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Analysis of boundary conditions and potentials for solar cooling systems within the sunbelt region based on geographical data

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ISES International Solar Energy Society

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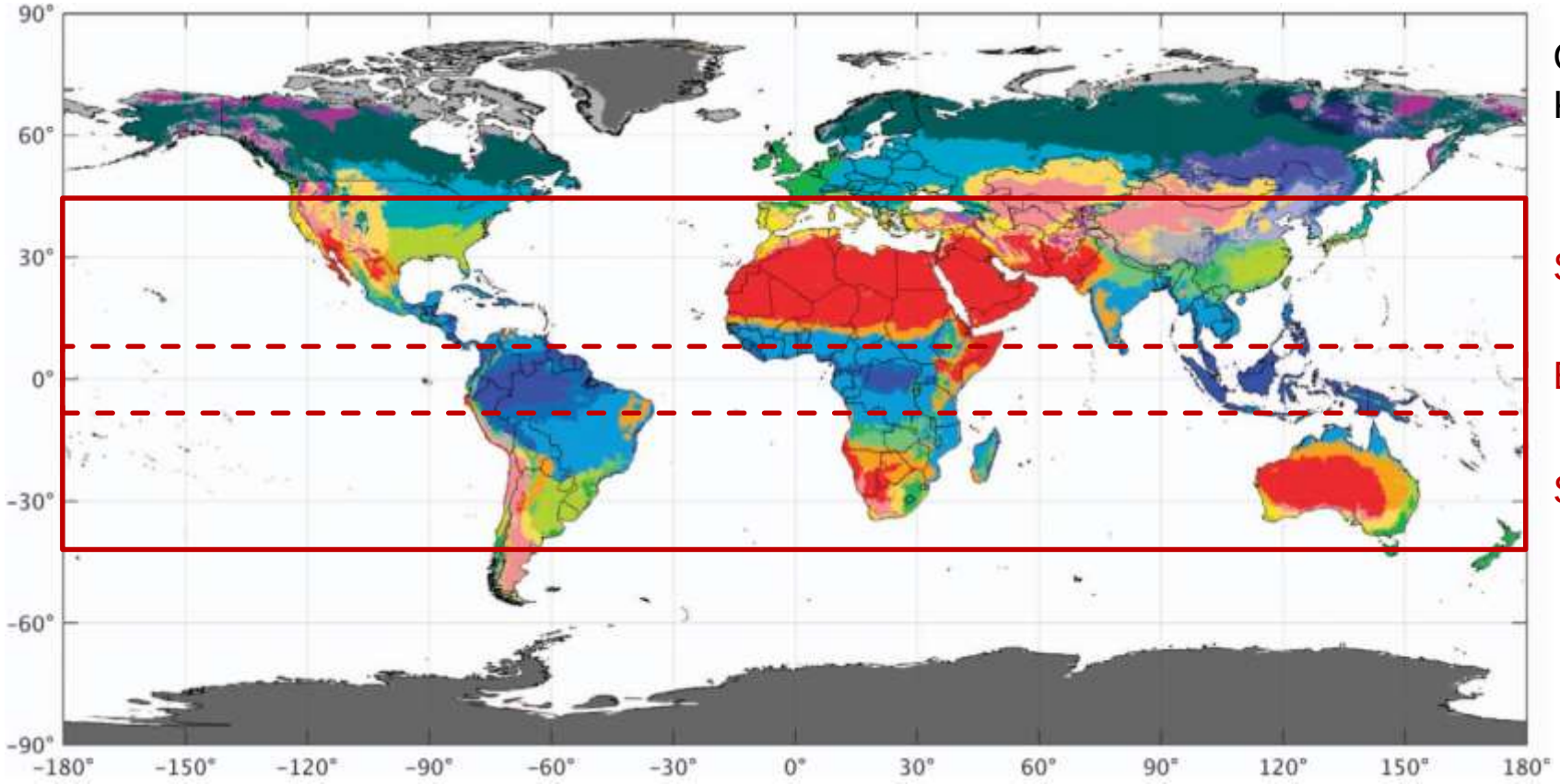
1. **Project objectives**
2. Data sources
3. Methodology & data processing
4. Boundary conditions for the SunBelt region
5. Showcase: Potentials for the SunBelt Chiller (SBC)
6. Outlook

Project objectives

How to evaluate boundary conditions and how to identify potentially appropiate locations for solar cooling systems



Climate zones according to Köppen-Geiger

Sunbelt	+20°.. +40°
Equatorial	-20°.. +20°
Sunbelt	-40°.. -20°

Source: GloH2O | http://www.gloh2o.org/koppen

Project objectives

Boundary conditions and locations for solar cooling systems

Identify potential cooling needs and their locations

- Where is what kind of cooling system suitable?

Evaluate boundary conditions for solar cooling systems

- What are the cooling needs and where are these located?
- What are the challenges and requirements for recooling systems there?
- What are the conditions for solar collectors and where are they located?
- What is the economic frame and where is it applicable?
- …

→ These questions have been addressed using selected data in a Geo Information System (GIS)

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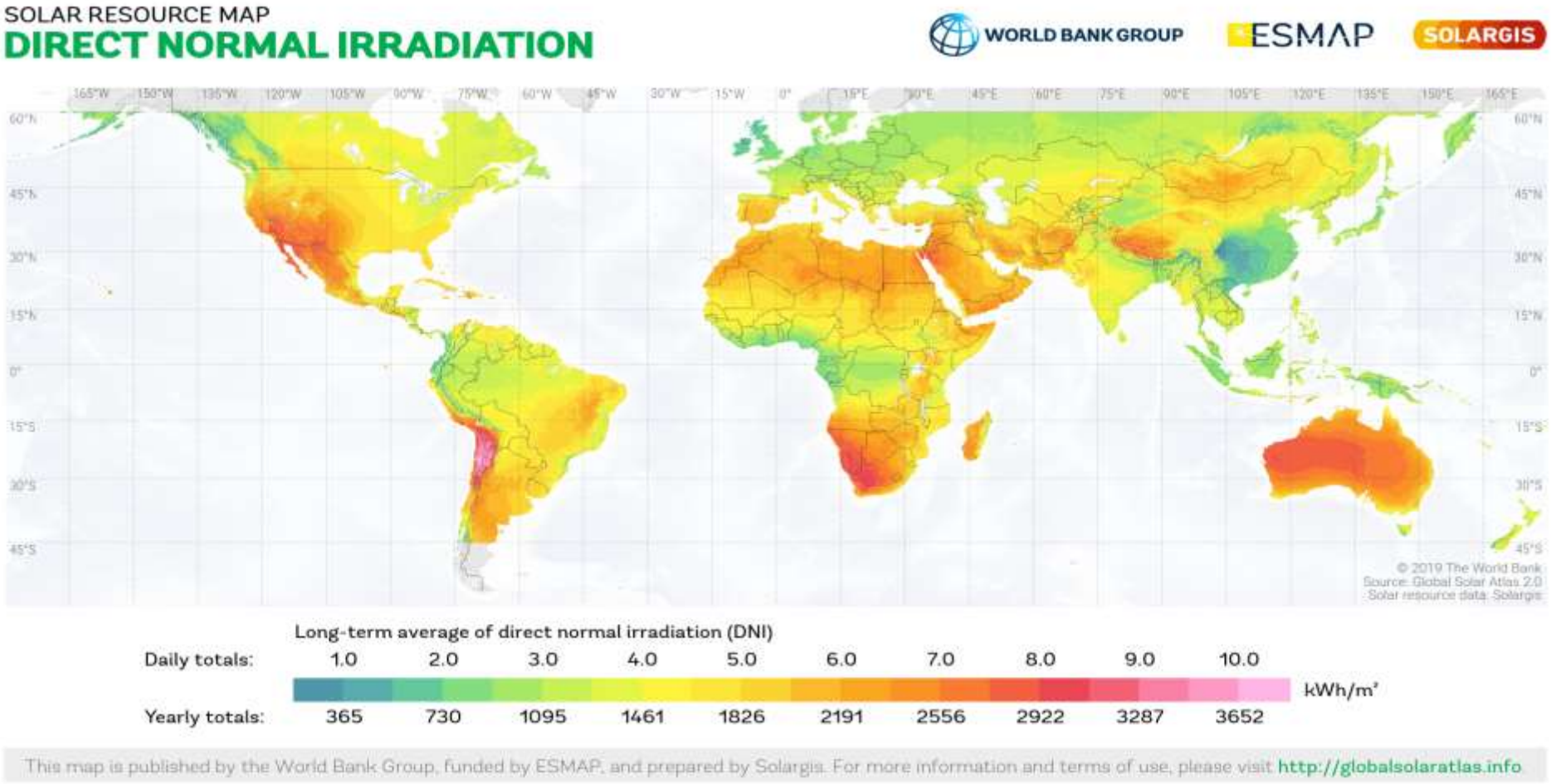
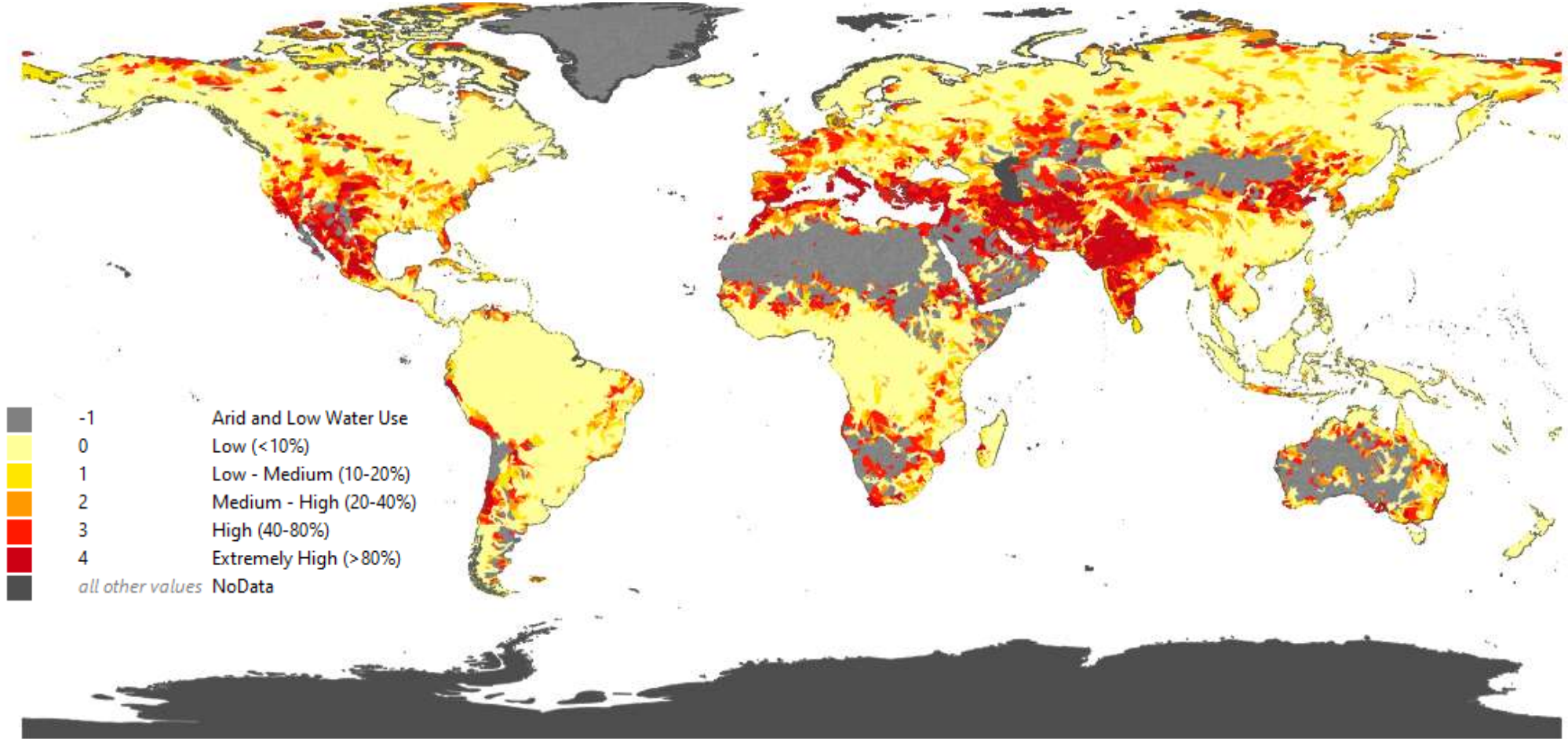
Data sources

Input source example – Solar irradiation



Data sources

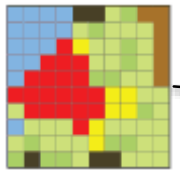
Input source example - Baseline water stress

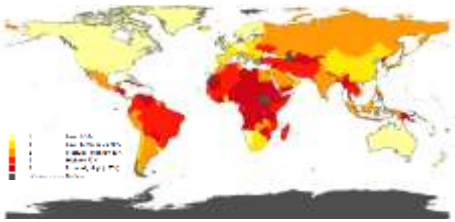


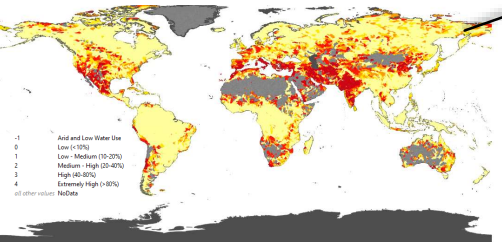
Source: Aqueduct Water Risk Atlas | World Resources Institute

Data sources

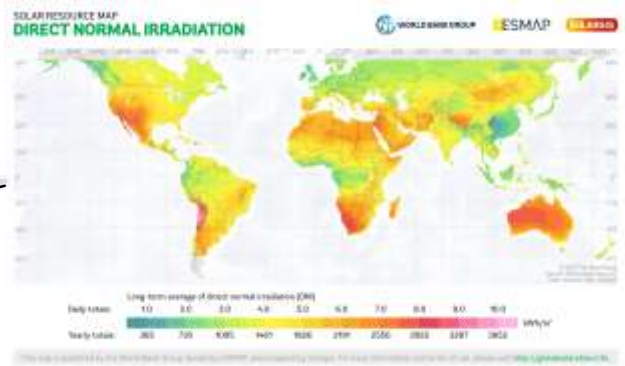
Input data







Input Data attributes	Data source type
Köppen-Geiger climate class	Vector polygon
Population	Raster
Settlement Model	Raster
Solar Irradiation	Raster
Gross domestic product per capita	Raster
Market risk	Vectorpolygon
Baseline Water Stress	Vector polygon
Buildings (Open Street Map)	Vector polygon extract
Countries, Continents	Vector polygon



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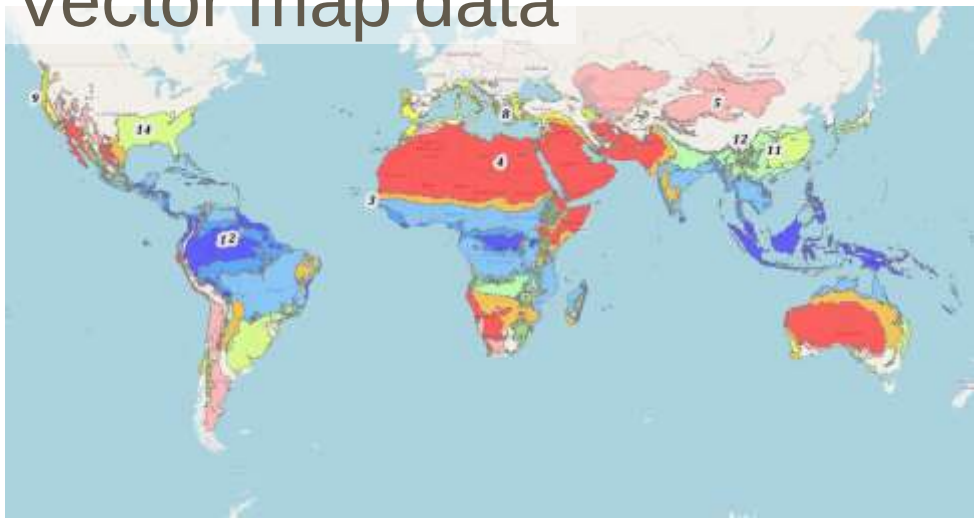
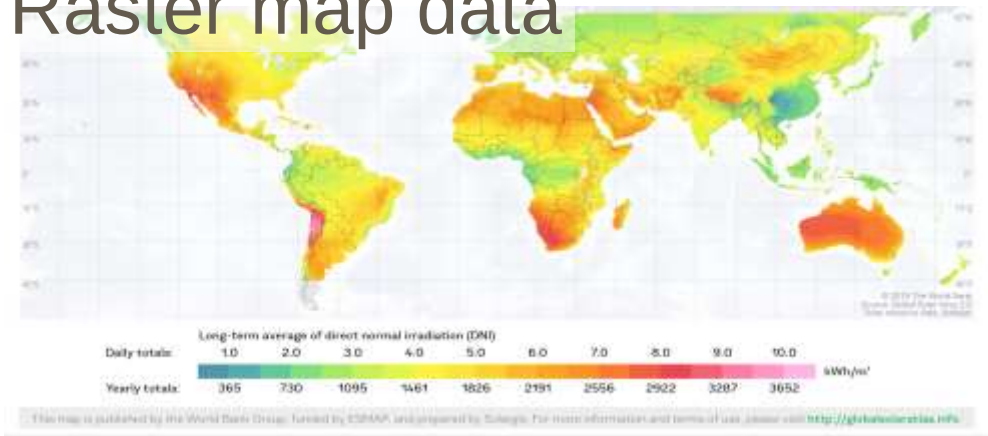
Methodology & data processing

Vector map data



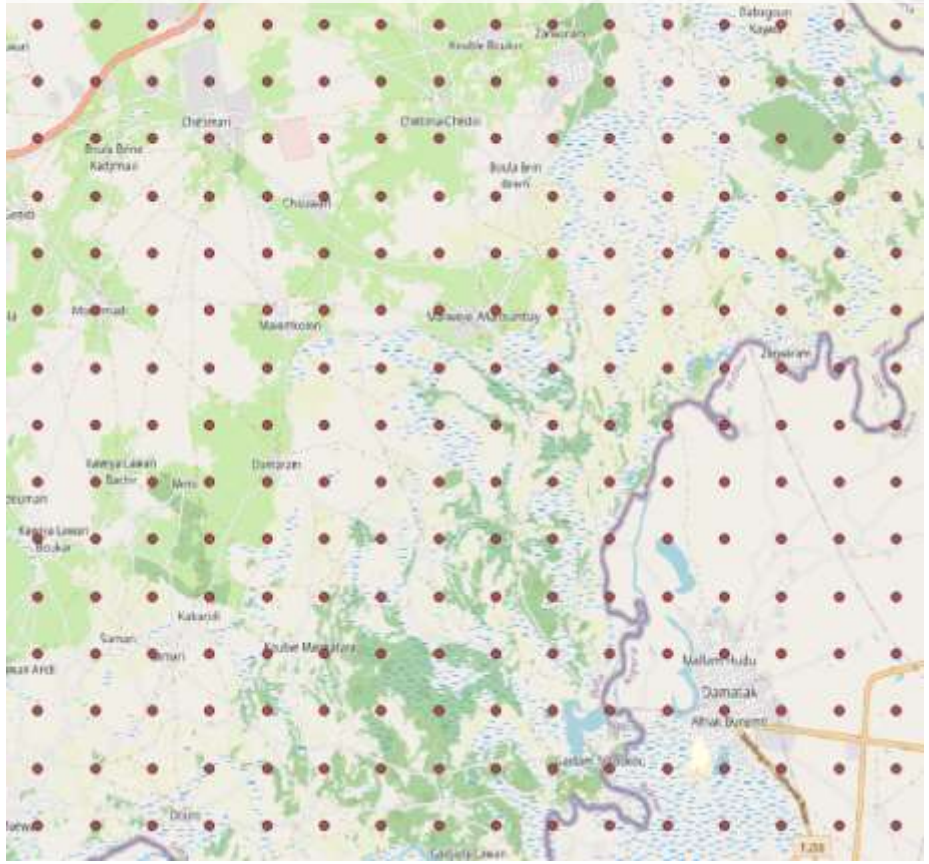
Raster map data



Join by location

Sampling

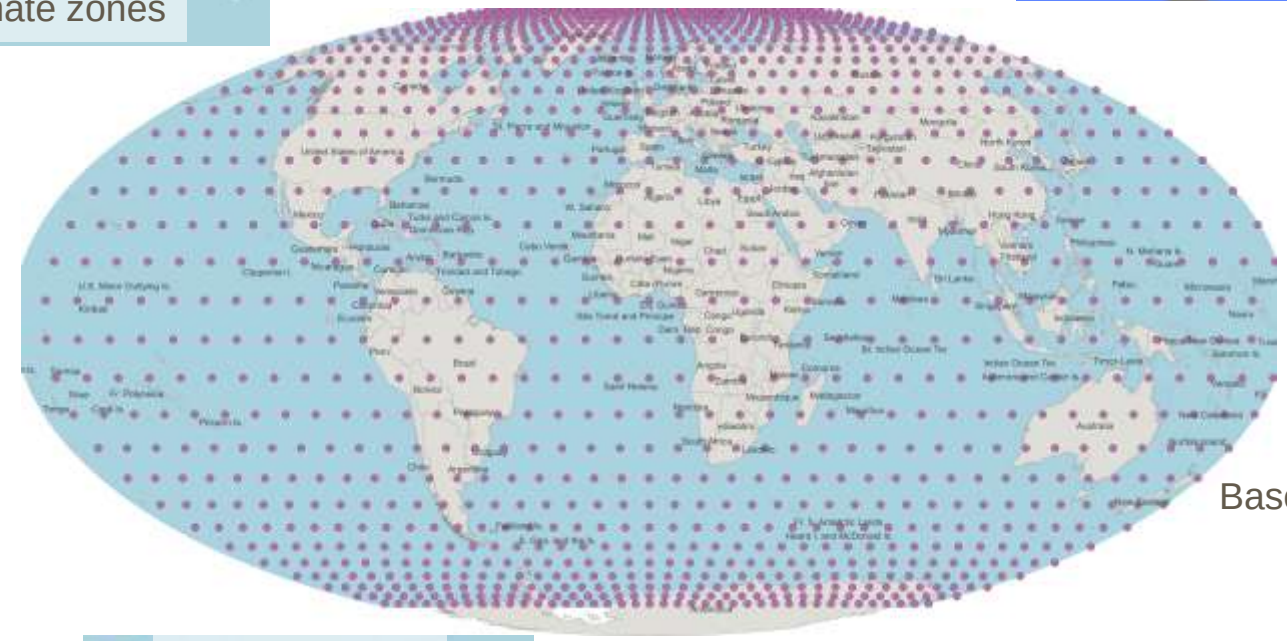
1 km x 1 km raster grid (predefined by population data source)



Methodology & data processing

Research and sampling of global geo data

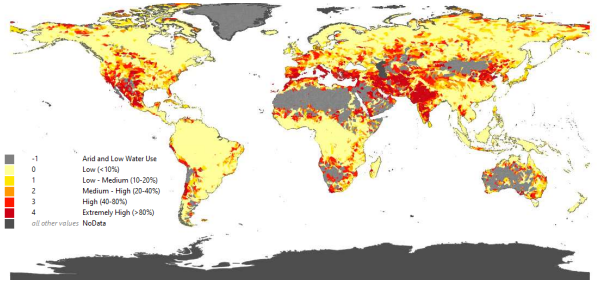
Settlement classification
(Settlement model)



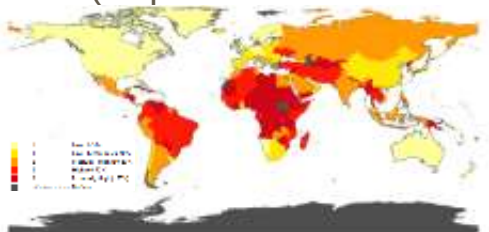
Direct Normal Irradiance
PV output
Global Horizontal Irradiance

GDP per capita /
Purchasing Power Parity

Baseline Water Stress



Market risk (Reputational Risk Index)



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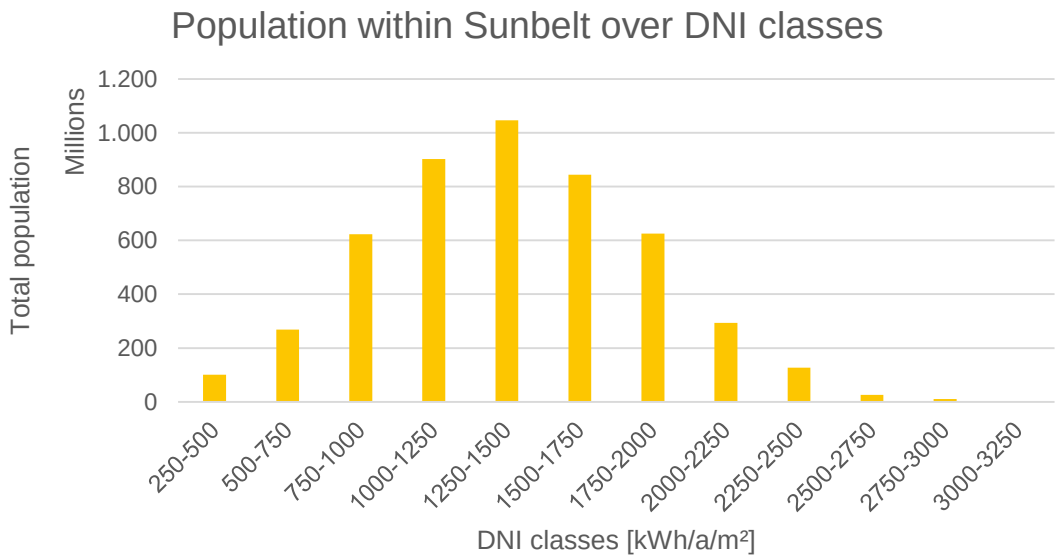
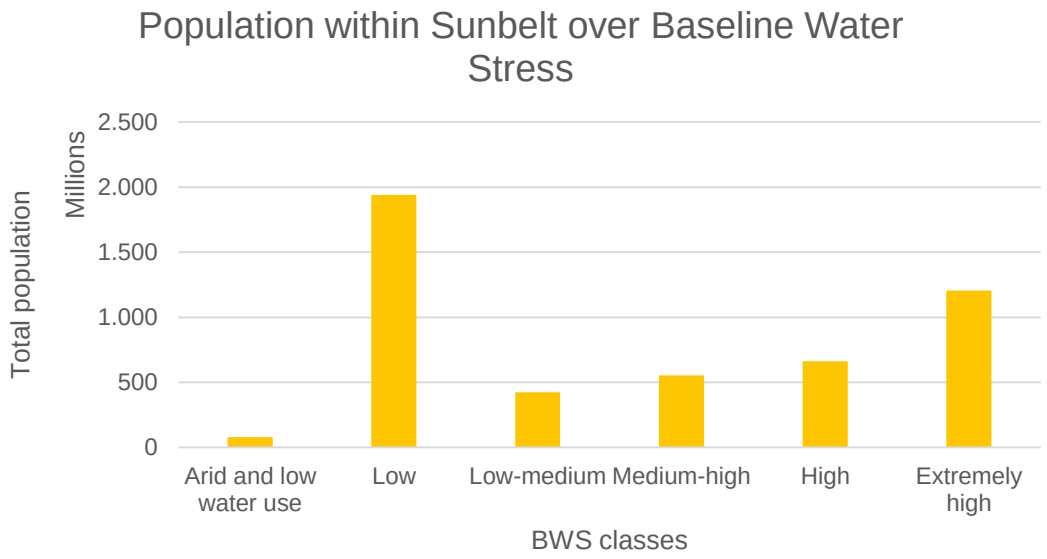
Boundary conditions for the SunBelt region

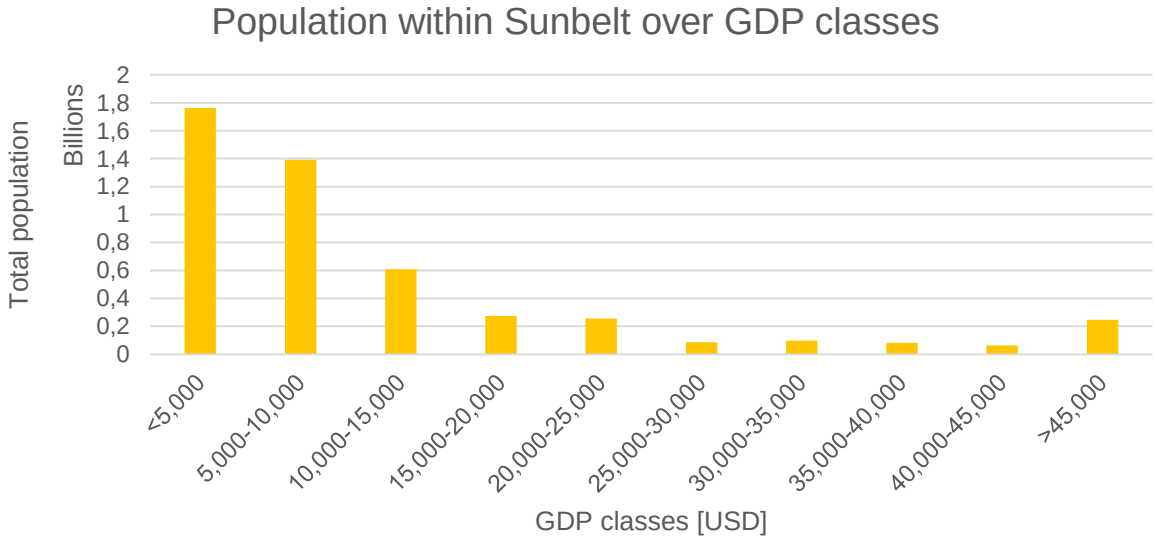
Data basis, value ranges and filter

Input source	*Filtered range / value range*	
Köppen-Geiger climate classes	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 …	Filter
Direct Normal Irradiance /day [kWh/m²/a]	0 500 1,000 1,500 2,000 2,500 3,000 … 3,753	
Population	0 .. 97,908.7	
Industrial area > 1000m² [m²]	1000 … 88,024.6	Results
Baseline Water Stress classes	-1 0 1 2 3 4	
Reputational Risk Index classes	0 1 2 3 4 5	
Gross Domestic Product per capita	137.3 … 135,000	

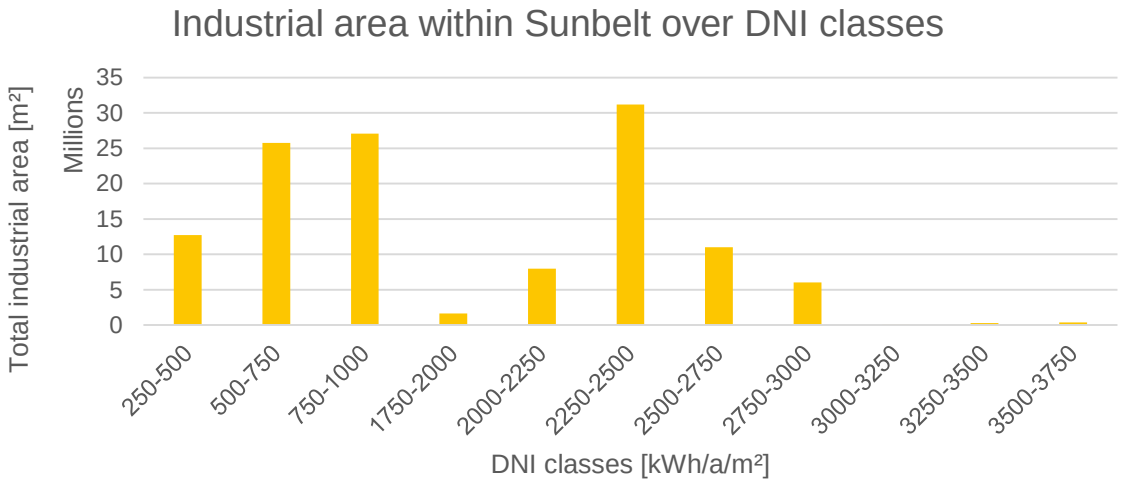
Generic boundary conditions resulting diagrams for climatisation (based on population data)

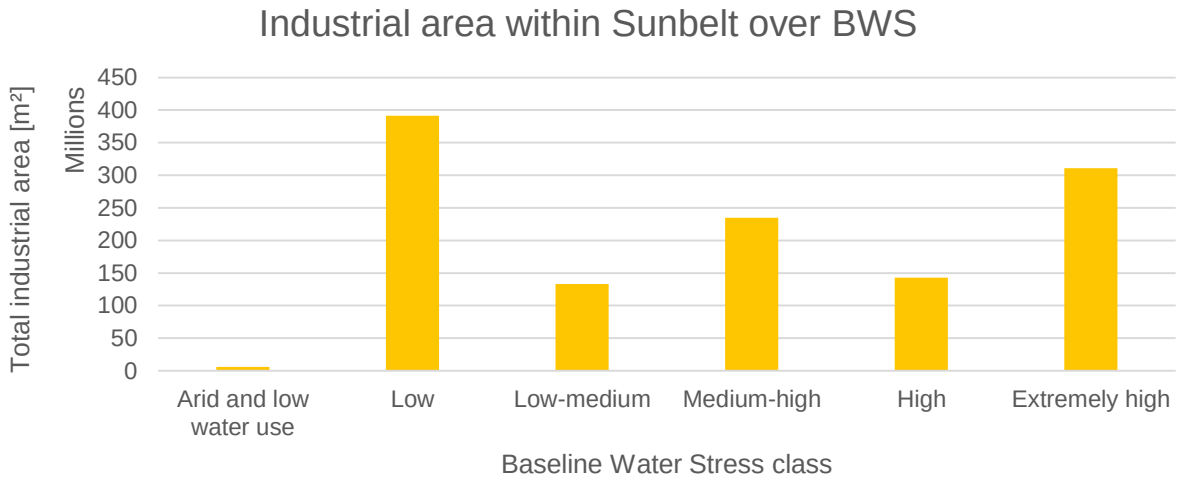


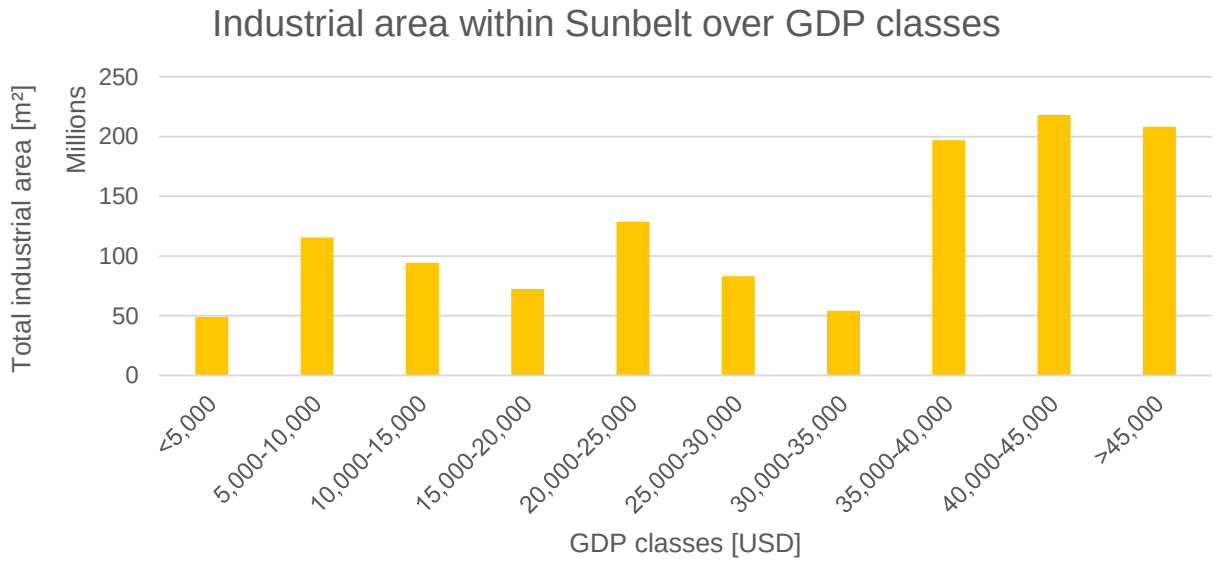




Generic boundary conditions resulting diagrams for industrial cooling potentials (based on industrial area data)







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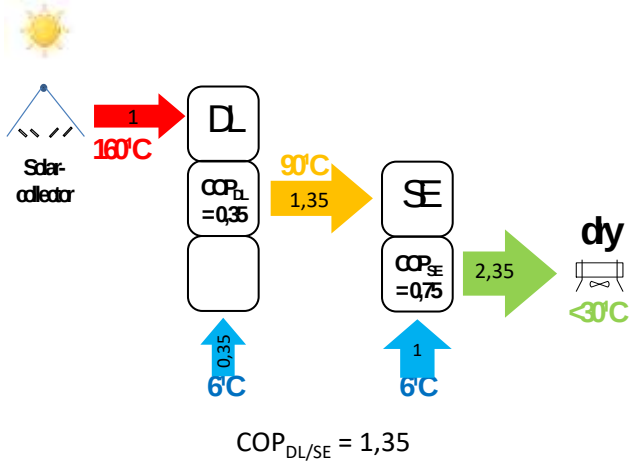
Showcase: Potentials for the SunBelt Chiller (SBC)

SunBelt Chiller (SBC) system overview

- Is a solar thermal cooling system
- Thermal driven chiller (absorption chiller)
- Uses concentrated solar panels as heat source
- Is able to perform in warm regions **without a wet cooling tower**
- Is a heating and cooling system
- Is suitable for larger buildings
- Has been developed and designed in an ongoing corporate research project by the partners ZAE Bayern and Industrial Solar



$COP_{DL/SE}$ = 1,35

Developed and designed in cooperation by

INDUSTRIAL SOLAR thermal solutions

ZAE BAYERN

funded by

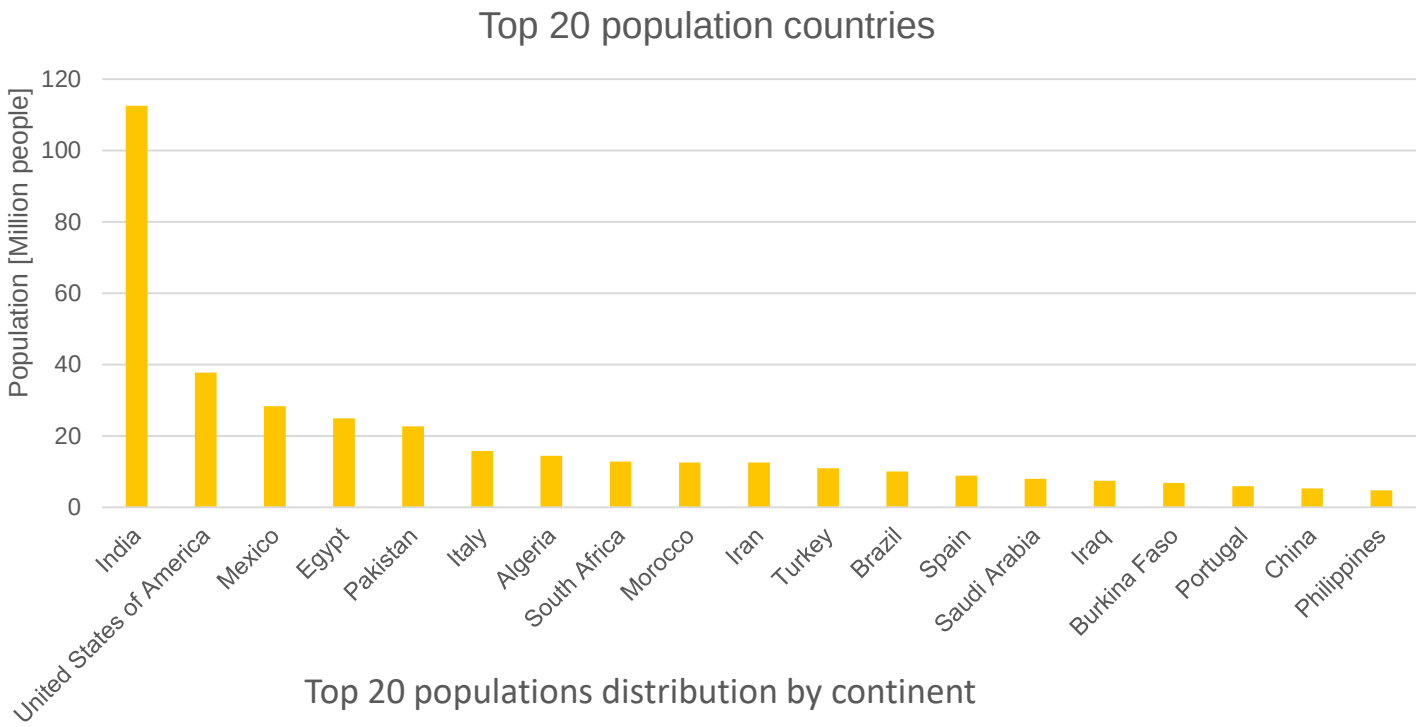
Federal Ministry for Economic Affairs and Climate Action

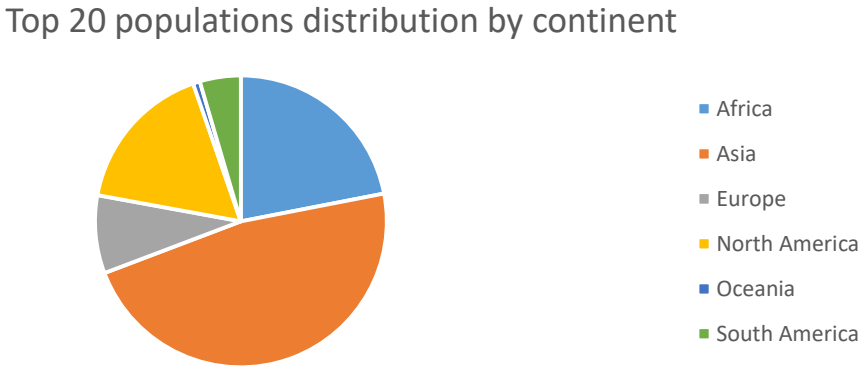
Showcase: Potentials for the SunBelt Chiller (SBC)

Predefined filter conditions for the SunBelt Chiller (SBC) system

Input source	*Filtered range / value range*	
Köppen-Geiger climate classes	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 …	Filter
Direct Normal Irradiance /day [kWh/m²/a]	0 500 1000 1500 2000 2500 3000 …	
Settlement Model classes	10 11 12 13 21 22 23 30	
Baseline Water Stress	-1 0 1 2 3 4	
Reputational Risk Index	0 1 2 3 4 5	
Population	0 .. 97,908.7	Results
Industrial area > 1000m² [m²]	1,000 … 88,024.6	

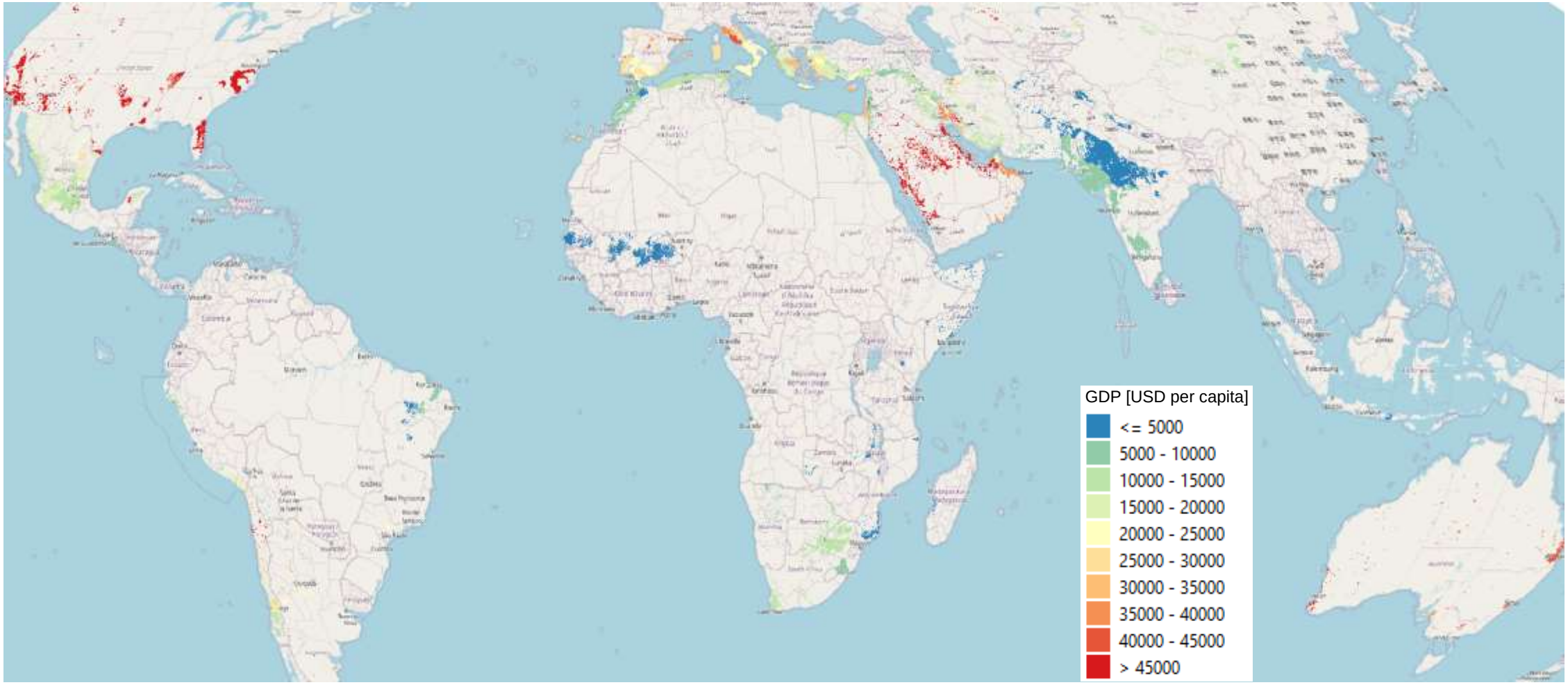
Showcase resulting diagrams of climatisation potentials (based on population)



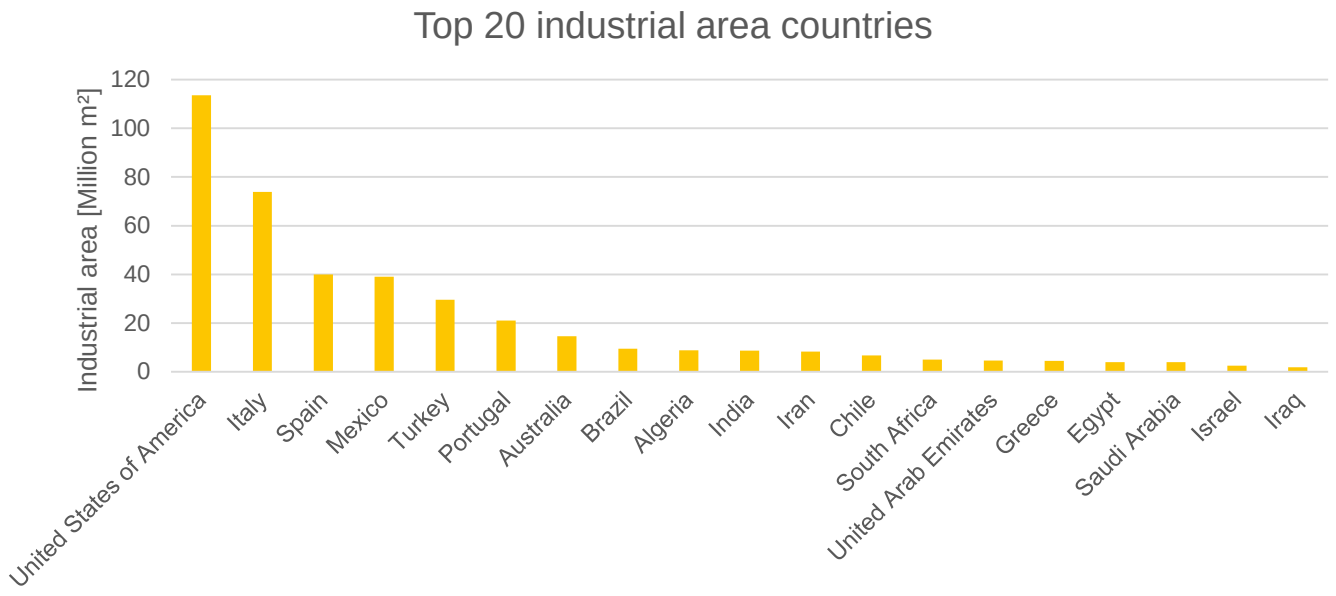


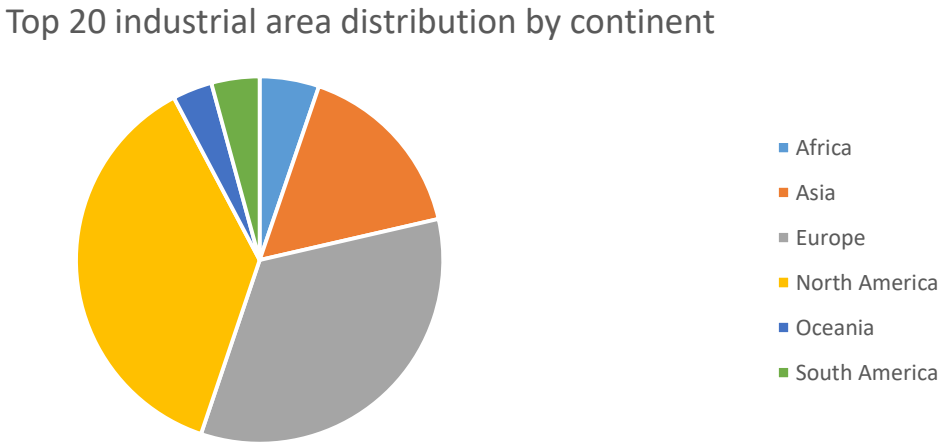
Name	Continent	Population	%
India	Asia	112.526.997	25,9%
United States of America	North America	37.790.449	8,7%
Mexico	North America	28.302.220	6,5%
Egypt	Africa	24.901.794	5,7%
Pakistan	Asia	22.665.825	5,2%
Italy	Europe	15.764.070	3,6%
Algeria	Africa	14.396.774	3,3%
South Africa	Africa	12.817.099	2,9%
Morocco	Africa	12.597.685	2,9%
Iran	Asia	12.573.519	2,9%
Turkey	Asia	10.926.784	2,5%
Brazil	South America	10.011.877	2,3%
Spain	Europe	8.893.241	2,0%
Saudi Arabia	Asia	7.996.659	1,8%
Iraq	Asia	7.435.280	1,7%
Burkina Faso	Africa	6.809.193	1,6%
Portugal	Europe	5.932.939	1,4%
China	Asia	5.277.926	1,2%
Philippines	Asia	4.769.140	1,1%

Showcase resulting GDP map of climatisation potentials (based on population)



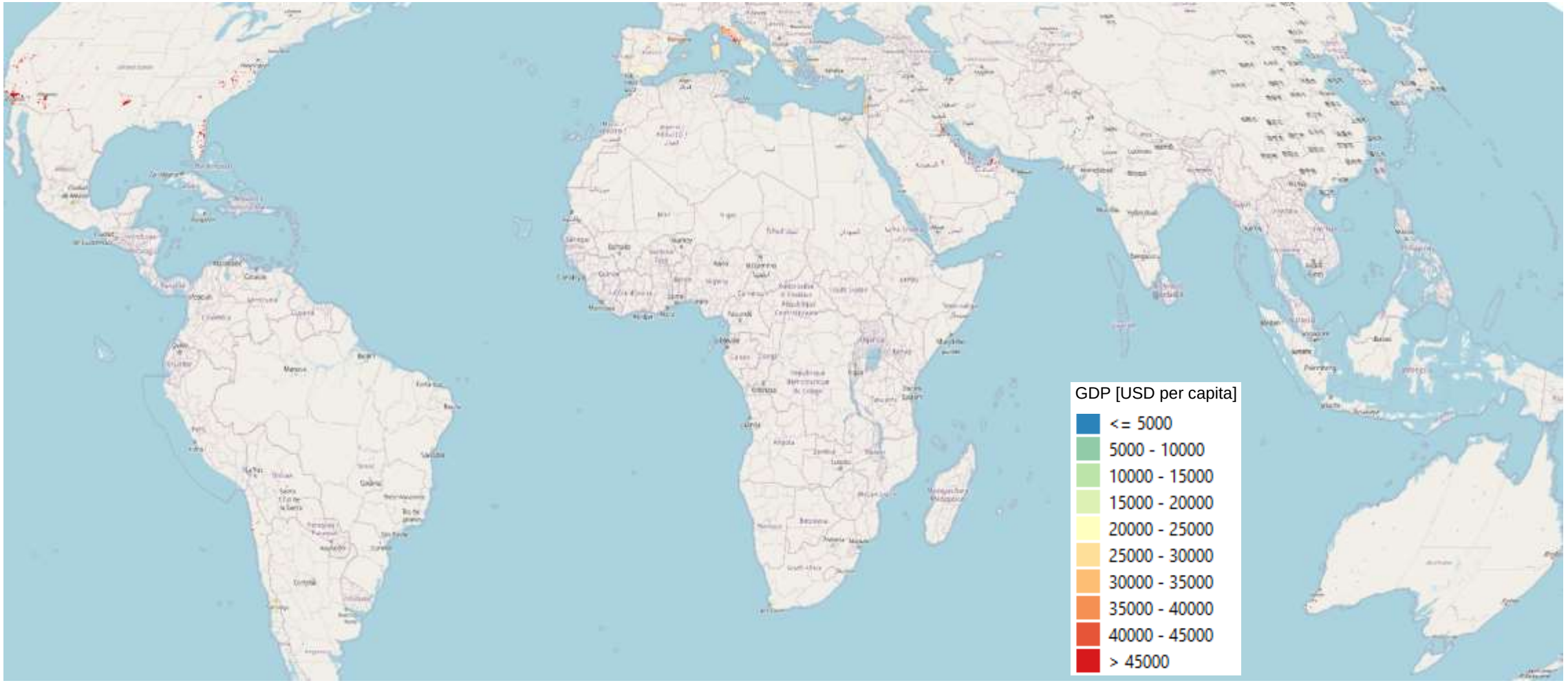
Showcase resulting diagrams of industrial cooling potentials (based on industrial area)





Country	Continent	Total industr. area	%
United States of America	North America	113.600.675	27,2%
Italy	Europe	73.894.564	17,7%
Spain	Europe	39.939.882	9,6%
Mexico	North America	38.974.190	9,3%
Turkey	Asia	29.546.435	7,1%
Portugal	Europe	20.974.159	5,0%
Australia	Oceania	14.549.795	3,5%
Brazil	South America	9.470.043	2,3%
Algeria	Africa	8.729.501	2,1%
India	Asia	8.658.072	2,1%
Iran	Asia	8.306.136	2,0%
Chile	South America	6.718.584	1,6%
South Africa	Africa	4.907.844	1,2%
United Arab Emirates	Asia	4.557.789	1,1%
Greece	Europe	4.373.360	1,0%
Egypt	Africa	3.935.987	0,9%
Saudi Arabia	Asia	3.872.843	0,9%
Israel	Asia	2.451.416	0,6%
Iraq	Asia	1.835.494	0,4%

Showcase resulting GDP map of industrial cooling potentials (based on industrial area)



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Outlook

Summary

What has been achieved

- Boundary conditions for solar cooling systems have been identified and evaluated
- Possible locations and potentials of a specific solar cooling system have been shown
- Even market potentials and risks can be spotted
- The methodology can be transferred to a wide range of other renewable energy technologies like heating and electricity supply or even to completely different fields

Outlook

Prospect

Opportunities for further investigation

- **Deeper analysis** of industrial areas and population to specifically identify clusters of large buildings to **illustrate the potential of cooling networks**
- Additional data sources such as **cooling degree days** could increase the significance of the results and data on **energy prices** would strengthen the method by taking economic factors into account
- Consider **more building types** besides industrial buildings (residential, commercial, hospital, university, etc.)
- The development of **interactive maps** explorable on the web