Contrasting different electricity futures by comparing a large number of optimized scenarios

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Image sources:
http://www.2050publications.com/wp-content/uploads/2012/10/offshore-wind-turbines1.jpg
http://inweekly.net/wordpress/wp-content/uploads/2011/03/cooling-towers-of-a-nuclear-power-station.jpg
http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2012/12/rooftop-solar-array-537x359.jpg

1 CSP dispatchability

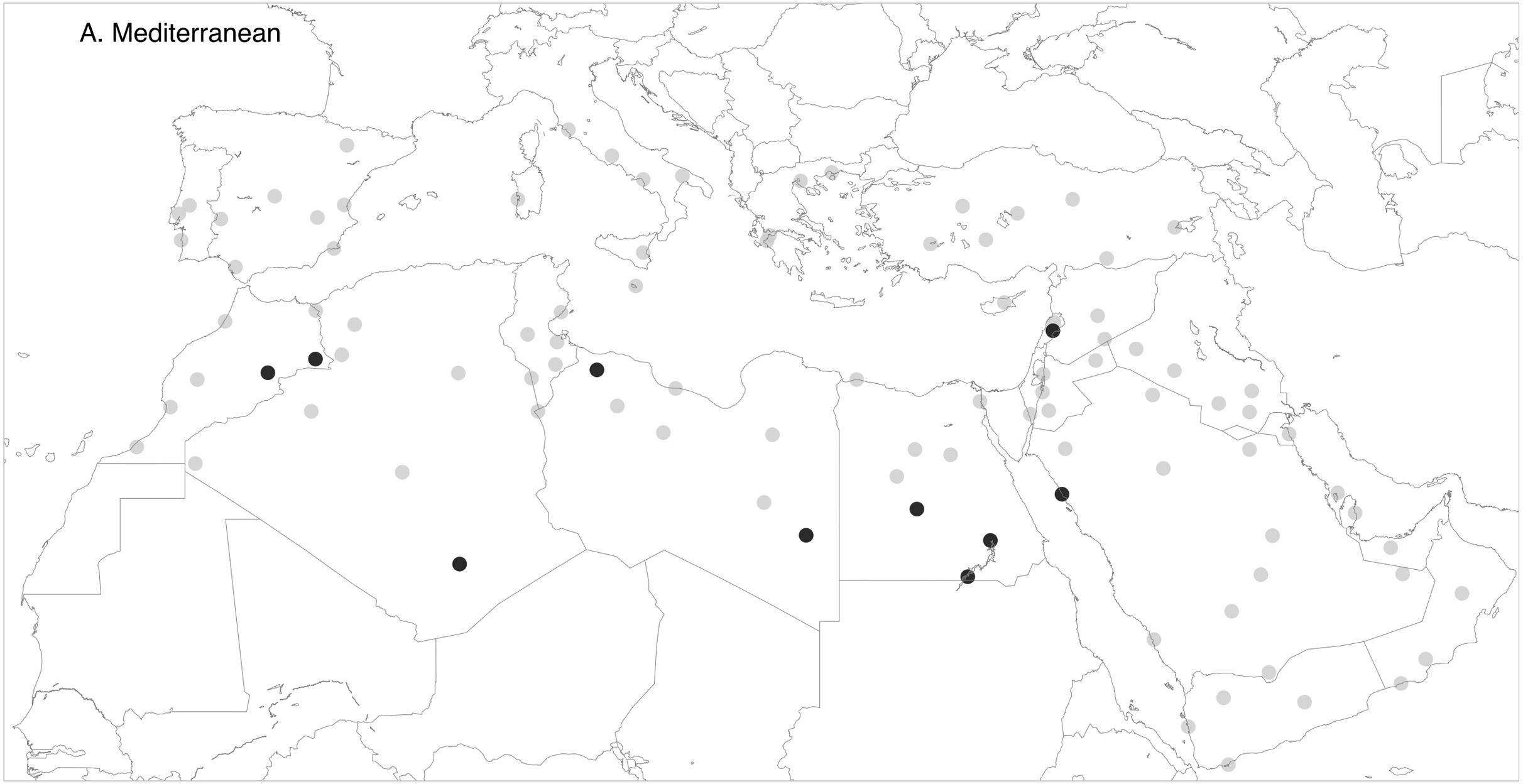
2 UK electricity scenarios

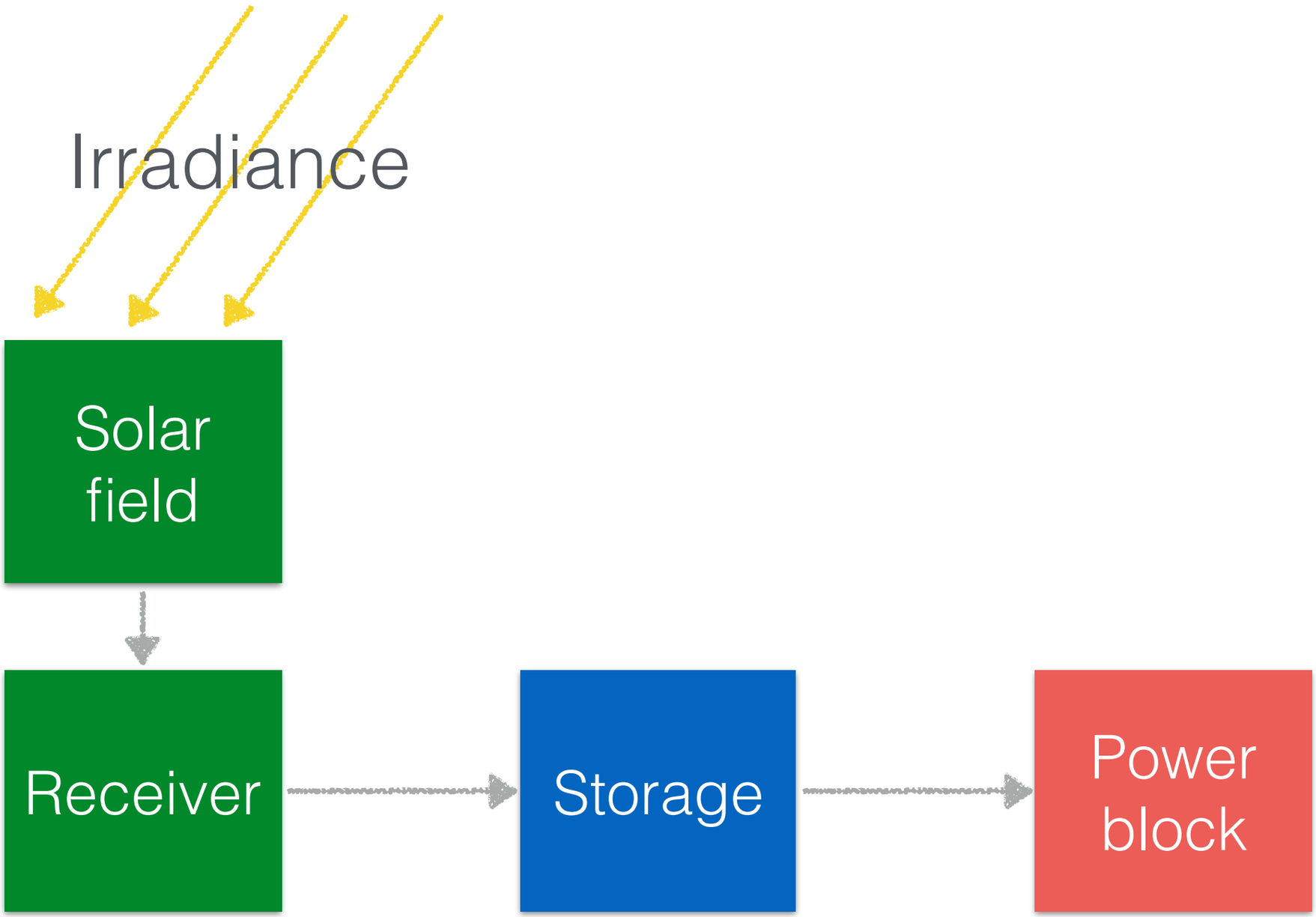
3 Future work

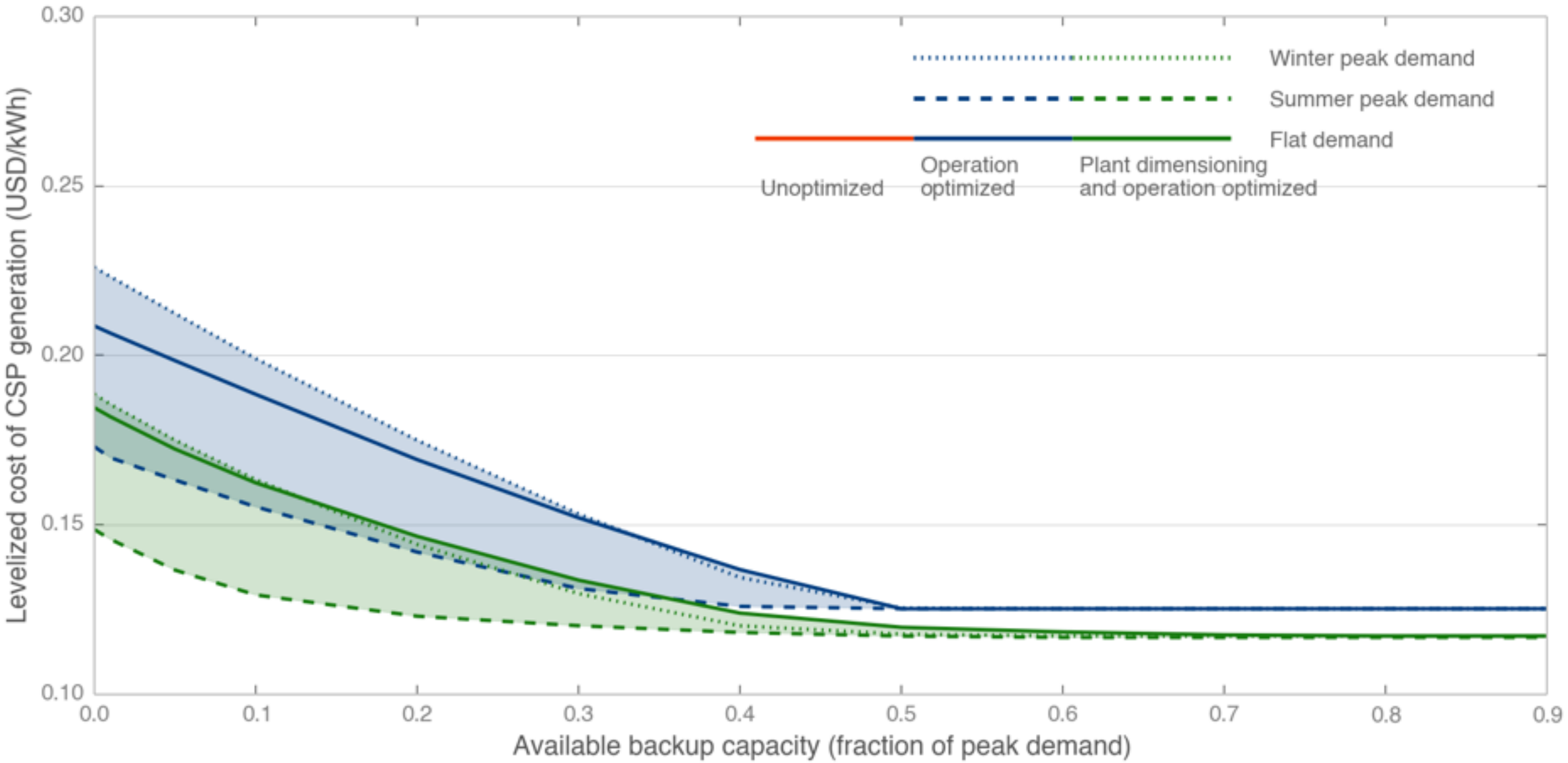
CSP:
Concentrating solar power

Image source: http://www.theatlantic.com/infocus/2014/03/the-ivanpah-solar-electric-generating-system/100692/

A. Mediterranean




Irradiance
Solar field
Receiver
Storage
Power block


0.30
0.25
0.20
0.15
0.10
Levelized cost of CSP generation (USD/kWh)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Available backup capacity (fraction of peak demand)
Winter peak demand
Summer peak demand
Flat demand
Unoptimized
Operation optimized
Plant dimensioning and operation optimized

Solar and weather data

Plant model
(Python)

Optimization
(GAMS)

Postprocessing
(Python)

Outputs

1 CSP dispatchability

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Solar and weather data

Plant model
(Python)

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(GAMS)

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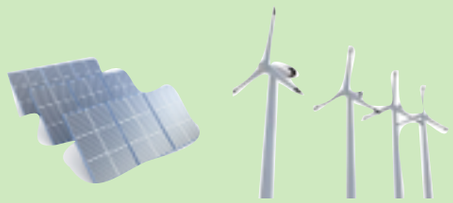
Outputs

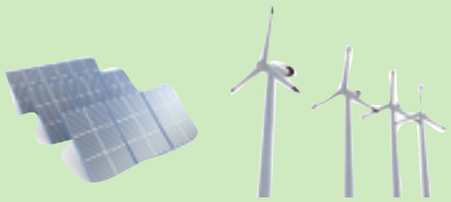


Spatially explicit technology models and data

Optimization
(GAMS)

Postprocessing
(Python)

Outputs



Spatially explicit technology models and data

Calliope

Energy systems modeling framework

Outputs

ETI-ESME

Spatial and temporal detail

Probabilistic scenarios

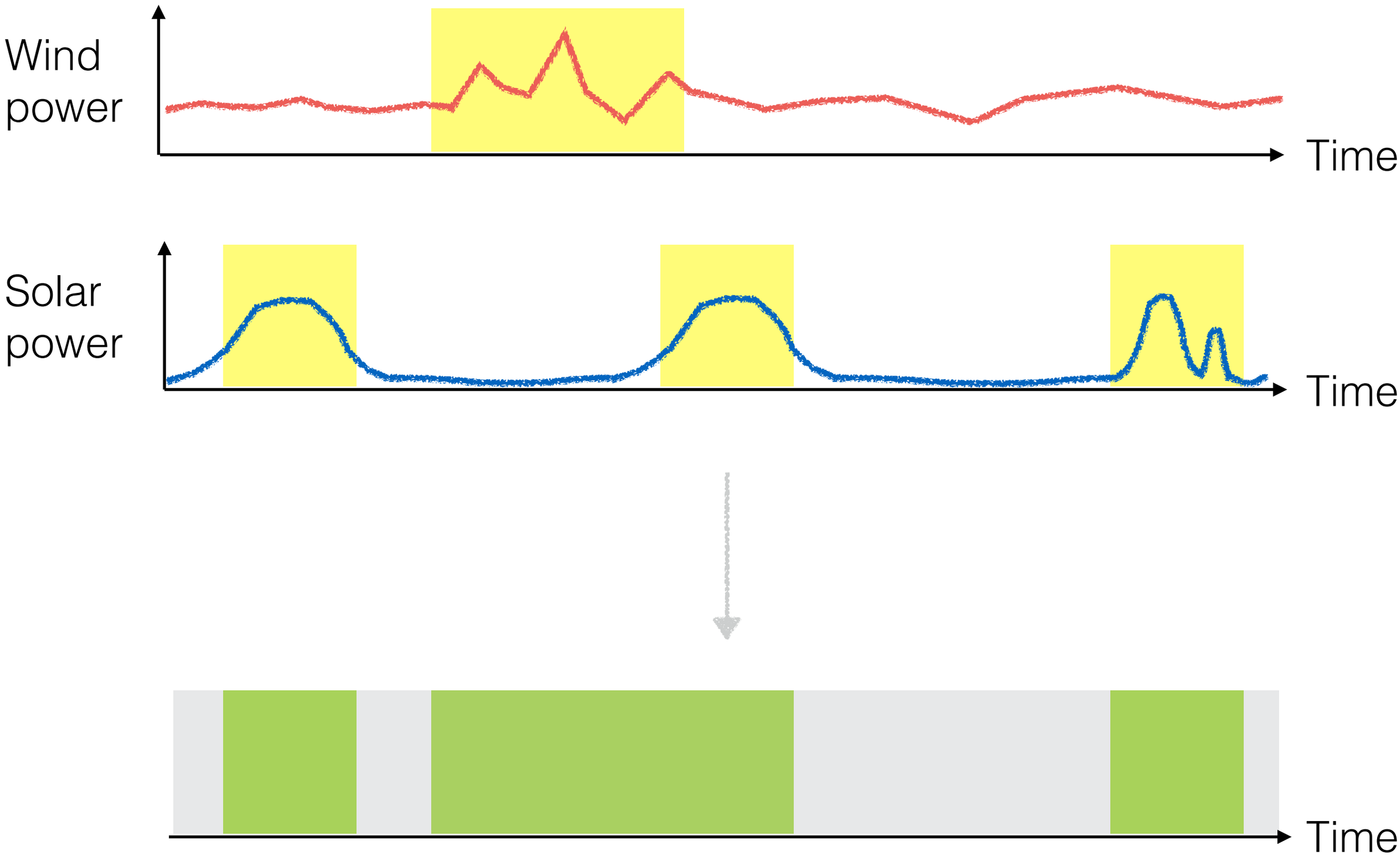
Temoa

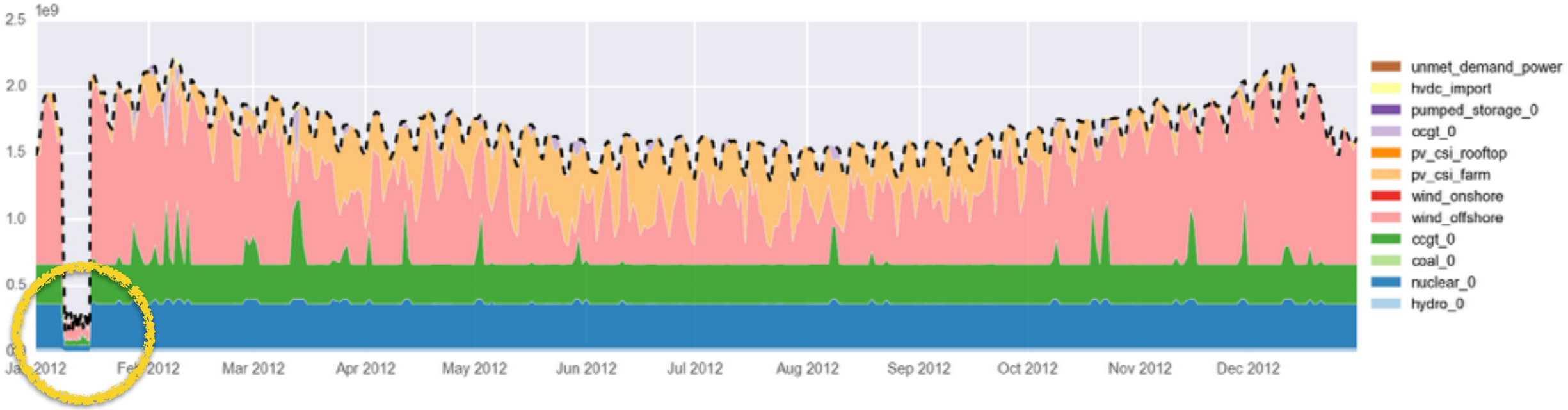
Open-source toolchain

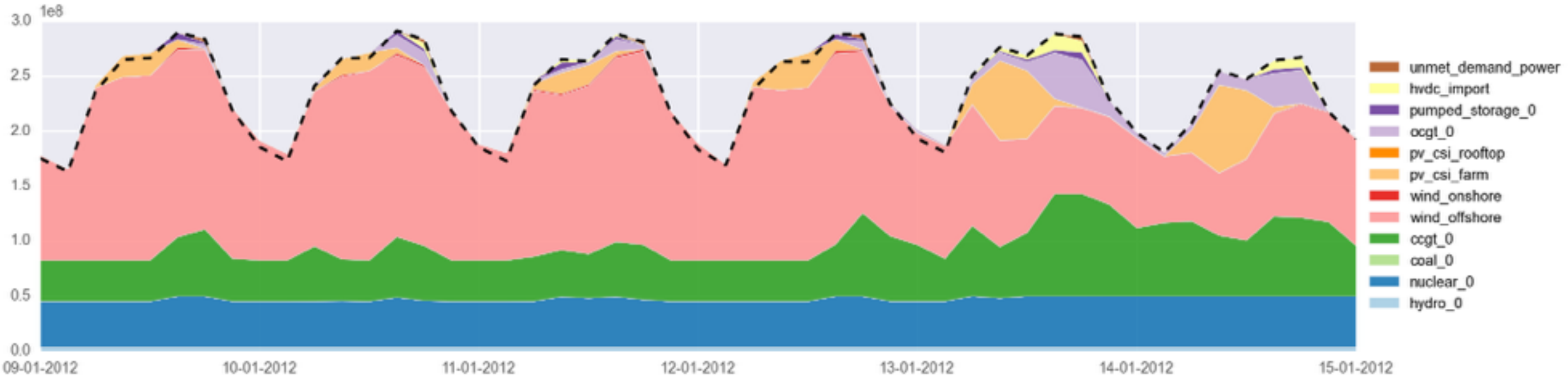
Run on computing cluster

Pluggable spatio-temporal
“resource streams”

Hybrid planning-operational mode
with dynamic timesteps


Wind
power
Time
Solar
power
Time
Time


1e9
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2012
Feb 2012
Mar 2012
Apr 2012
May 2012
Jun 2012
Jul 2012
Aug 2012
Sep 2012
Oct 2012
Nov 2012
Dec 2012
unmet_demand_power
hvdc_import
pumped_storage_0
ocgt_0
pv_csi_rooftop
pv_csi_farm
wind_onshore
wind_offshore
ccgt_0
coal_0
nuclear_0
hydro_0


1e8
3.0
2.5
2.0
1.5
1.0
0.5
0.0
09-01-2012
10-01-2012
11-01-2012
12-01-2012
13-01-2012
14-01-2012
15-01-2012
unmet_demand_power
hvdc_import
pumped_storage_0
ocgt_0
pv_csi_rooftop
pv_csi_farm
wind_onshore
wind_offshore
ccgt_0
coal_0
nuclear_0
hydro_0

Fossil

Nuclear

Renewable

100% Renewable

Renewable

Fossil

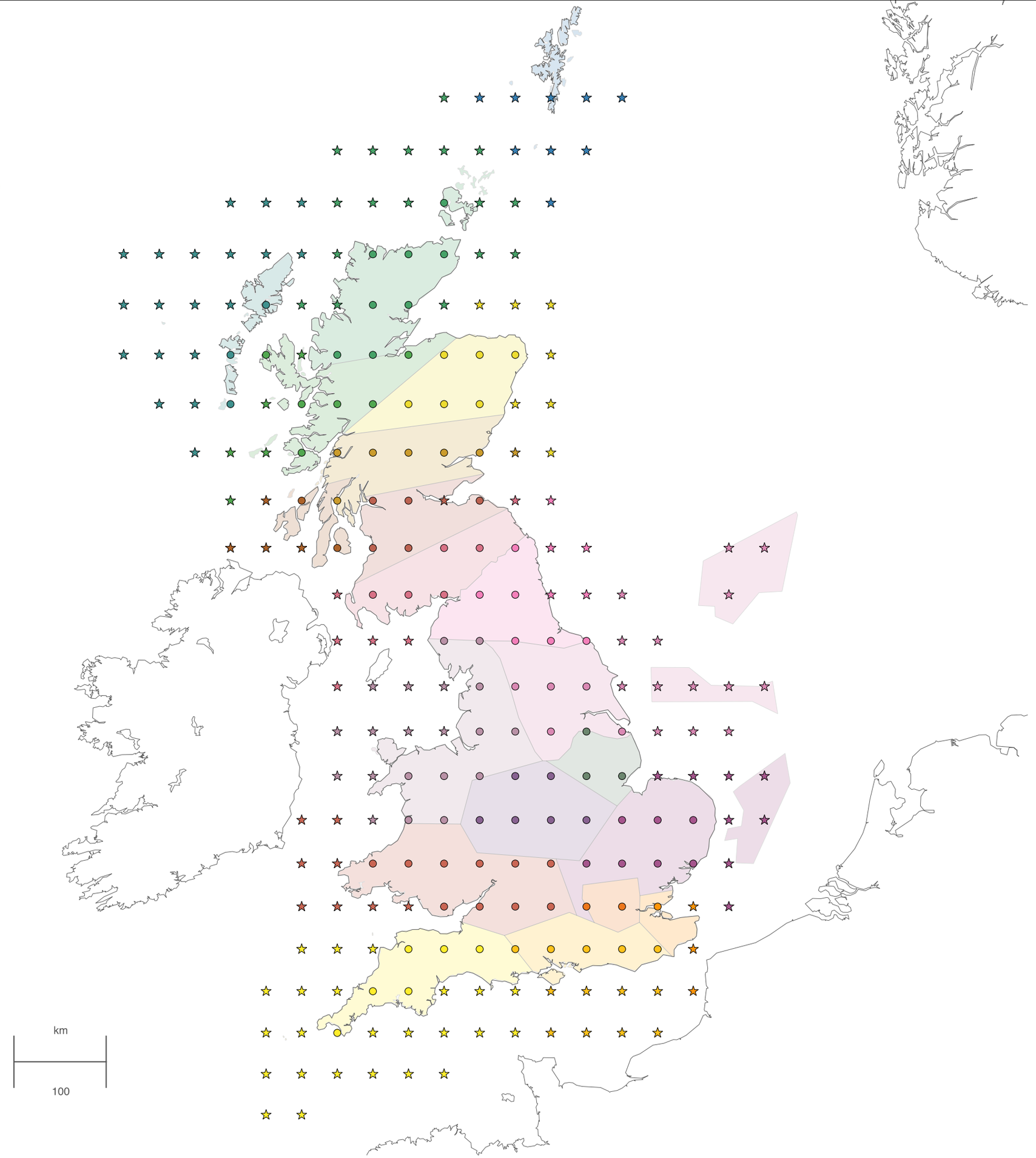
50% Renewable
50% Nuclear

50% Renewable
50% Fossil

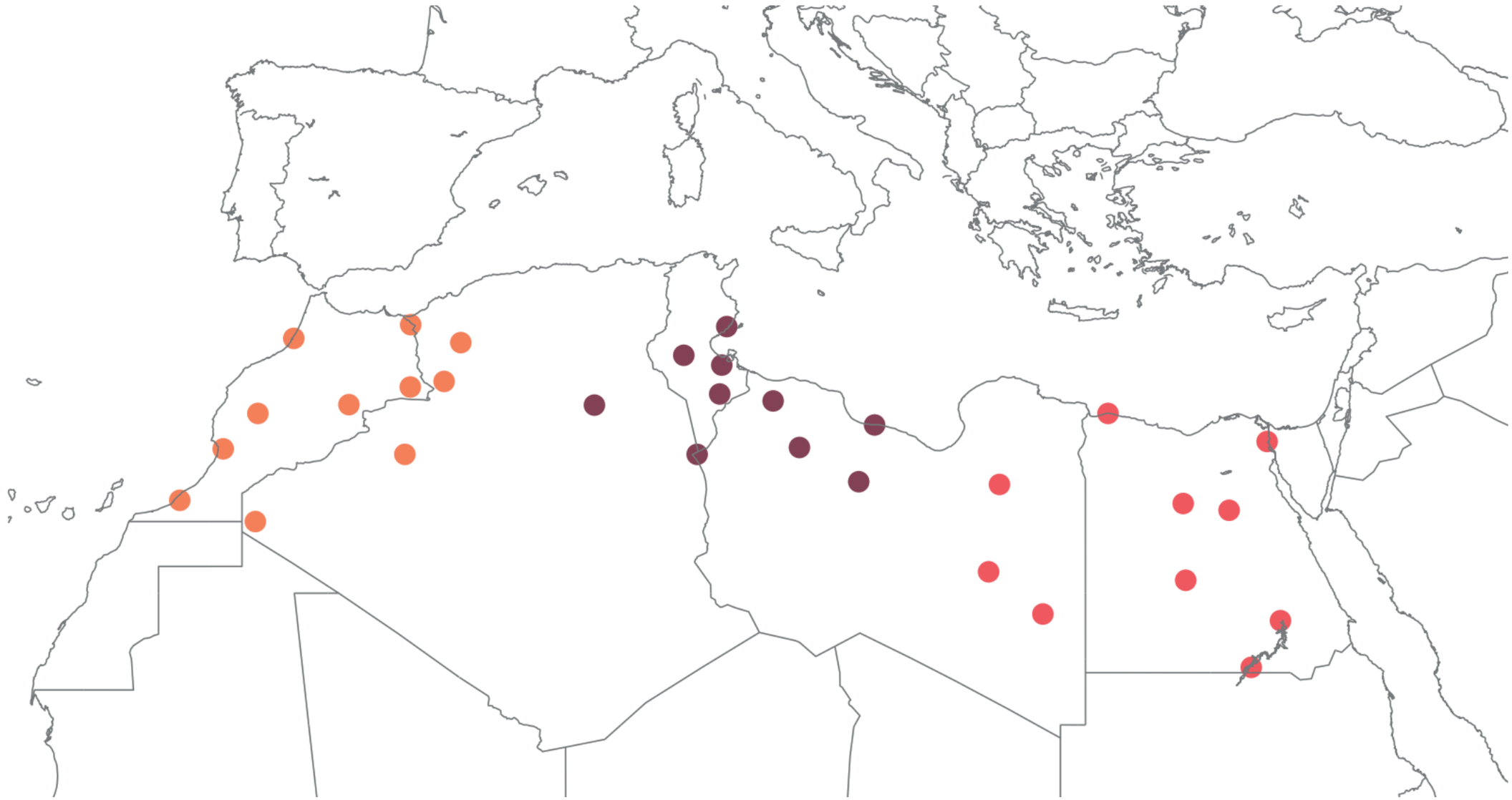
60% Fossil
25% Nuclear
15% Renewable

Image sources:
http://www.clker.com/cliparts/f/5/4/6/12427968391741677025Nuclear_symbol.svg.hi.png
http://wattsupwiththat.files.wordpress.com/2008/04/lump_of_coal.jpg
http://etap.com/renewable-energy/renewable-energy-images/operate-solar-farms-with-etap.jpg

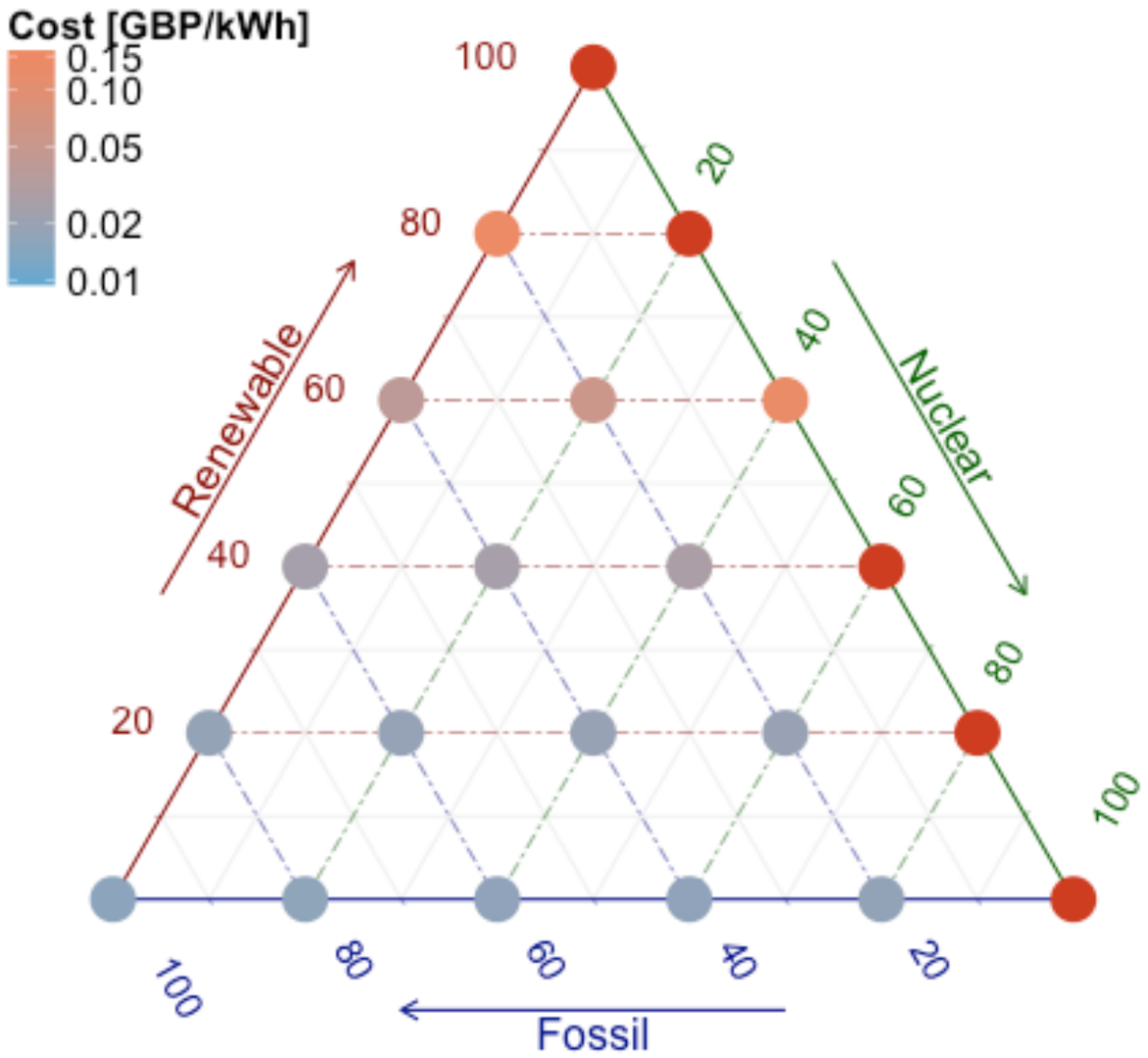
UK zones



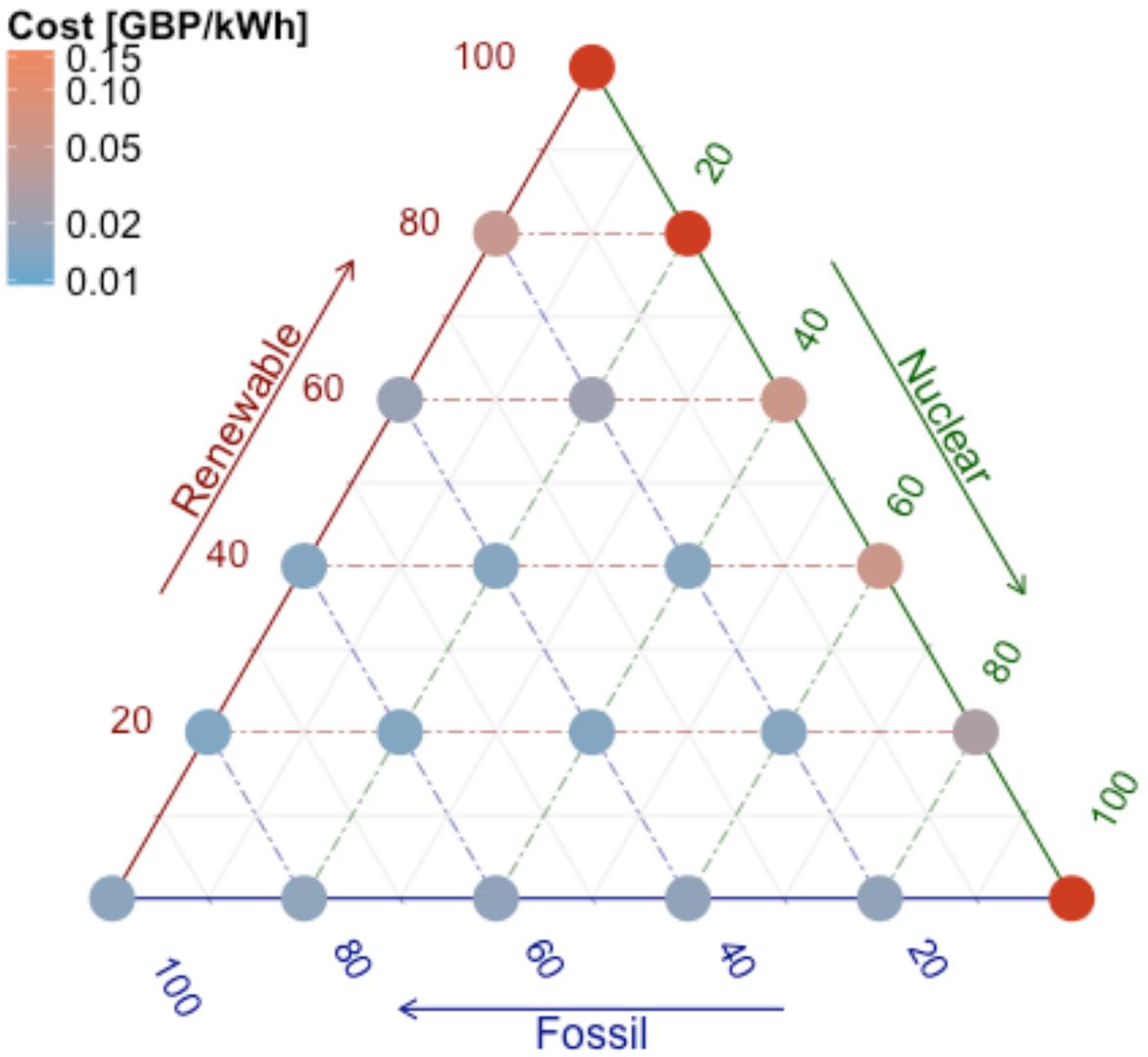
Desert solar imports



System-wide costs

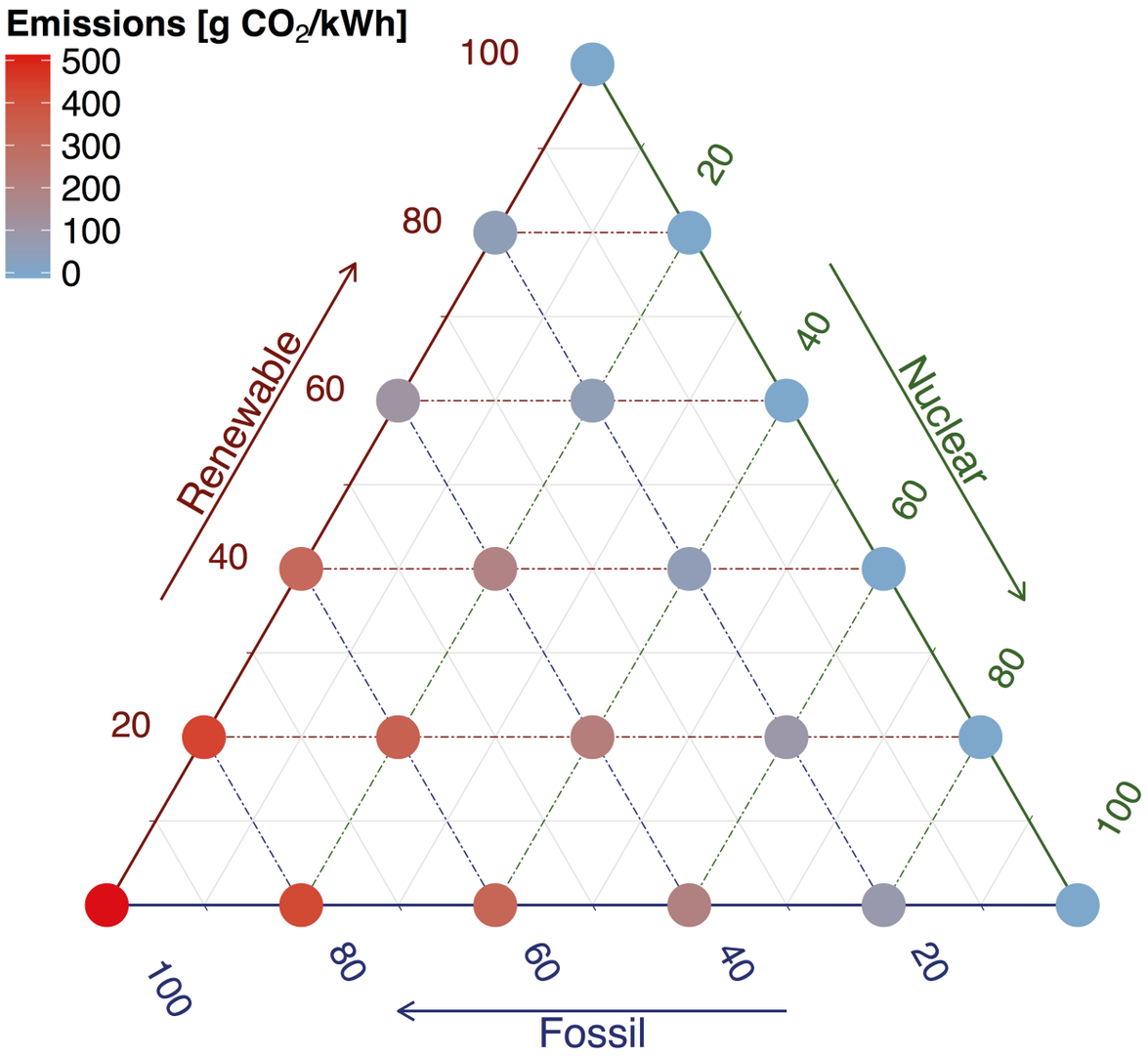


No imports



Desert solar imports

Emissions


Emissions [g CO2/kWh]
500
400
300
200
100
0
100
80
60
40
20
Renewable
20
40
60
80
100
Nuclear
100
80
60
40
20
Fossil

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Next steps for Calliope framework

- Improved **operational constraints** for hybrid planning-operational mode

- Examine **heat – electricity link** with spatial and temporal detail

- **Other methods** than global optimization that better capture complexity

Questions or comments?

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