Model-Based Optimization of a Solar-Powered Car

L I G H T Y E A R

Clean mobility for everyone

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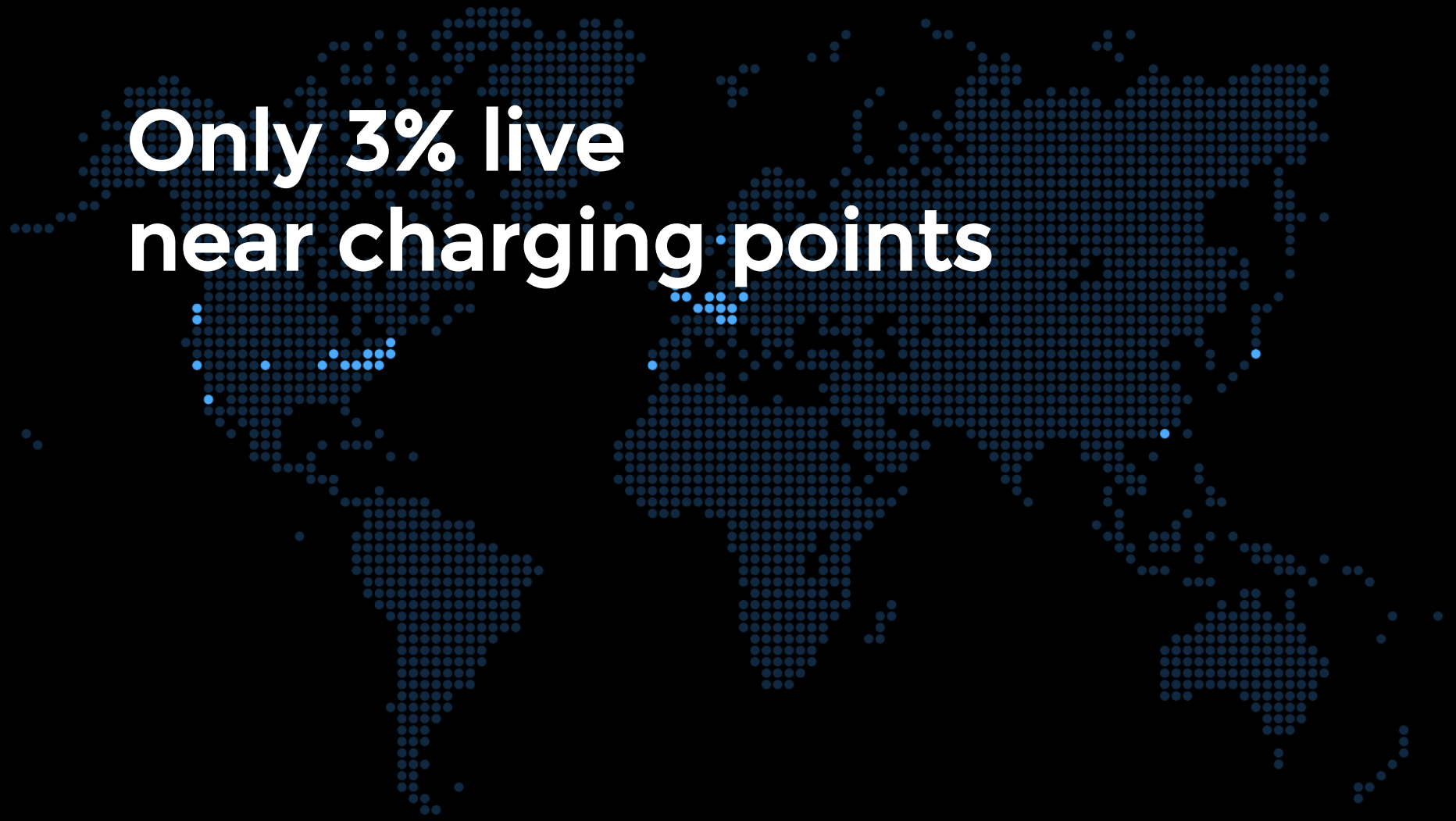
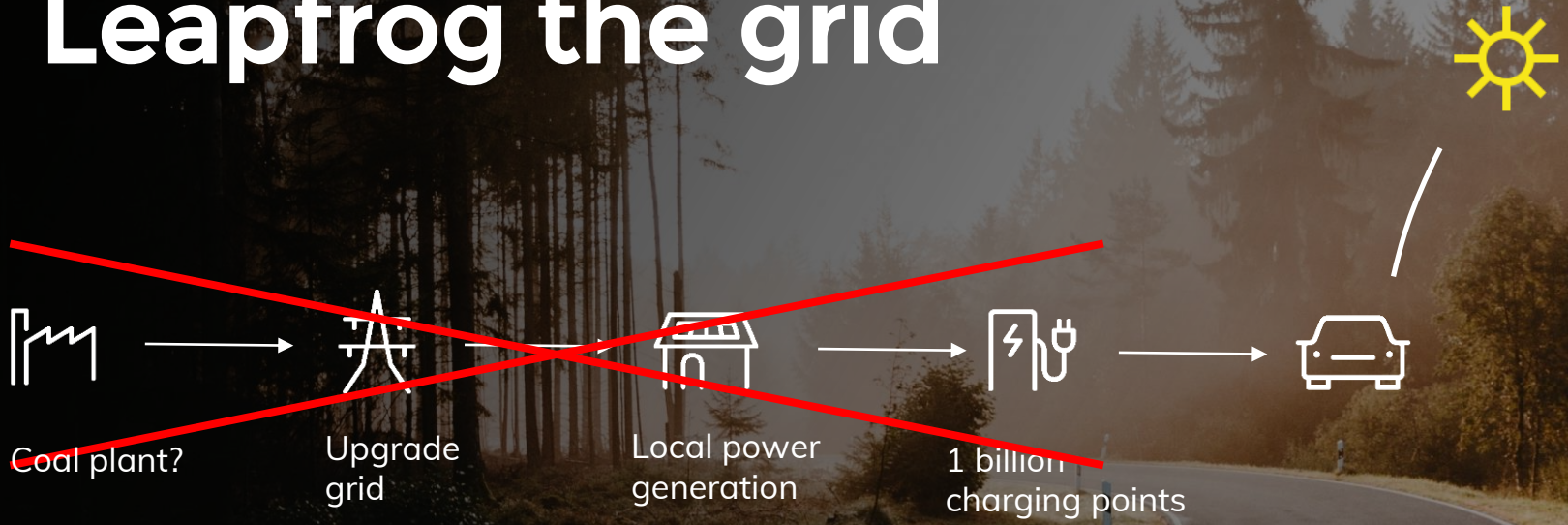
May 21st, 2019


Clean mobility for everyone


Only 3% live
near charging points

Leapfrog the grid



Lightyear One

Solar panels on roof and hood

10.000km

Solar range per year, in NL

Solar-electric family car

725km

WLTP range

12km/kWh

Efficiency

60kWh

Battery

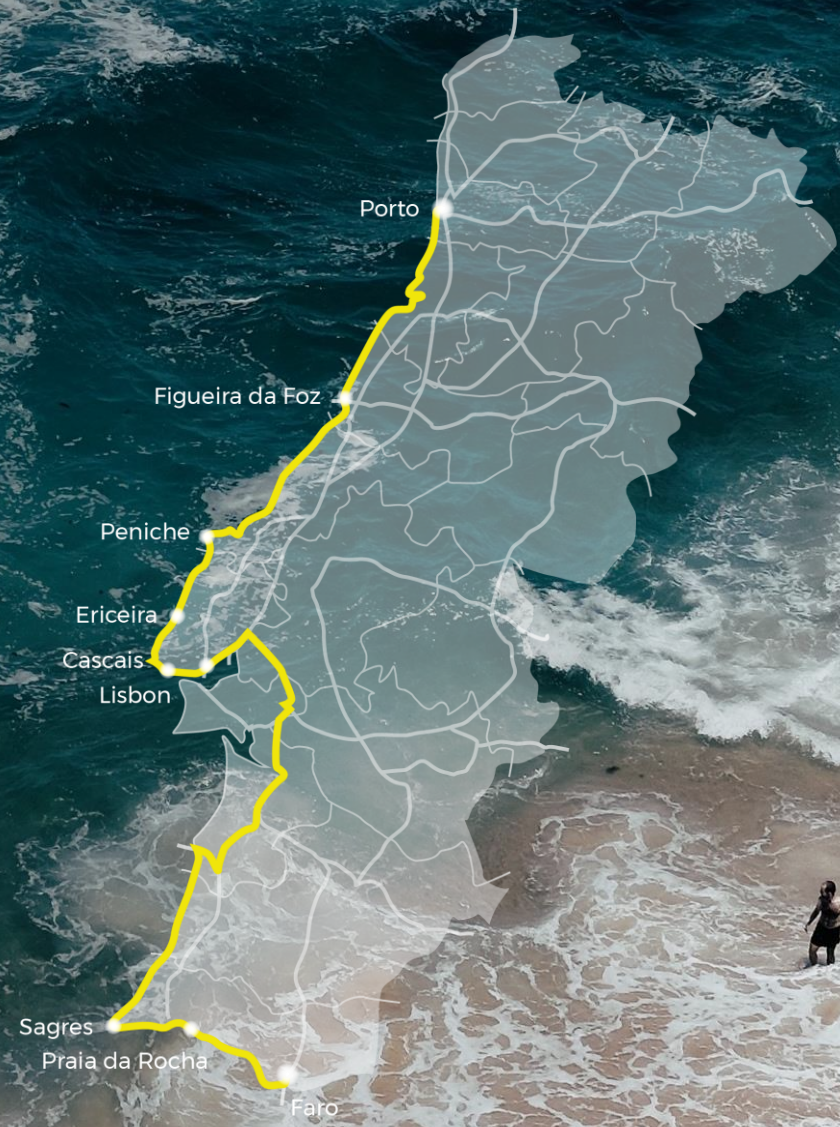
A two week surf trip in Portugal

1.154 km
Total distance

0
Grams of CO_2

0
Charging stops

6
Surfspots



100+ engineers on a mission

200+ years of automotive experience

The first pioneers

€119,000

Excluding taxes

65

Early investors

80+

Signed reservations

10

Signature editions

Re-imagine the car

Solar cells are just the start

Lightweight materials

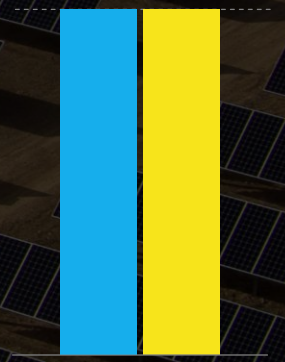
Lightweight cycle

In-wheel motors

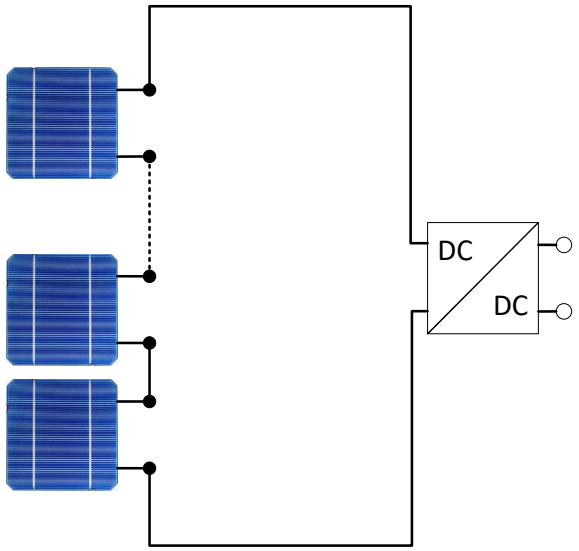
Improved aerodynamics

Solar panel size

Solar panel efficiency

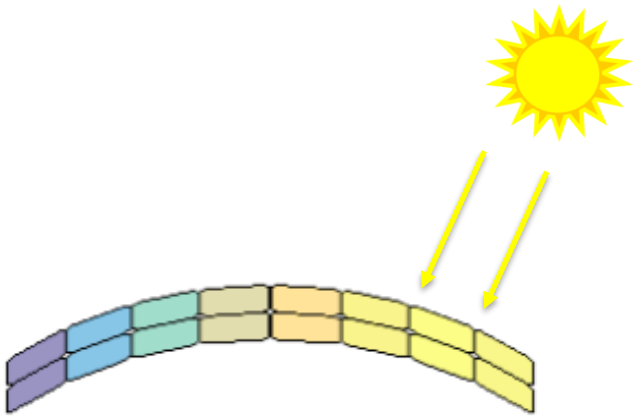


Energy use vs solar yield



State-of-the-art for SEV:

- 3 strings of 125 cells
- The **weakest** cell determines the string current



Curved Surfaces and **Shadows** cause mismatches between cells

Therefore, Solar Electric Vehicles have flat solar roofs

This limits **design freedom** and **aerodynamic** performance

LIGHTYEAR

Grouping Efficiency: *ratio between the individual cell MPPs and the suboptimal group MPPs*

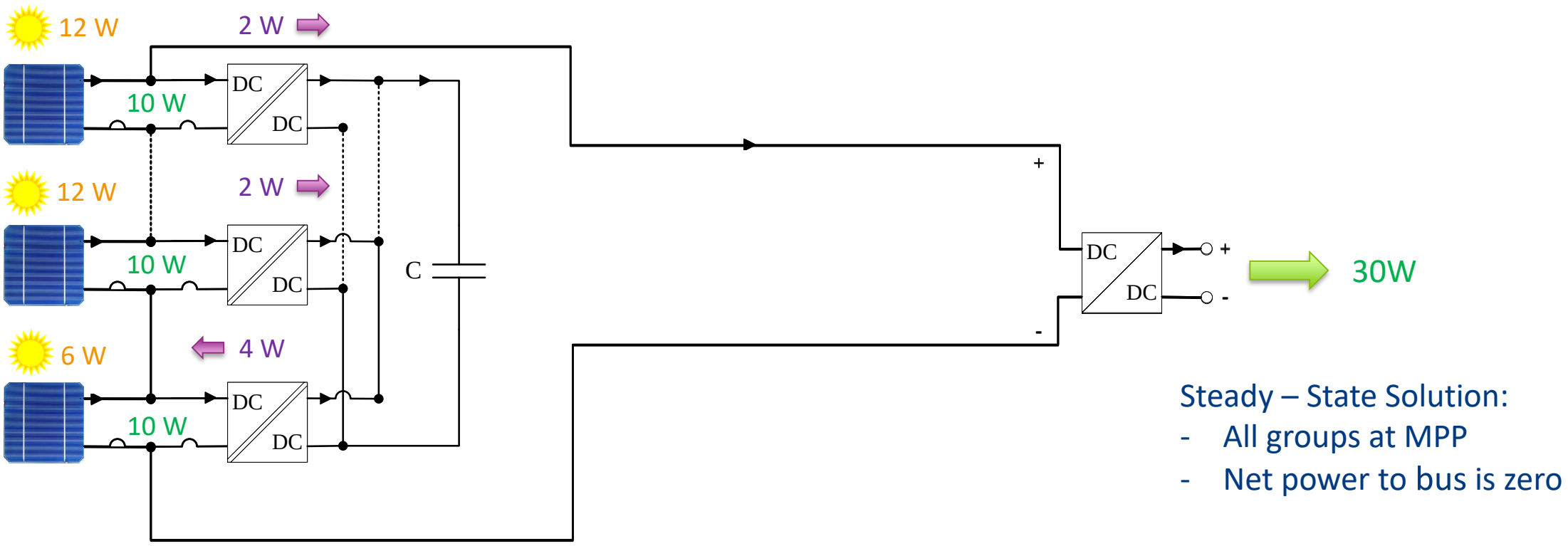
$$\eta_{group} = \frac{\sum P_{mpp,group}}{\sum P_{mpp,cell}}$$

$\eta_{group} = 98.6\ \%$

$\eta_{group} = 75\ \%$

Solution: Smaller groups, AKA Distributed Maximum Power Point Tracking

PV to Isolated Bus Architecture (Olalla, 2013)



Steady – State Solution:

- All groups at MPP
- Net power to bus is zero

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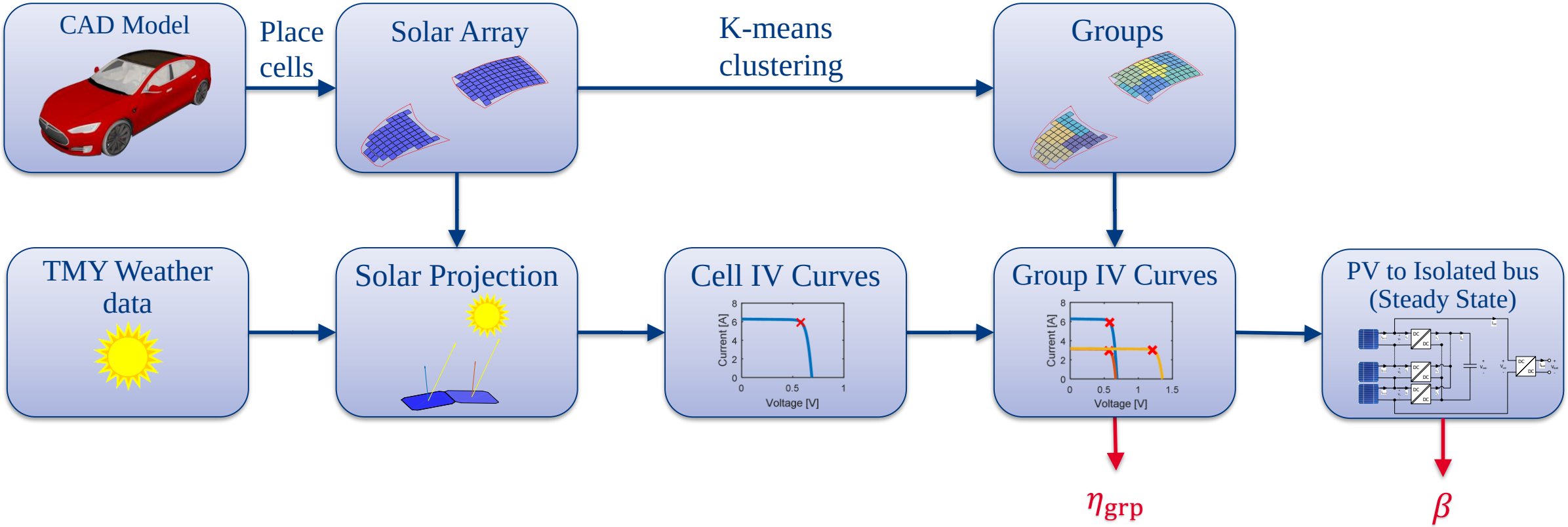
MATLAB Solar Simulator Model



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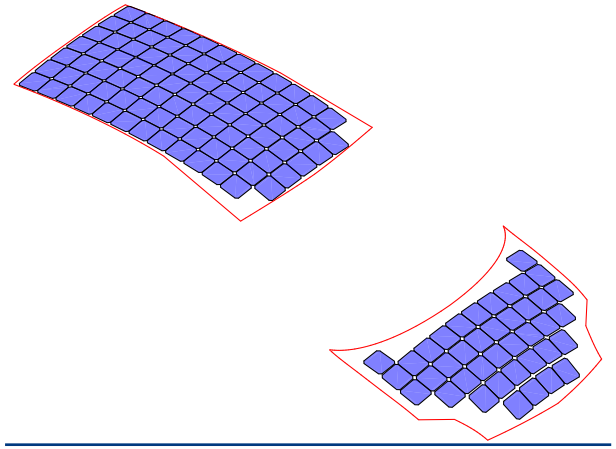
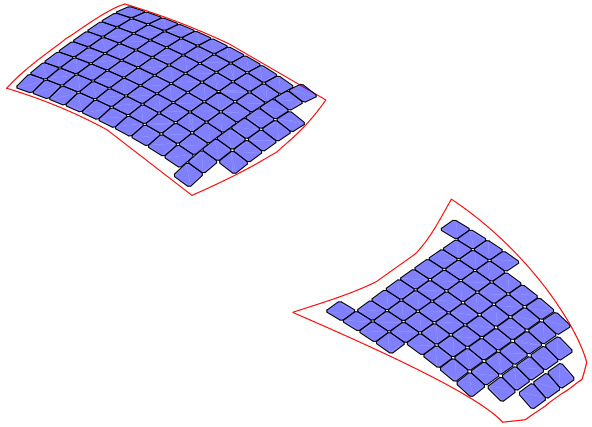
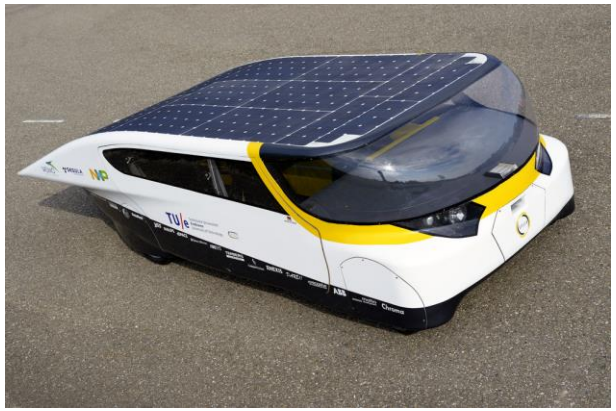
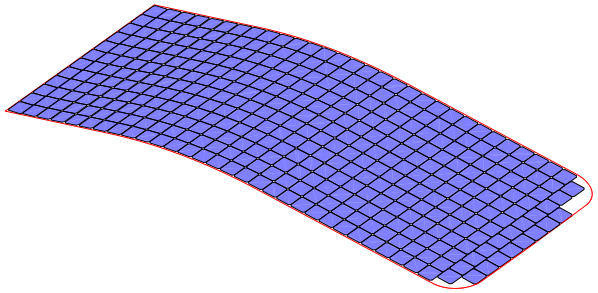


Fiat Grande Punto	
#cells	129
A_{solar}	1.98 m^2

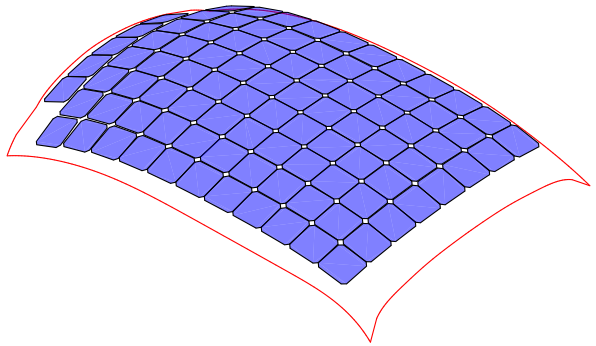


Tesla Model S	
#cells	159
A_{solar}	2.44 m^2





Stella	
#cells	380
A_{solar}	5.84 m^2



VW Beetle	
#cells	93
A_{solar}	1.43 m^2

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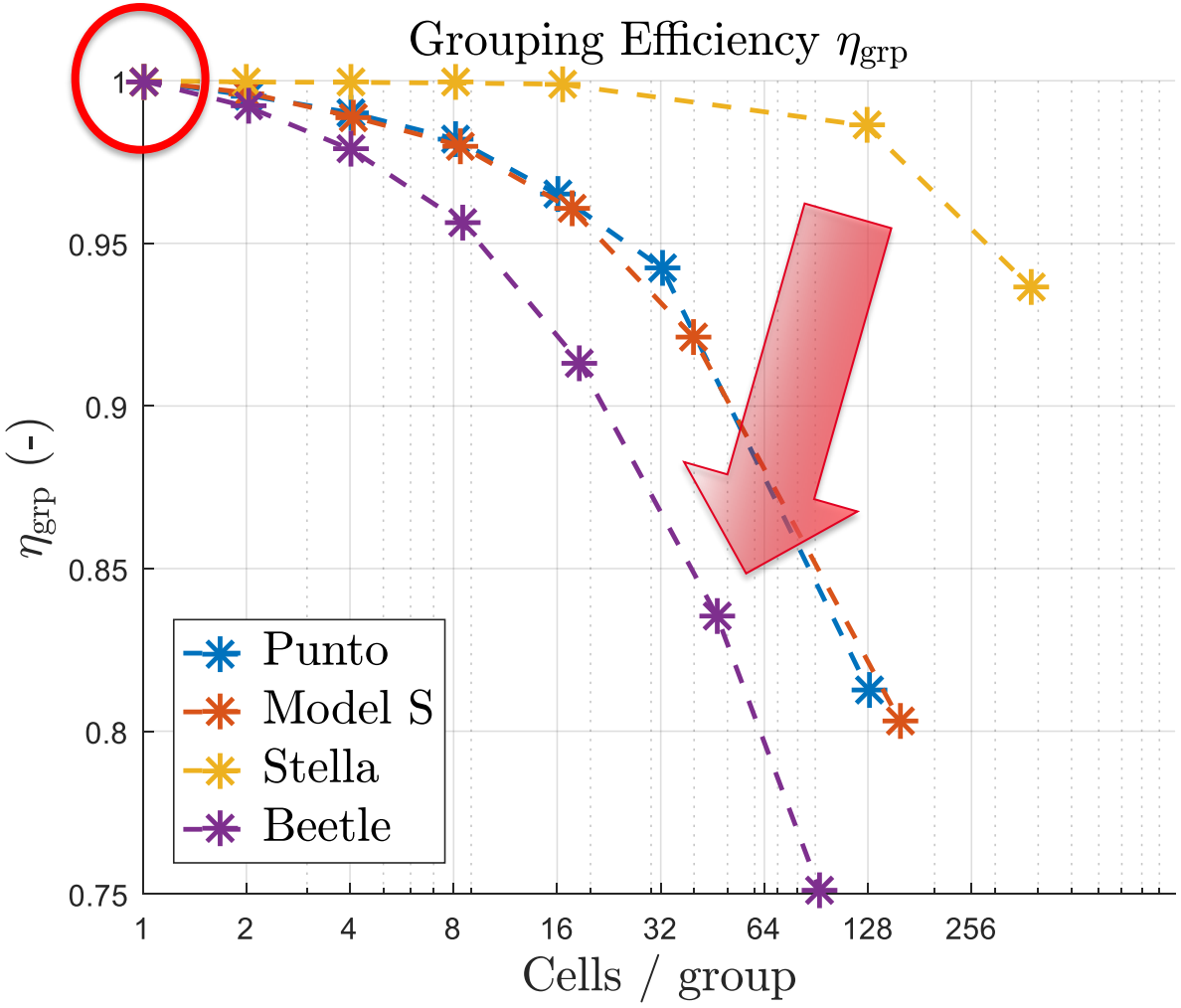
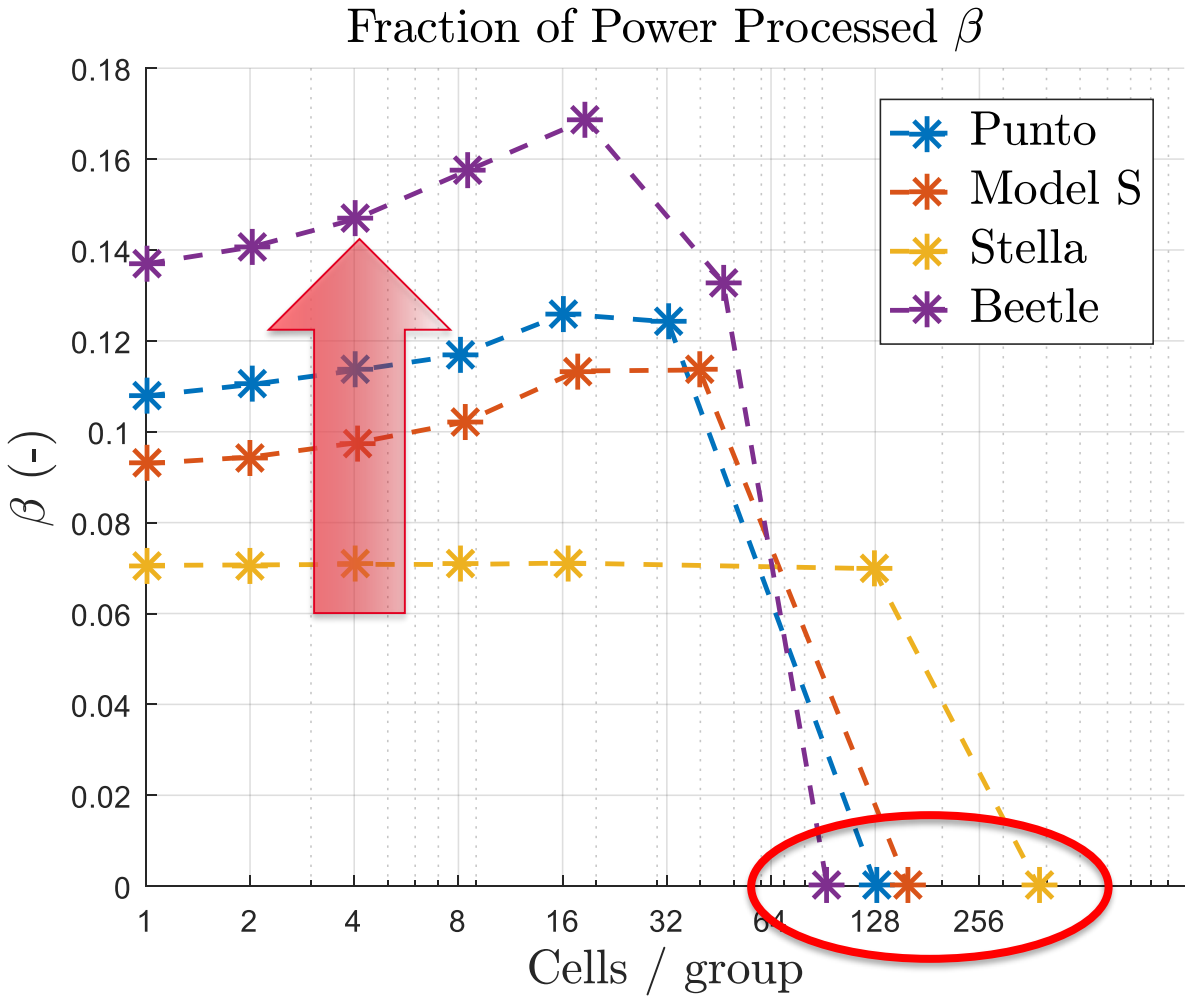

Grouping Efficiency η_{grp}
η_{grp} (-)
1
0.95
0.9
0.85
0.8
0.75
1
2
4
8
16
32
64
128
256
Cells / group
Punto
Model S
Stella
Beetle


Fraction of Power Processed β
β (-)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
2
4
8
16
32
64
128
256
Cells / group
Punto
Model S
Stella
Beetle

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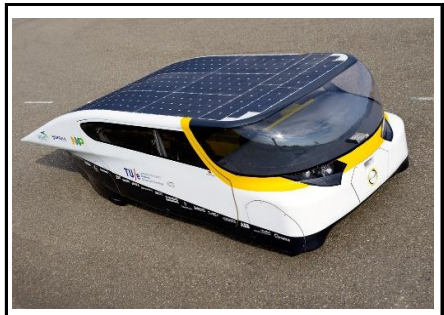
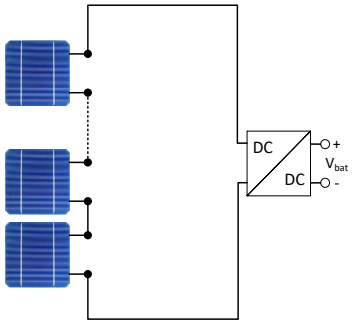
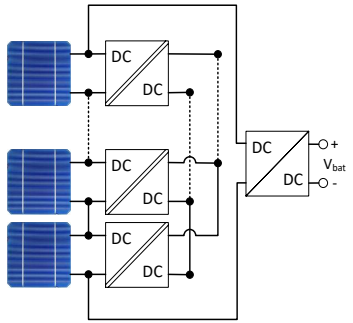
More Curvature



Old System	Grouping Efficiency		99%	80%	75%
	Conversion Efficiency		98%	98%	98%
	System Efficiency		**97%**	**79%**	**74%**
New System	Grouping Efficiency		100%	99%	98%
	Conversion Efficiency		96%	95%	94%
	System Efficiency		**96%**	**94%**	**92%**

-1 +15 +18

LIGHTYEAR

A look into the future

2019

Lightyear One prototypes

2020

First deliveries of Lightyear One

2021

1000 deliveries of Lightyear One

Start Lightyear Two

Key Takeaways

Detailed modelling is key to understanding the design space and creating optimized solutions

For typically curved cars, the DMPPT system can improve performance by up to 18%-points

The diversity of MATLAB / Simulink allows It to be used as a ‘swiss army knife’ for engineers

Thank you

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