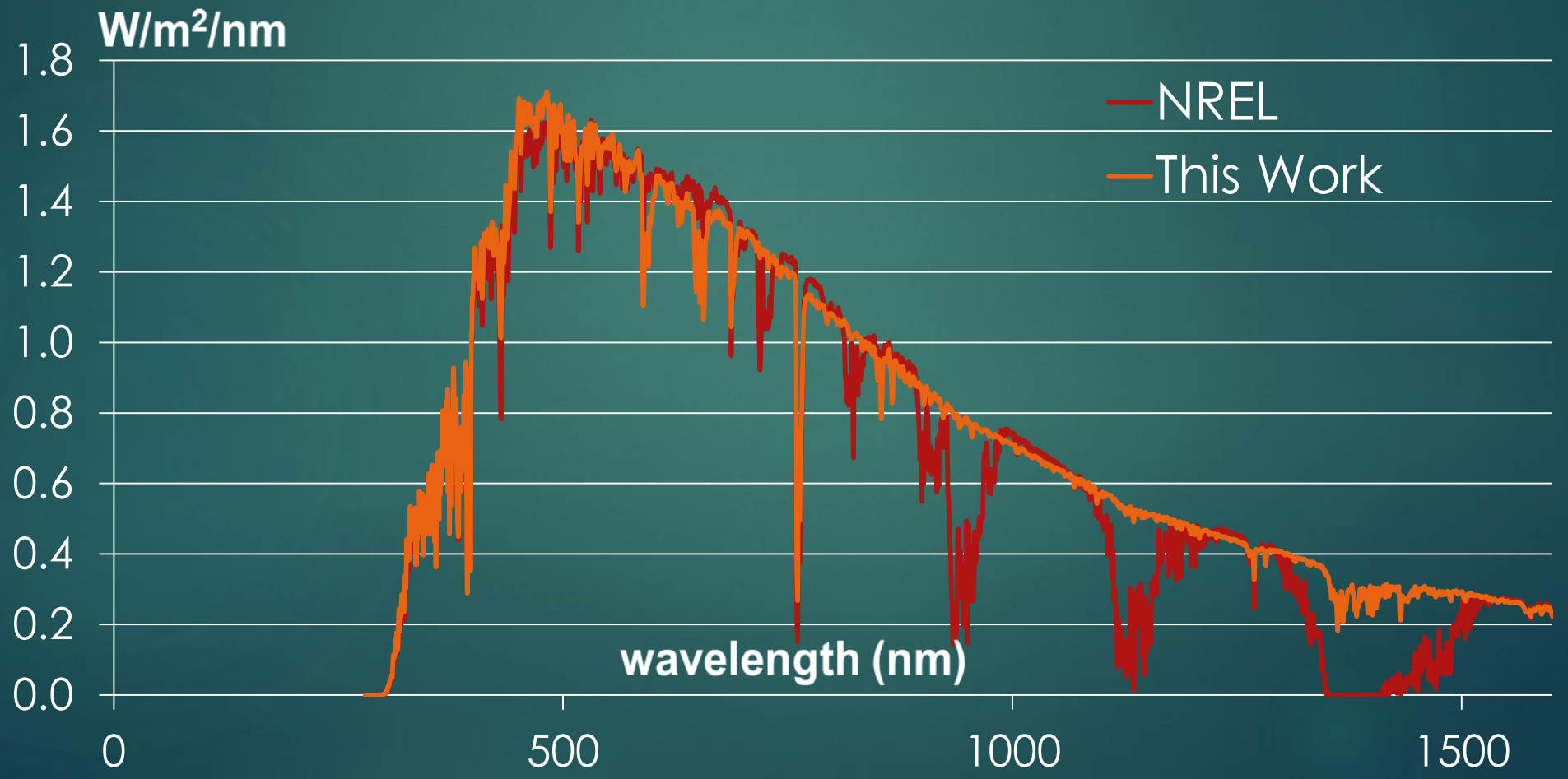


Why this paper?

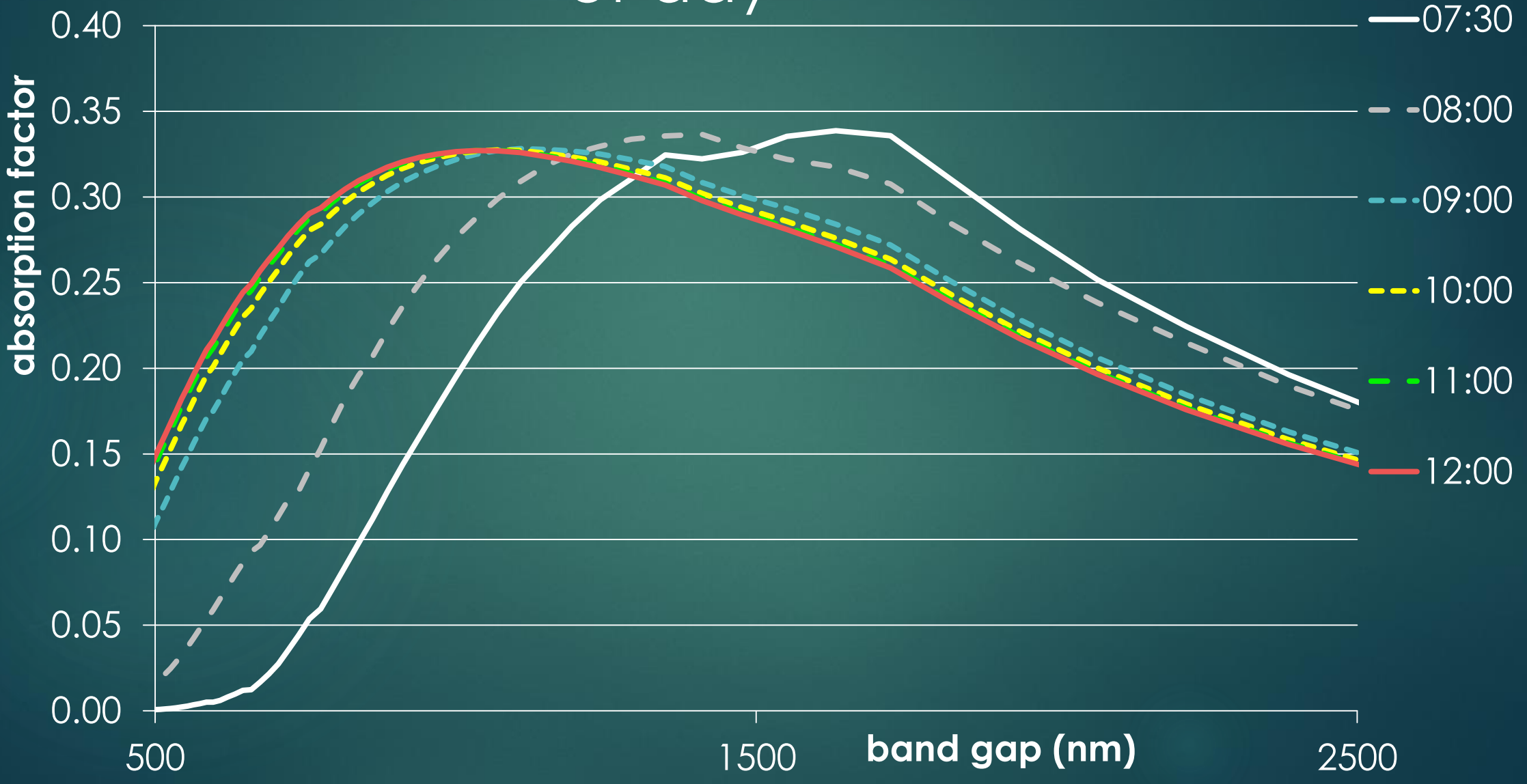
- Single solar spectrum used
- Creating single optimal peak
- Solar spectrum changes with zenith angle and with atmosphere composition
- Thus the optimal band gap will differ for different locations and different atmospheric conditions
- How much will it differ for South Africa

De Aar 21 June vs NREL1.5AM

- Higher air mass
- Lower precipitable water



Shockley-Queisser limit for different times of day



Result for 21 June

- 10 minute intervals
- Optimal band gap - 1089 nm
- Efficiency for band gap 925nm – 31.67%
- Efficiency for band gap 1089nm – 33.34%
- Thus 5.3% higher energy yield

Results

Date	Efficiency for 925nm [%]	Optimal efficiency [%]	Optimal band gap [nm]	Increase in power [%]
2000/06/21	31.67	33.34	1089	5.3
2000/07/21	31.34	32.57	1089	3.9
2000/08/21	31.76	32.84	1089	3.4
2000/09/21	31.70	32.56	1073	2.7
2000/10/21	31.52	32.56	1105	3.3
2000/11/21	31.21	32.25	1105	3.4
2000/12/21	31.80	32.51	1066	2.2

Conclusion

- There is significant variance in optimal bandgap with atmospheric conditions.
- Bandgap should be considered when designing solar power plants.
- Target location should be considered when designing solar cells.
- for South African conditions, a lower energy band gap is optimal.
  - High latitude
  - Peak power demand in winter

Questions ?