

Genetic Algorithms for PV Power Simulation and Digital Twinning

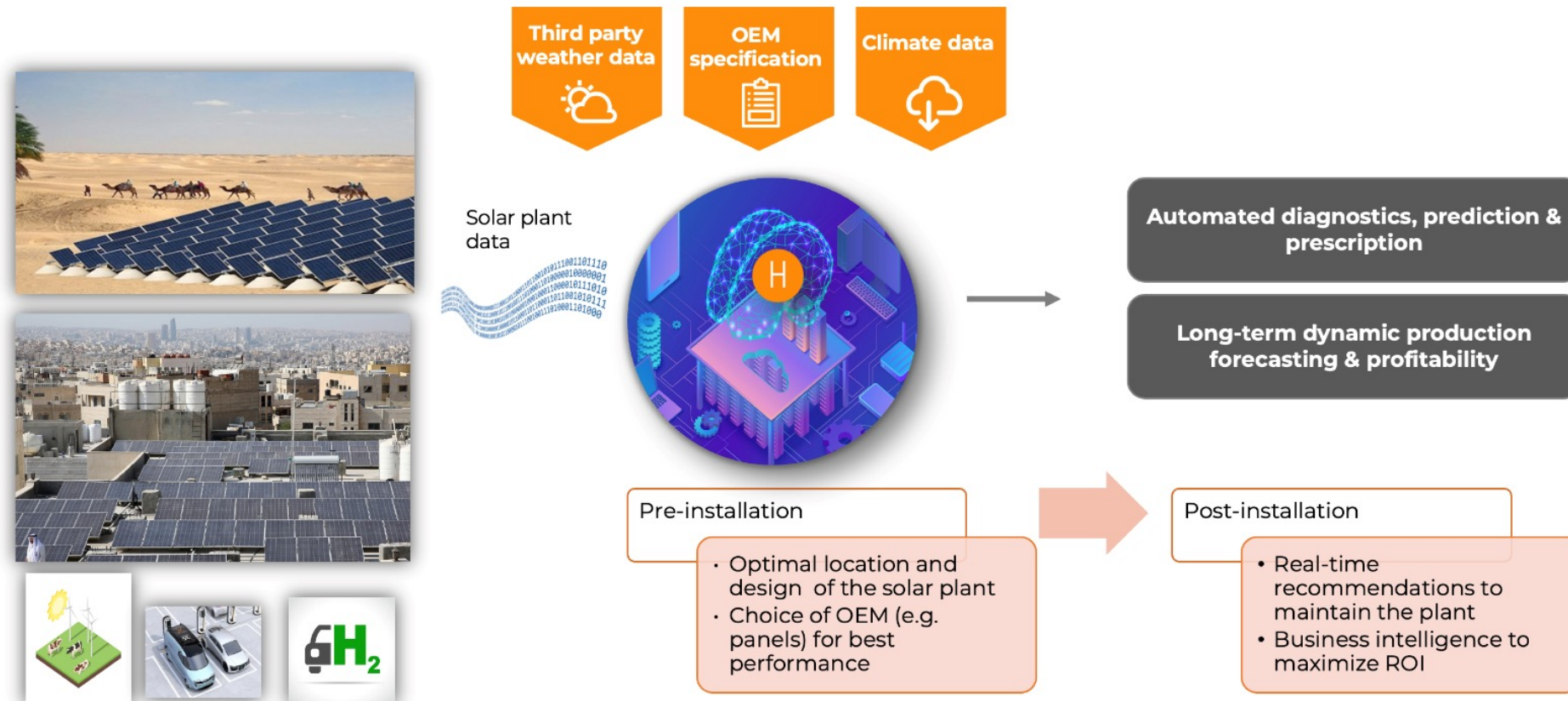
Dorian Guzman
Head of Data Science
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AML, Ecublens Switzerland
30/04/2022



About SmartHelio

SmartHelio (Certified B Corporation) is a Big Data Clean Energy Intelligence company based out of Switzerland. SmartHelio is the doctor for solar plants: we remotely diagnose existing problems, predict faults and prescribe solutions in real time.



How do we help you?



FORECASTING & ASSET DUE DILIGENCE

Get a realistic future assessment of your asset's performance.



PREDICTIVE ANALYTICS

Using our physics-based pattern recognition technology, we predict faults and help avoiding system failures.



UNKNOWN REASONS FOR UNDERPERFORMANCE

We detect, categorize and quantify losses of your system that you might not even be aware of.



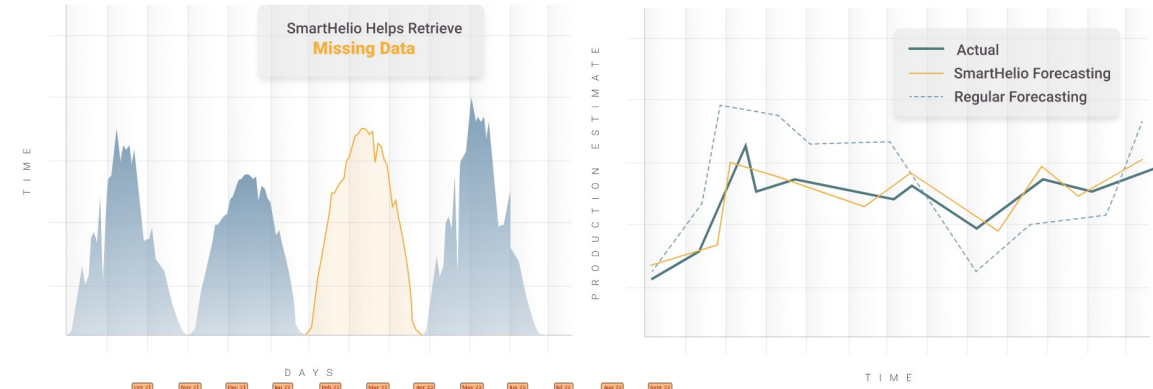
RECOVER MISSING DATA

With over 98% accuracy using our Machine/Deep Learning models.

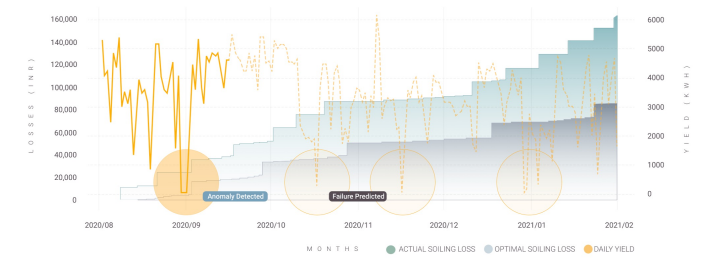


PANEL-LEVEL ANALYTICS

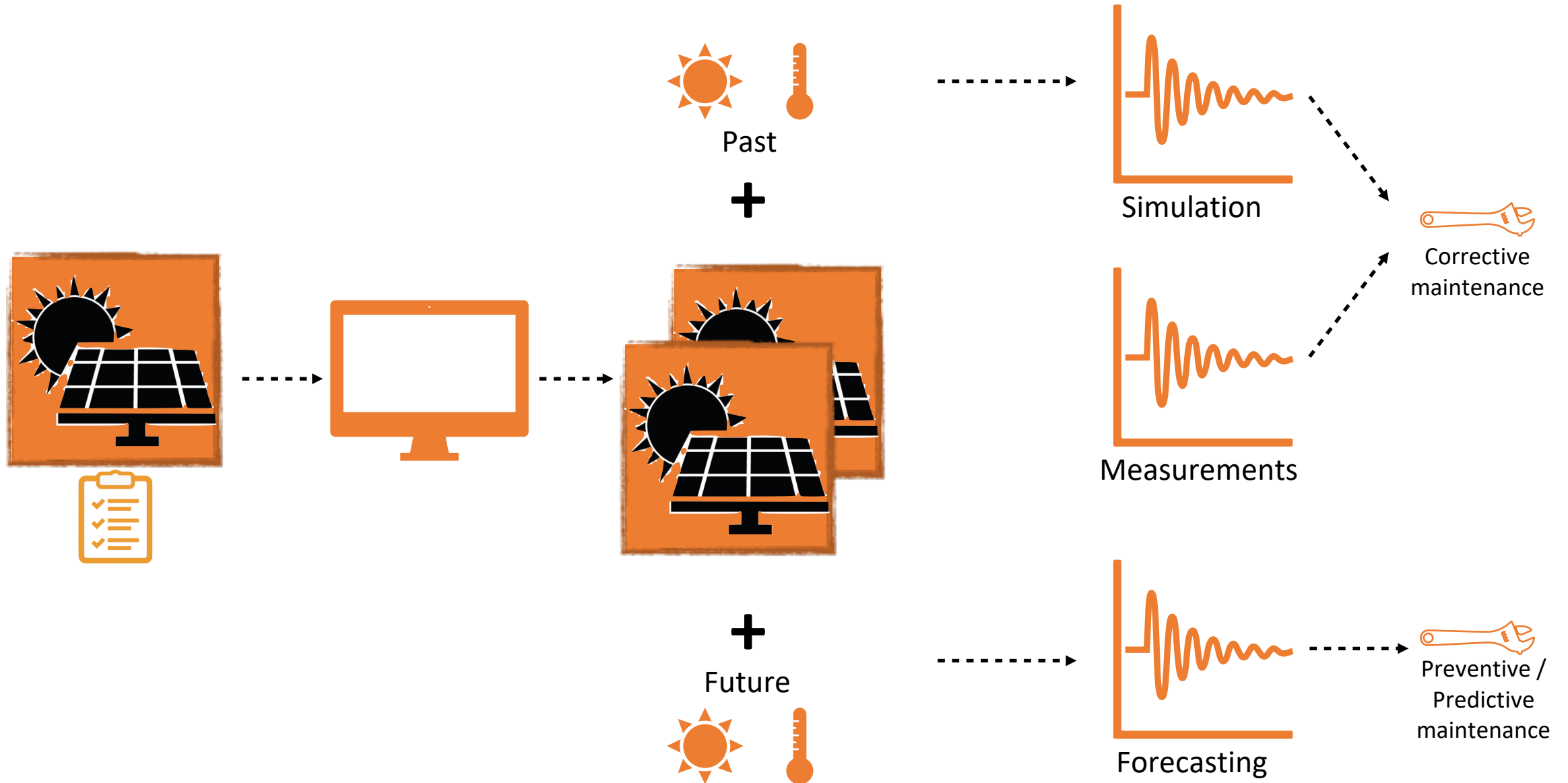
Track the performance of your plant at the panel-level, know precisely your modules' health status and increase their life expectancy by 1.5 times.



	Oct 21	Nov 21	Dec 21	Jan 22	Feb 22	Mar 22	Apr 22	May 22	Jun 22	Jul 22	Aug 22	Sep 22	
INV12	Sailing level: 1.71%	3.02%	3.75%	4.15%	3.89%	5.36%	9.82%	9.17%	8.42%	1.24%	2.71%	1.97%	Cleaning cost = 265CHF
	Lost energy: 7.89kWh	20.68kWh	24.88kWh	25.88kWh	80.48kWh	204.68kWh	448.48kWh	860.48kWh	788.48kWh	31.48kWh	54.68kWh	79.48kWh	
	Lost income: 1.0CHF	9.0CHF	10.0CHF	10.0CHF	30.0CHF	80.0CHF	180.0CHF	350.0CHF	310.0CHF	11.0CHF	14.0CHF	20.0CHF	
INV02	Sailing level: 1.79%	3.17%	3.52%	4.48%	4.44%	6.89%	10.38%	9.79%	8.57%	1.24%	1.94%	2.84%	Cleaning cost = 256CHF
	Lost energy: 6.98kWh	17.68kWh	21.18kWh	29.68kWh	29.68kWh	79.68kWh	121.68kWh	178.68kWh	158.68kWh	31.68kWh	46.68kWh	68.68kWh	
	Lost income: 3.0CHF	7.0CHF	8.0CHF	11.0CHF	11.0CHF	18.0CHF	28.0CHF	24.0CHF	21.0CHF	4.0CHF	6.0CHF	9.0CHF	
INV19	Sailing level: 0.75%	0.81%	0.82%	0.87%	0.89%	0.96%	1.14%	0.94%	0.86%	0.34%	0.87%	1.22%	Cleaning cost = 156CHF
	Lost energy: 2.68kWh	3.08kWh	3.48kWh	3.78kWh	3.98kWh	4.88kWh	6.88kWh	4.88kWh	4.48kWh	1.28kWh	3.08kWh	4.18kWh	
	Lost income: 1.0CHF	1.0CHF	1.0CHF	1.0CHF	1.0CHF	1.0CHF	1.0CHF	1.0CHF	1.0CHF	0.0CHF	1.0CHF	1.0CHF	
INV16	Sailing level: 2.38%	4.12%	4.75%	5.42%	5.32%	8.89%	9.22%	8.42%	5.89%	0.86%	1.42%	1.97%	Cleaning cost = 265CHF
	Lost energy: 21.68kWh	28.68kWh	30.68kWh	31.68kWh	32.68kWh	125.68kWh	131.68kWh	121.68kWh	88.68kWh	70.68kWh	32.68kWh	44.68kWh	
	Lost income: 4.0CHF	12.0CHF	12.0CHF	16.0CHF	16.0CHF	28.0CHF	28.0CHF	25.0CHF	18.0CHF	7.0CHF	14.0CHF	19.0CHF	

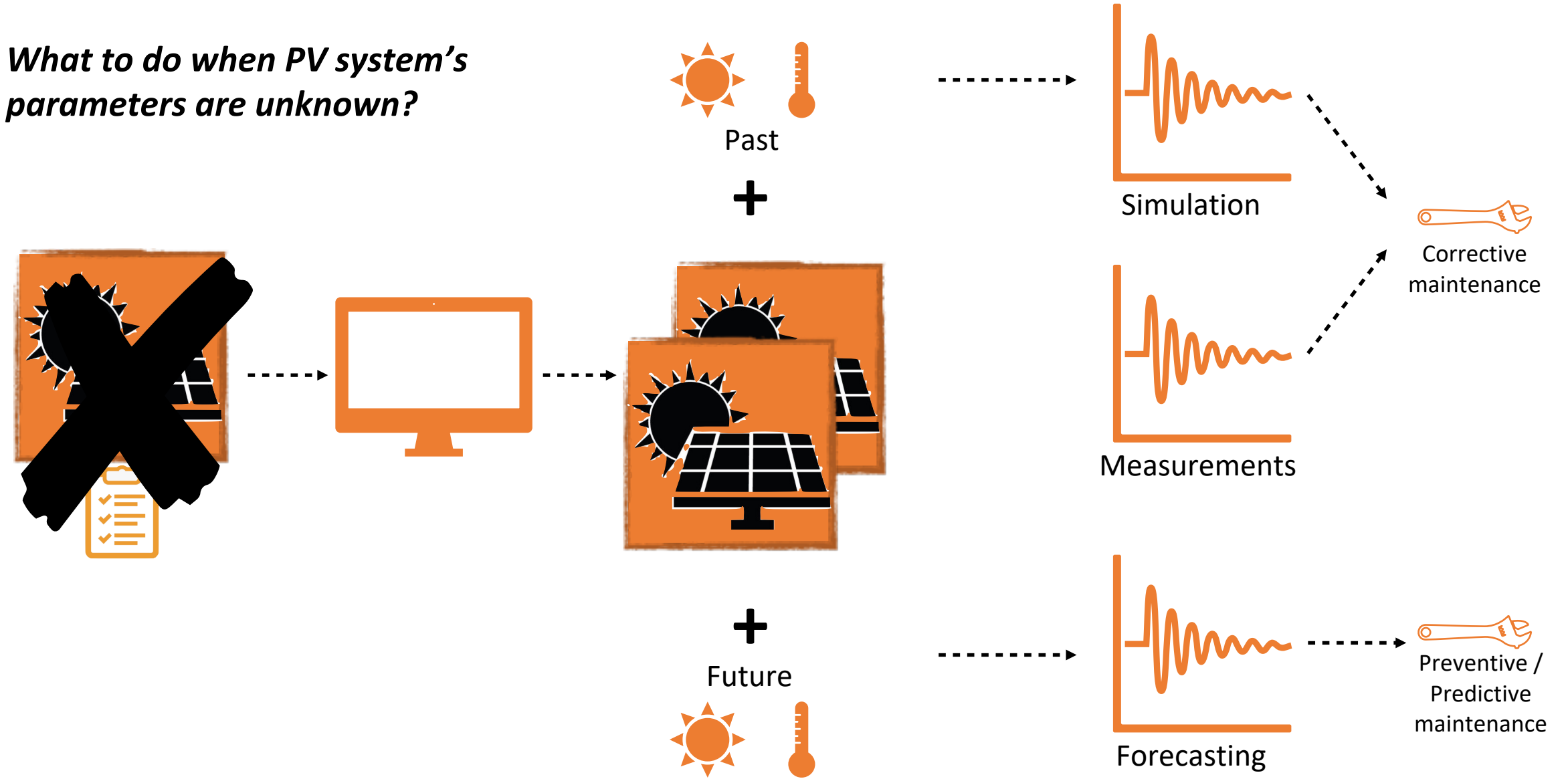


Case Study



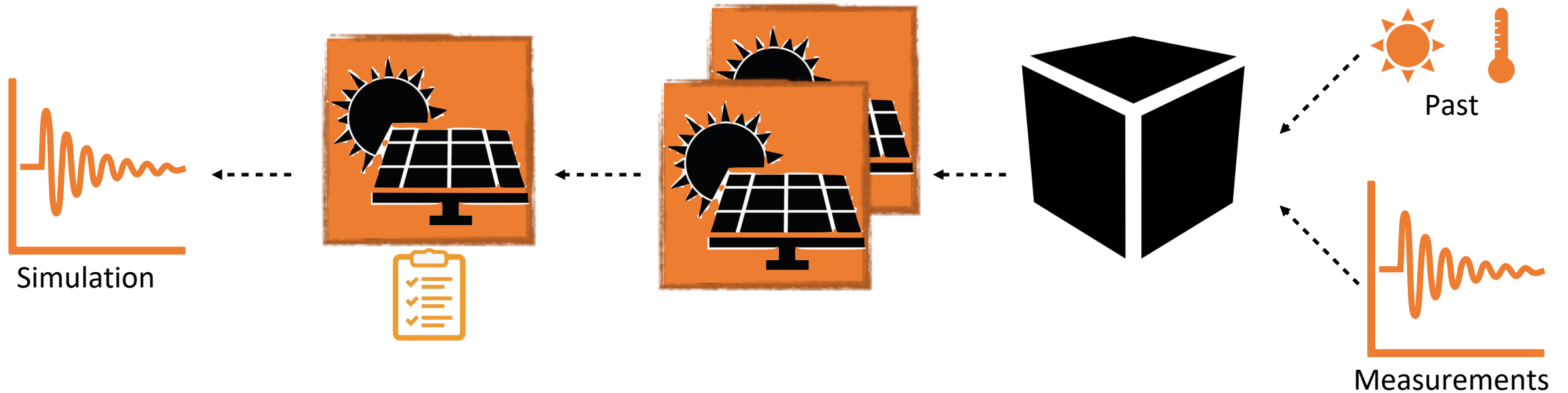
Case Study

What to do when PV system's parameters are unknown?

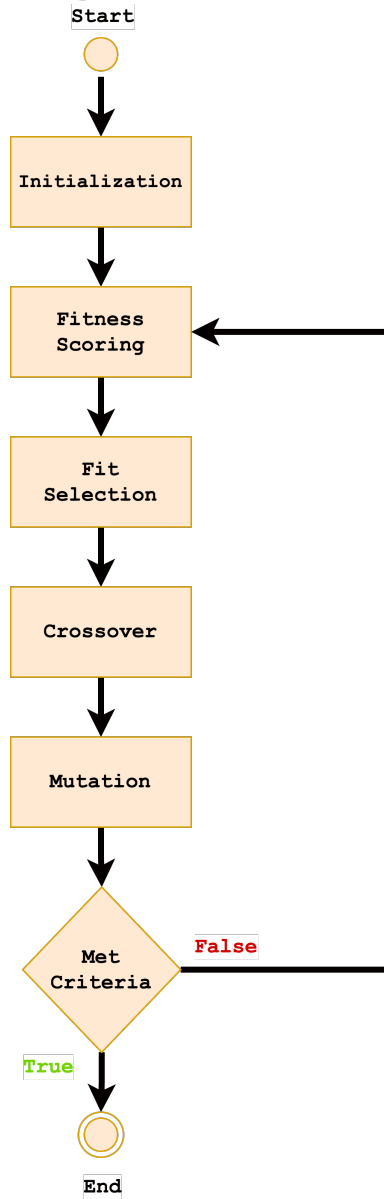


Case Study

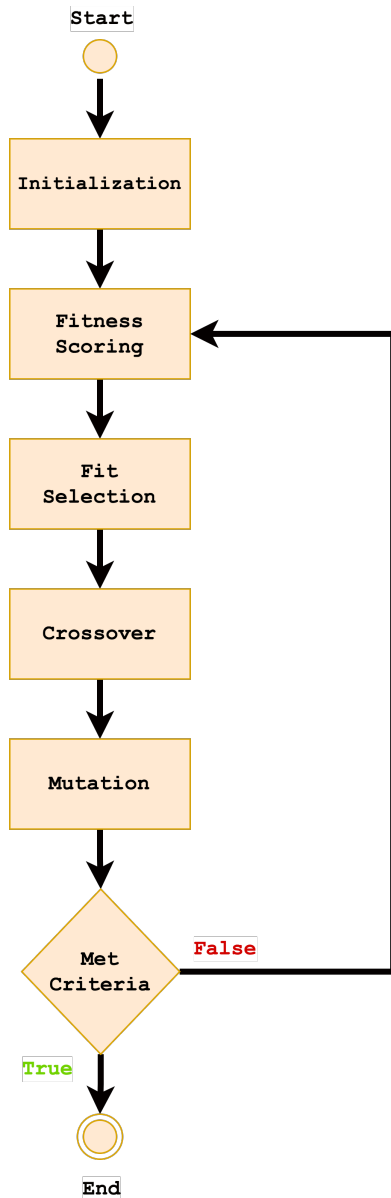
What to do when PV system's parameters are unknown?



Genetic Algorithm Optimization



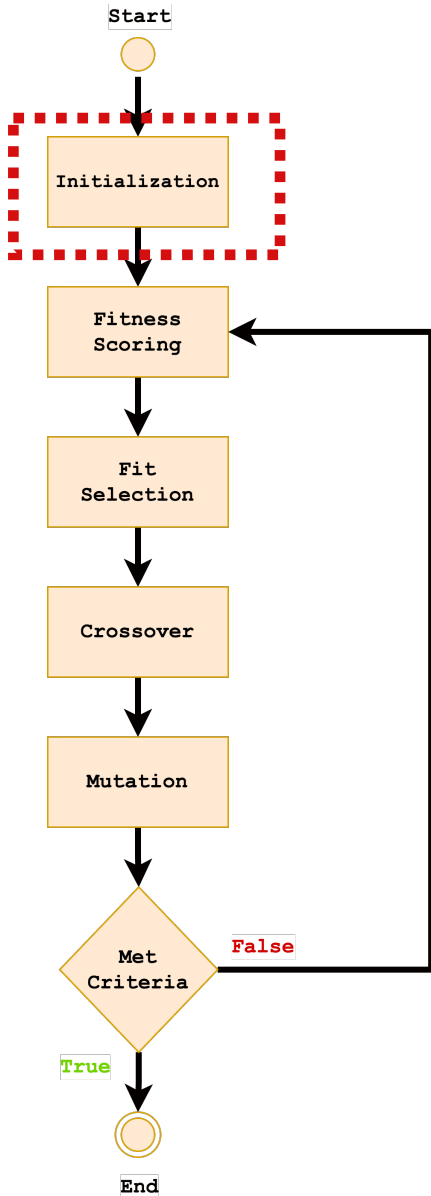
Genetic Algorithm Optimization



6 PV system parameters:

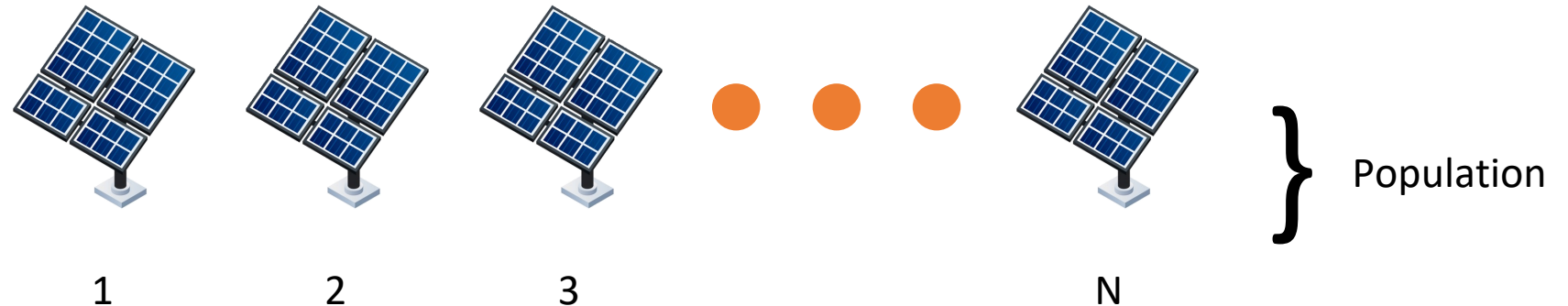
- *Nominal power*
- *Tilt angle*
- *Azimuth angle*
- *Albedo effect on irradiance*
- *Power temperature coefficient*
- *DC/AC ratio*

Genetic Algorithm Optimization

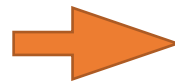
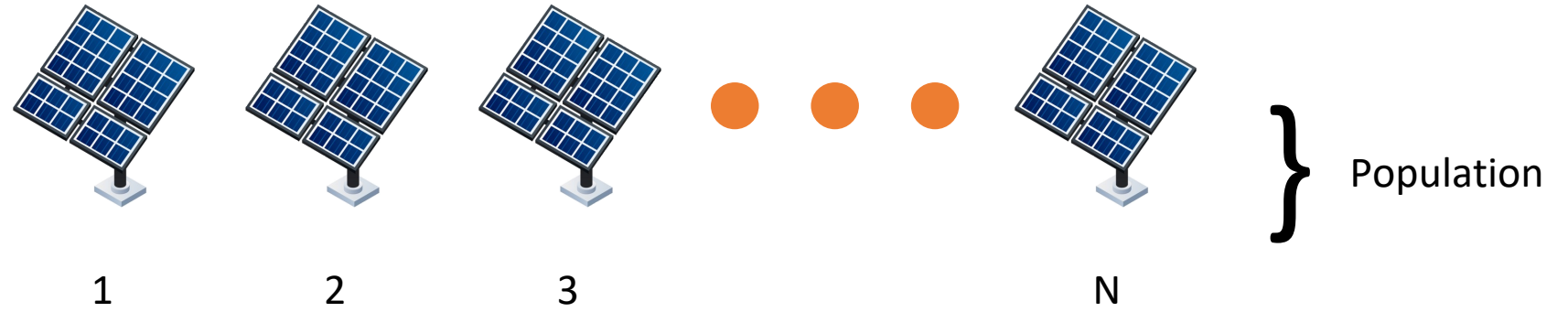
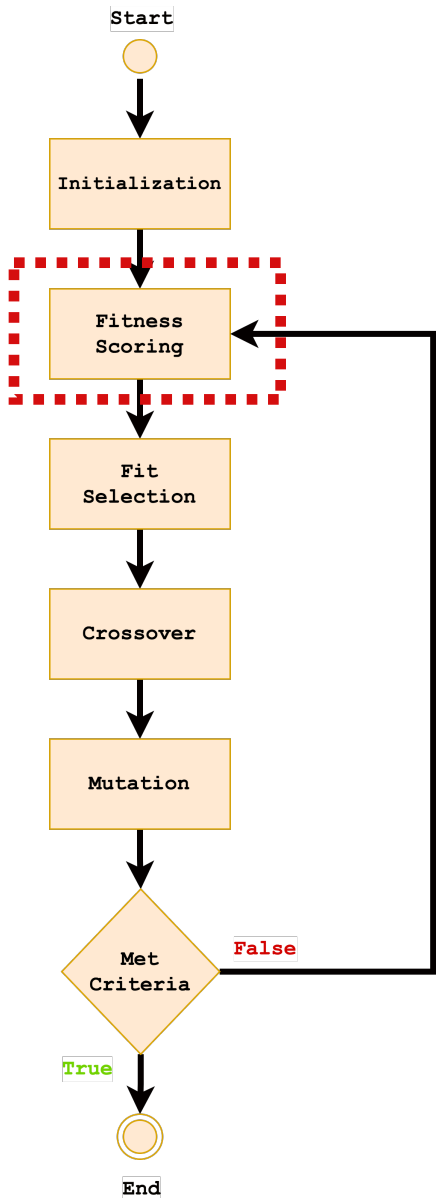


6 PV system parameters:

- Nominal power
- Tilt angle
- Azimuth angle
- Albedo effect on irradiance
- Power temperature coefficient
- DC/AC ratio

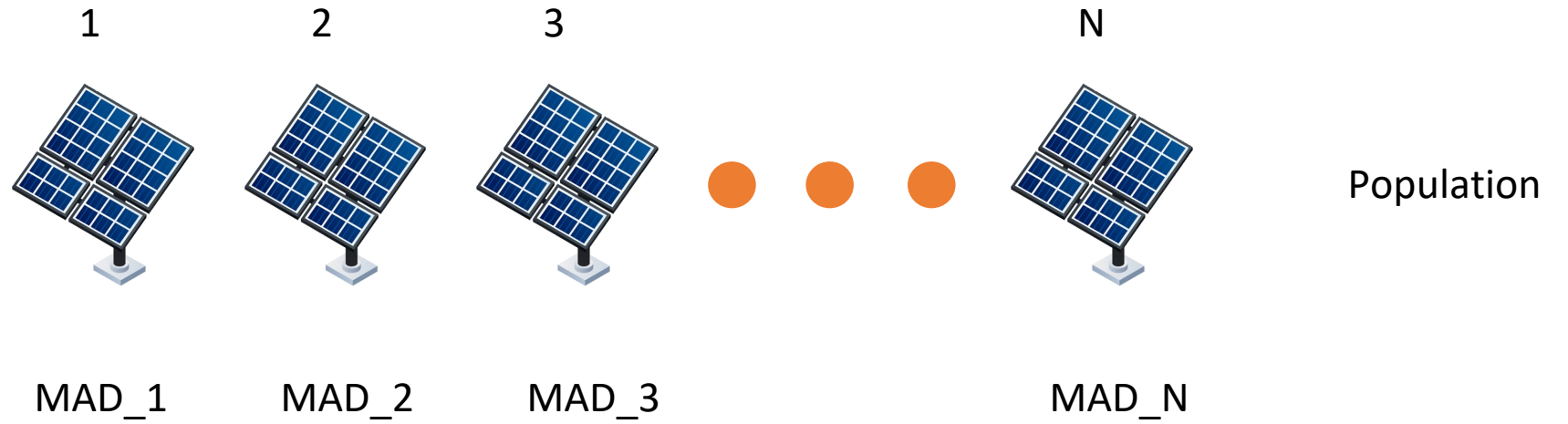
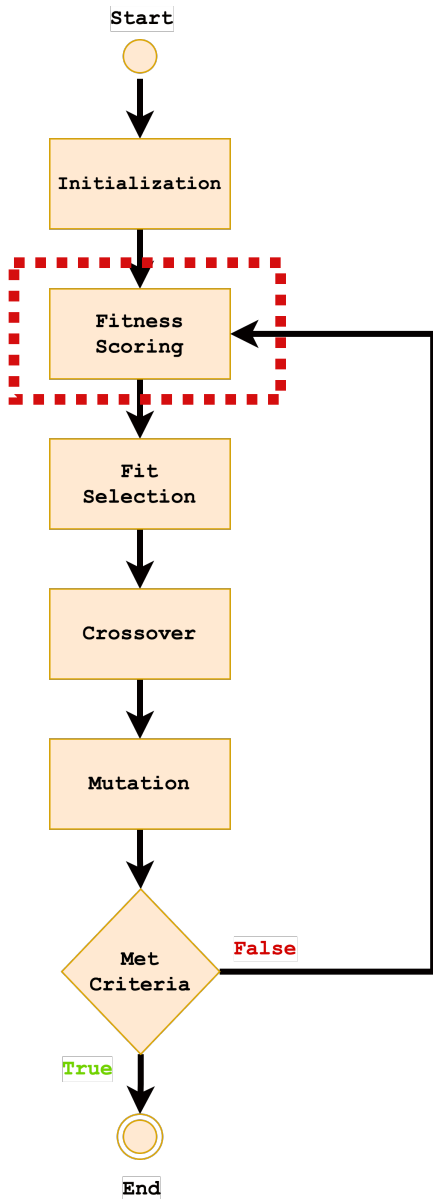


Genetic Algorithm Optimization

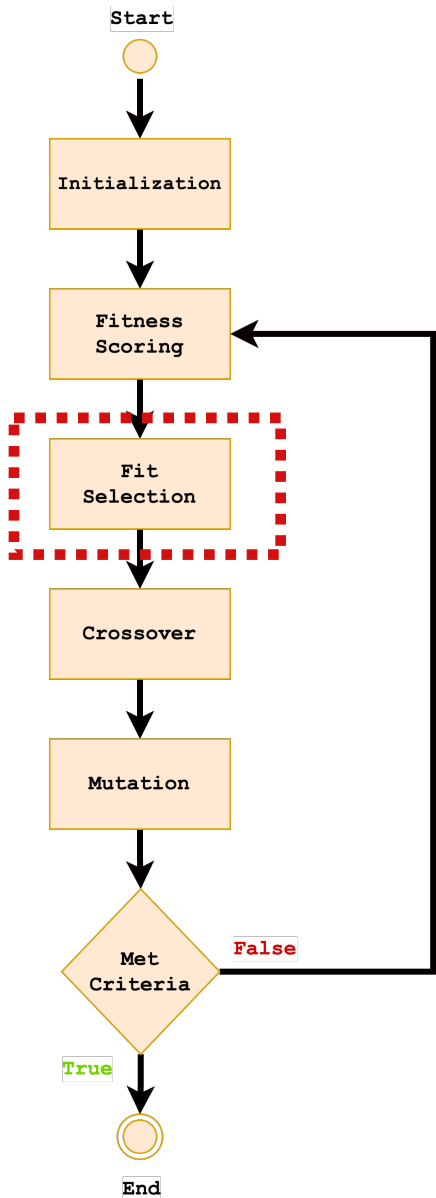


Mean Absolute Deviation (MAD)

Genetic Algorithm Optimization



Genetic Algorithm Optimization

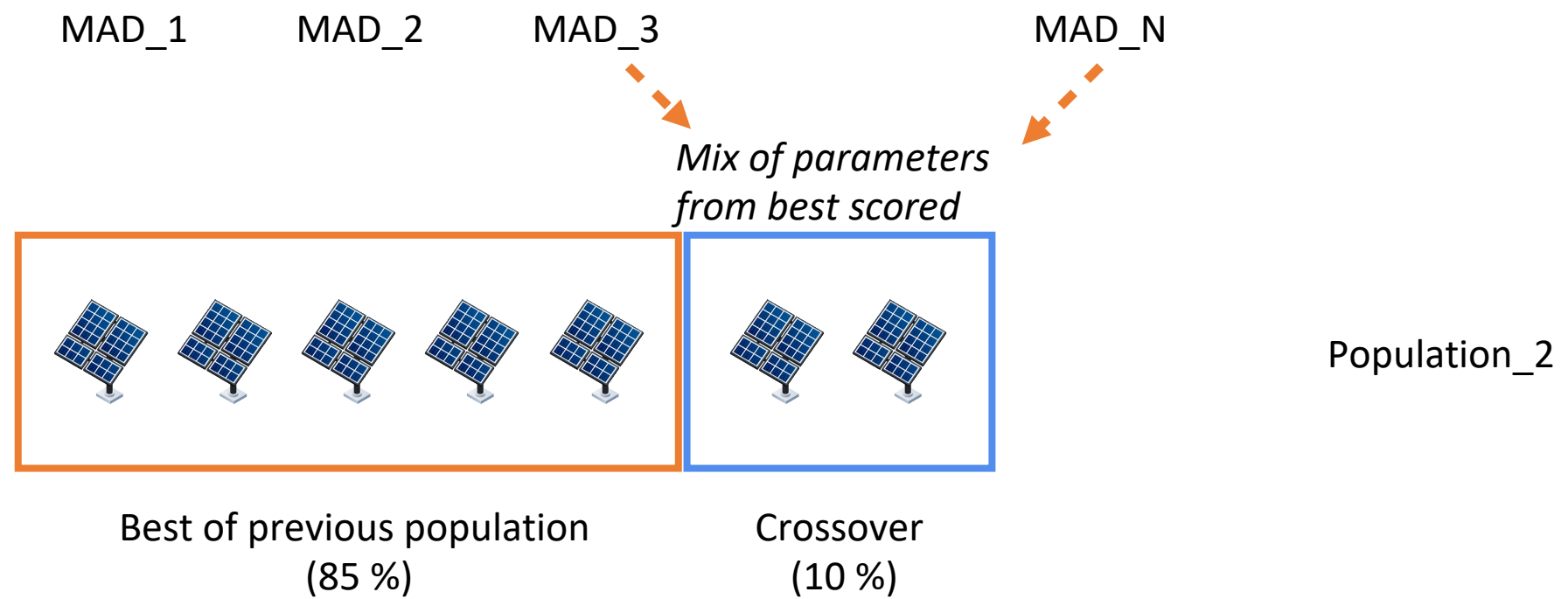
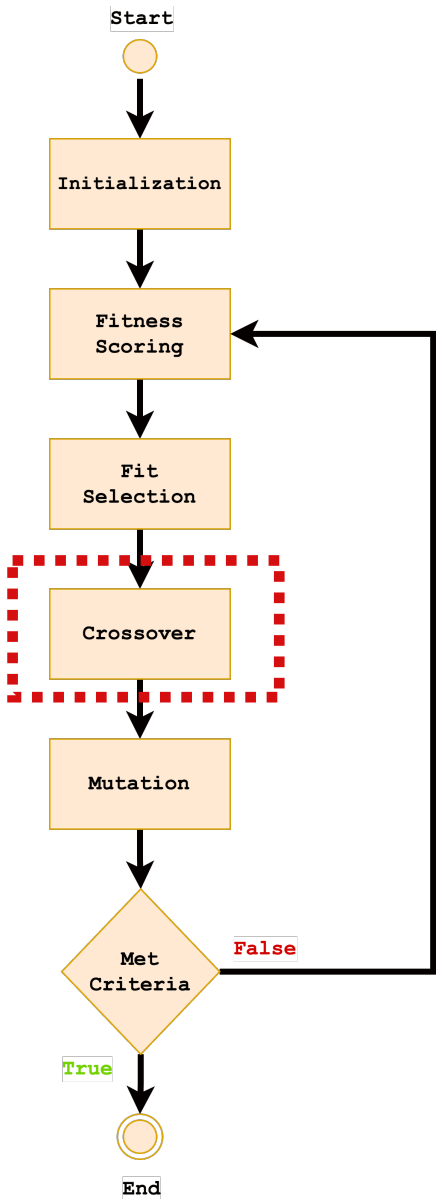


High score = High probability

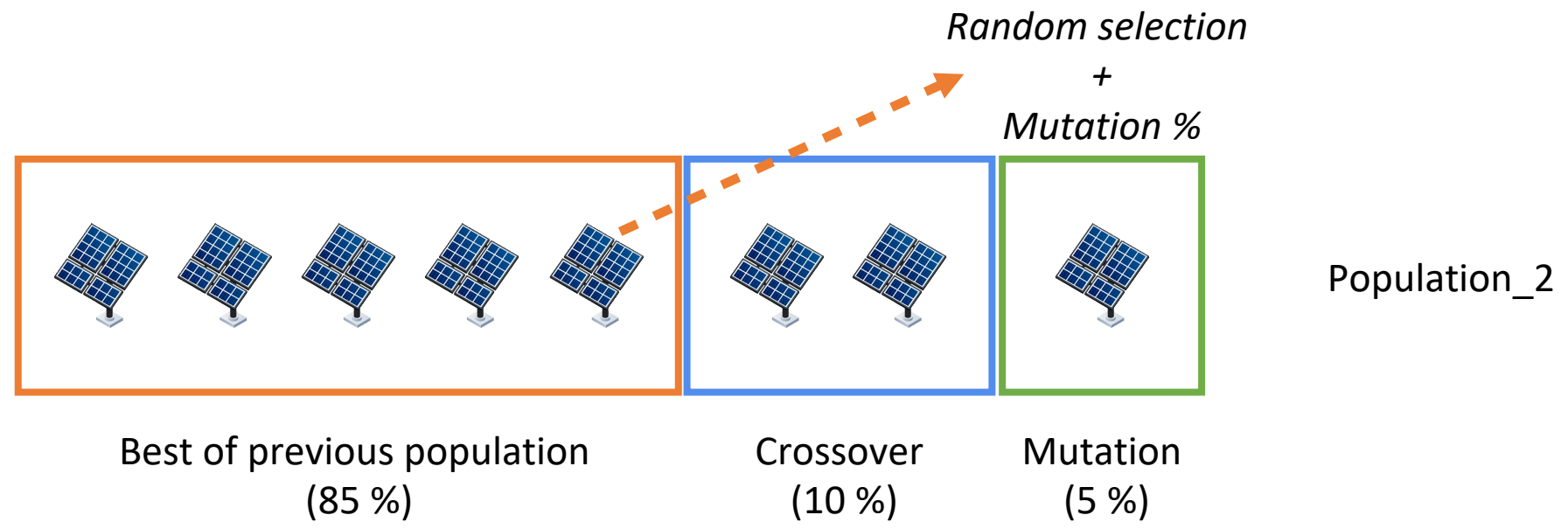
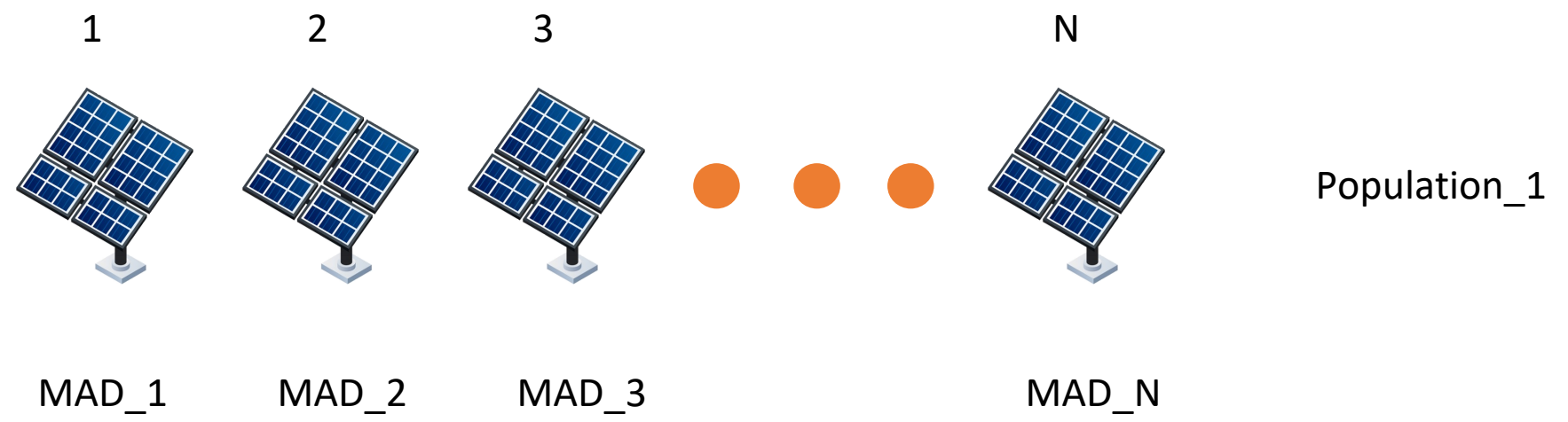
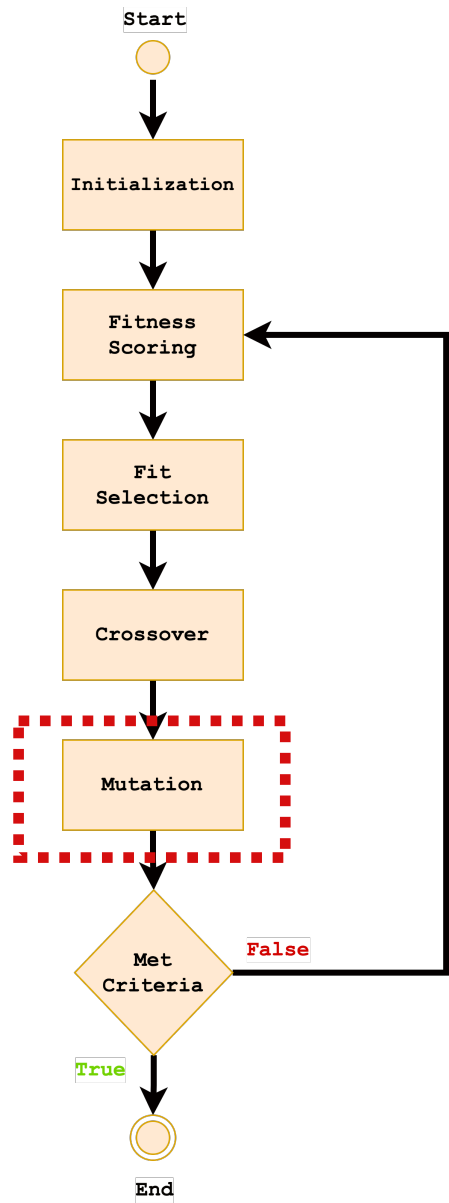


Best of previous population
(85 %)

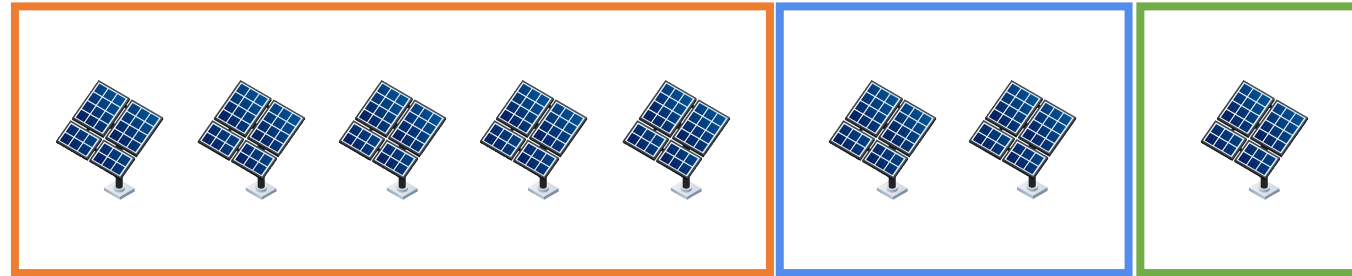
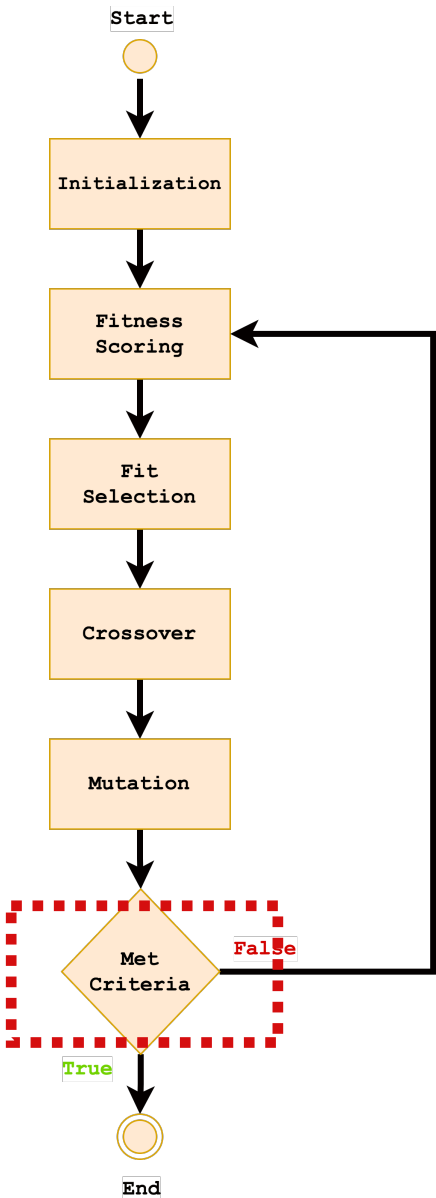
Genetic Algorithm Optimization



Genetic Algorithm Optimization



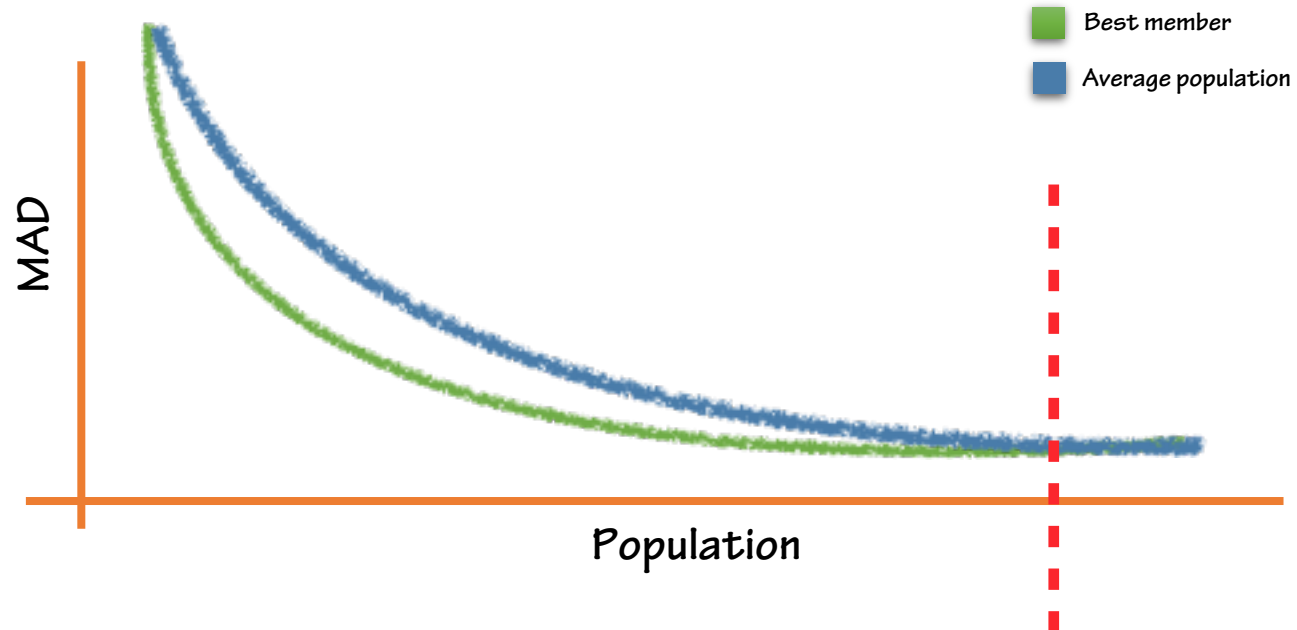
Genetic Algorithm Optimization



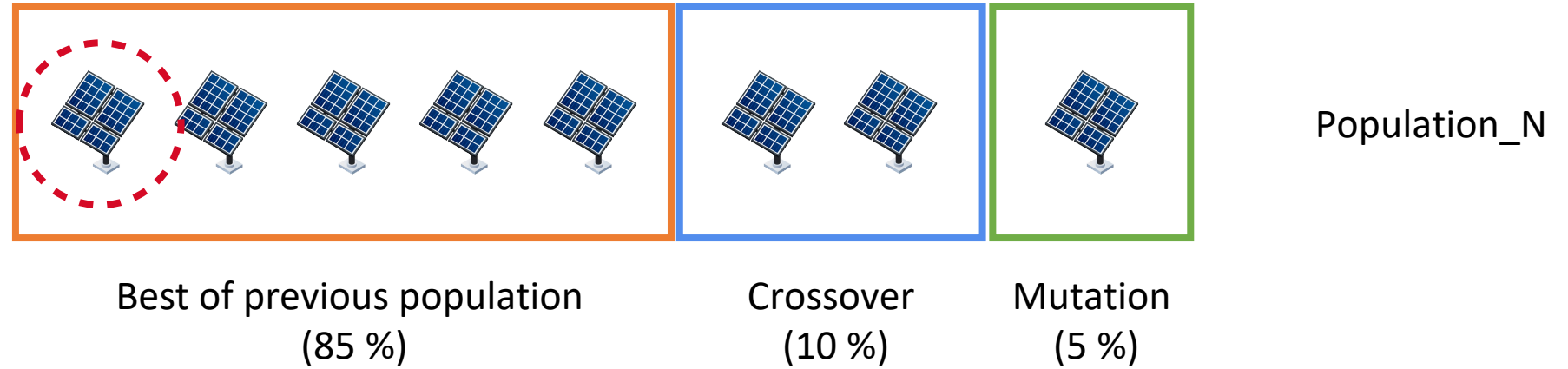
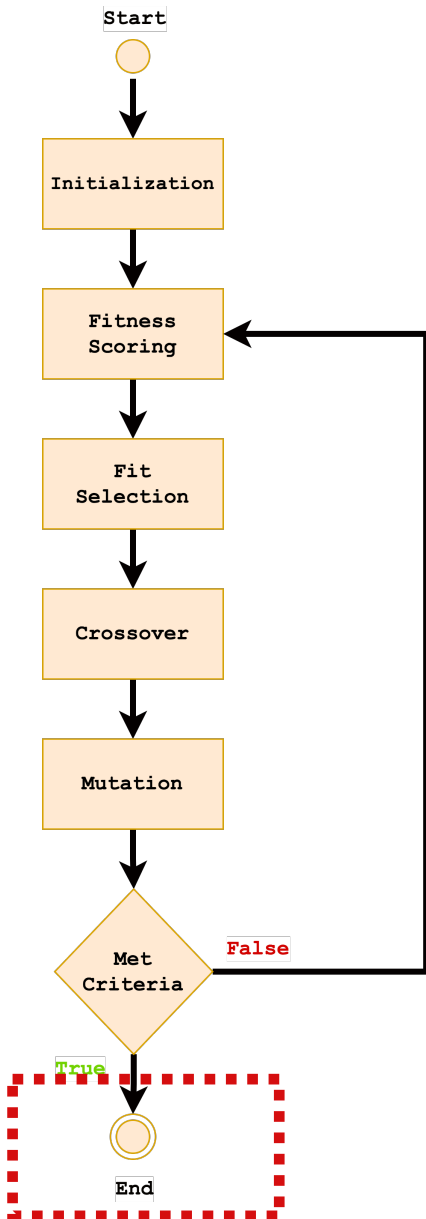
Best of previous population
(85 %)

Crossover
(10 %)

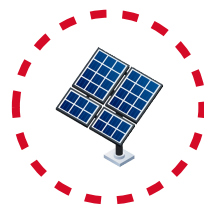
Mutation
(5 %)



Genetic Algorithm Optimization

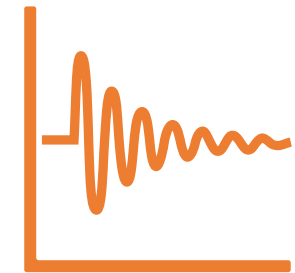


Best member



Digital twin:

- Nominal power
- Tilt angle
- Azimuth angle
- Albedo effect on irradiance
- Power temperature coefficient
- DC/AC ratio



Additional information

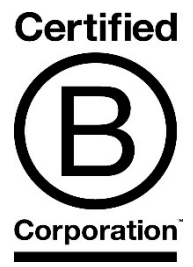
*Guzman Razo, D.E.; Müller, B.; Madsen, H.; Wittwer, C. A Genetic Algorithm Approach as a Self-Learning and Optimization Tool for PV Power Simulation and Digital Twinning. **Energies** 2020, **13**, 6712, doi:10.3390/en13246712.*



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THANK YOU

