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Open data in renewable energy utility scale projects

Monica Gutierrez and Ricardo Velasco

Renewable Energy Engineers

Content

- **Introducing Mott MacDonald**

- **Examples of open data use in utility scale renewable energy projects**

→ Constraints mapping

→ Solar resource assessment

MOTT MACDONALD

Introducing Mott MacDonald

We’re a global engineering, management and development consultancy focused on guiding our clients through many of the planet’s most intricate challenges.

Sectors

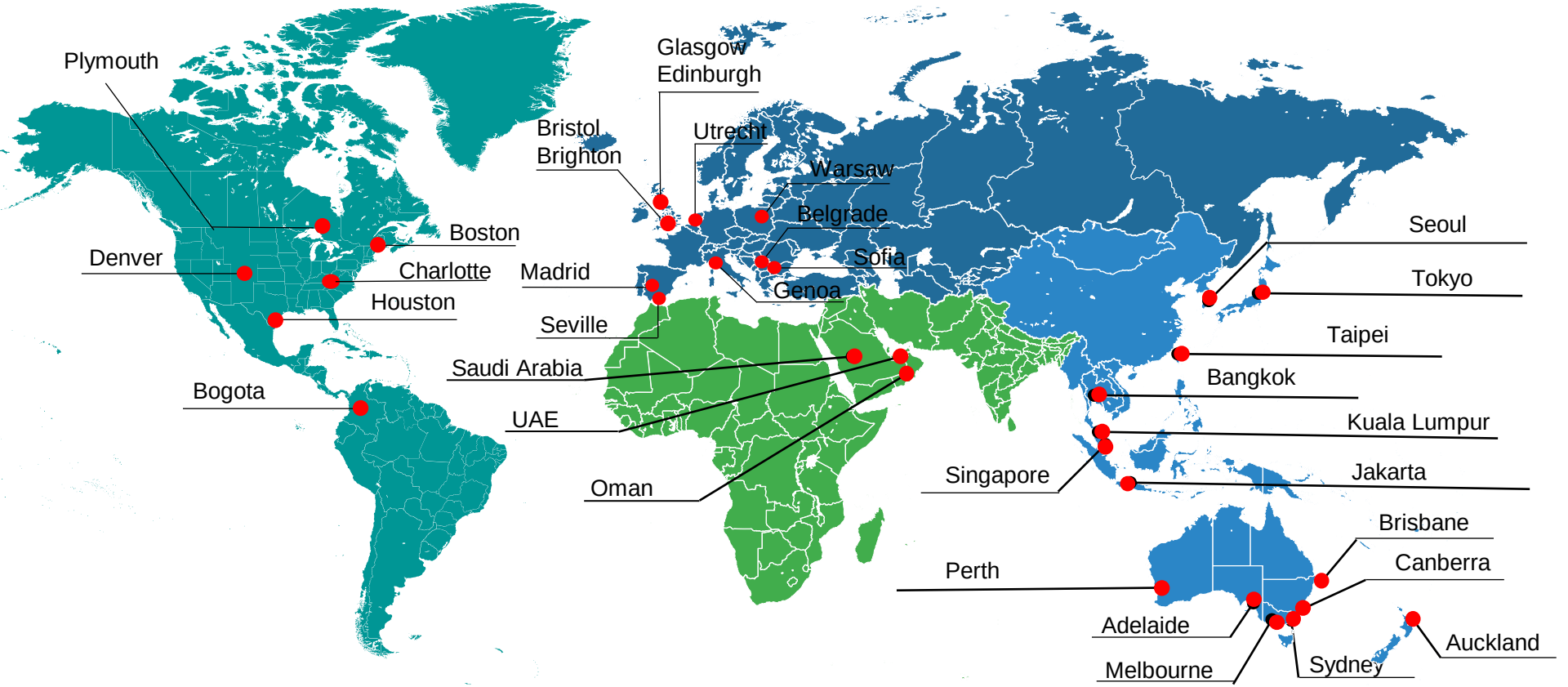
- Climate change
- Coastal
- Education
- Energy
- Environment
- Health
- Highways and bridges
- International development
- Ports
- Rail and transit
- Transportation planning
- Tunnels
- Water and wastewater

We work in **135** countries

170 permanent offices in over 50 countries

20k staff

Solar and Wind Business Offices – 2024



Key subsectors

Solar Photovoltaic (PV)

Concentrated Solar Power (CSP)

Hybrid & Storage Options

Onshore Wind

Offshore Wind

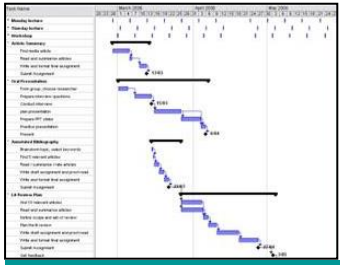
Options Studies / LCOE Analysis

Summary of Services

Technology Assessment

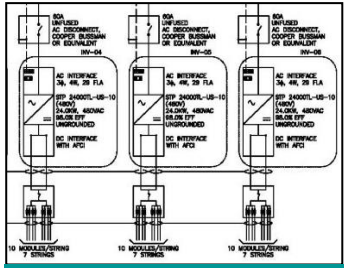
Energy Yield Analysis

Feasibility & Technical Studies



Project & Programme Management

Design Review



Electrical & Civil Engineering

Technical Due Diligence

Construction & Operation Monitoring

Summary of Services (continued)

Agreements & Contracts Review

Market & Strategic Advice

Tendering & Procurement Advice

Environmental & Social Impact Studies

Planning & Permitting

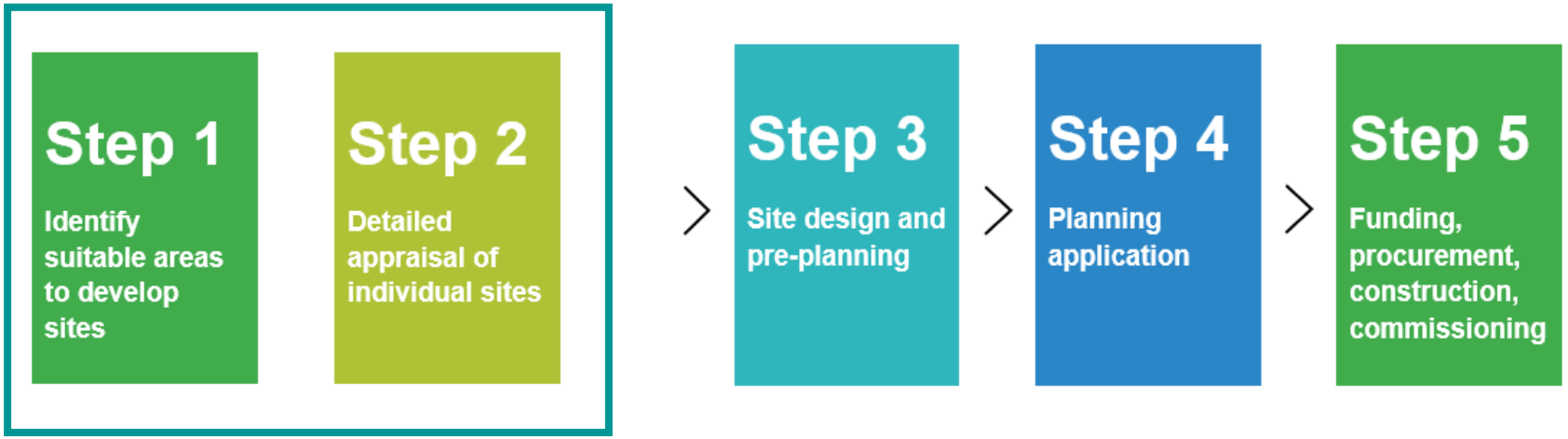
Risk Assessment

Bankability Studies

Health & Safety

Constraints mapping

Typical lifecycle of new energy generation projects



What do we do in a feasibility assessment?

Constraints mapping

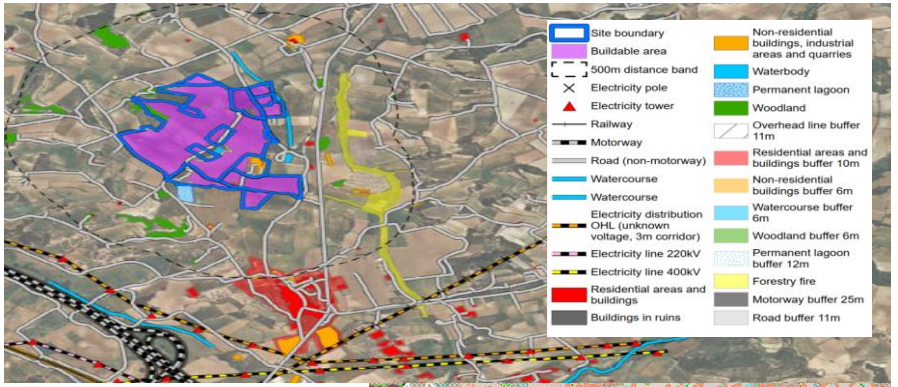
Estimate capacity and yield

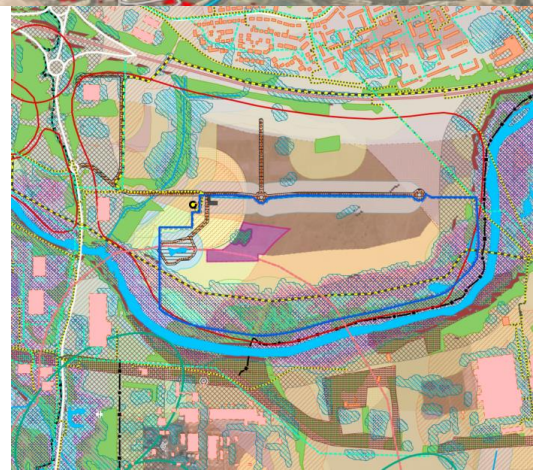
Economic assessment

What do we do in a feasibility assessment?

Constraints mapping

Tool that allows visualisation of constraints that could limit the development of a project





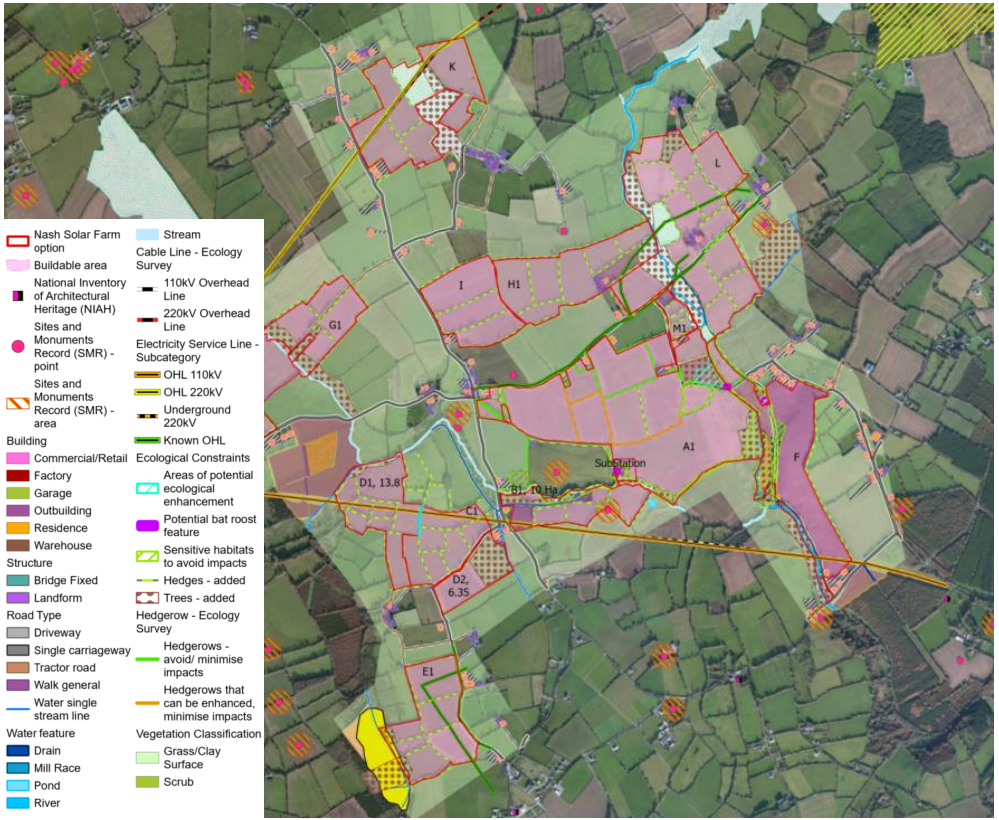
What could limit the development of an RE project?

Infrastructure constraints:

- Roads
- Railways
- Buildings and close renewable energy sites
- Utilities infrastructure – OHL and underground (telecoms, water, gas, electricity)

Environmental constraints:

- Terrain slope
- Land classification
- Environmental protected areas and peat
- Heritage assets
- Water sources and flood risks
- Sites of scientific interest



Where can I find this data ?

Open Street Map layers

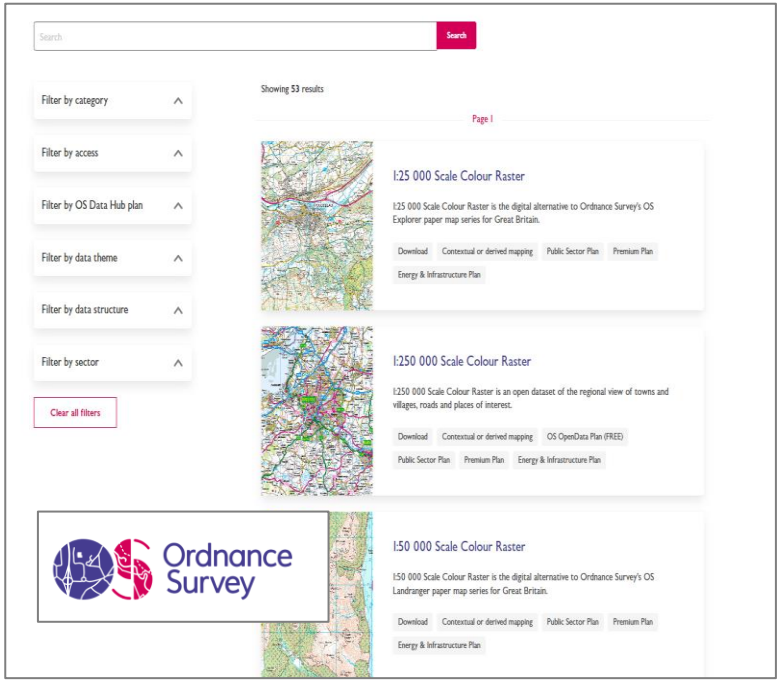
Open data to be downloaded from different platforms

Digital Model Terrain (DTM)

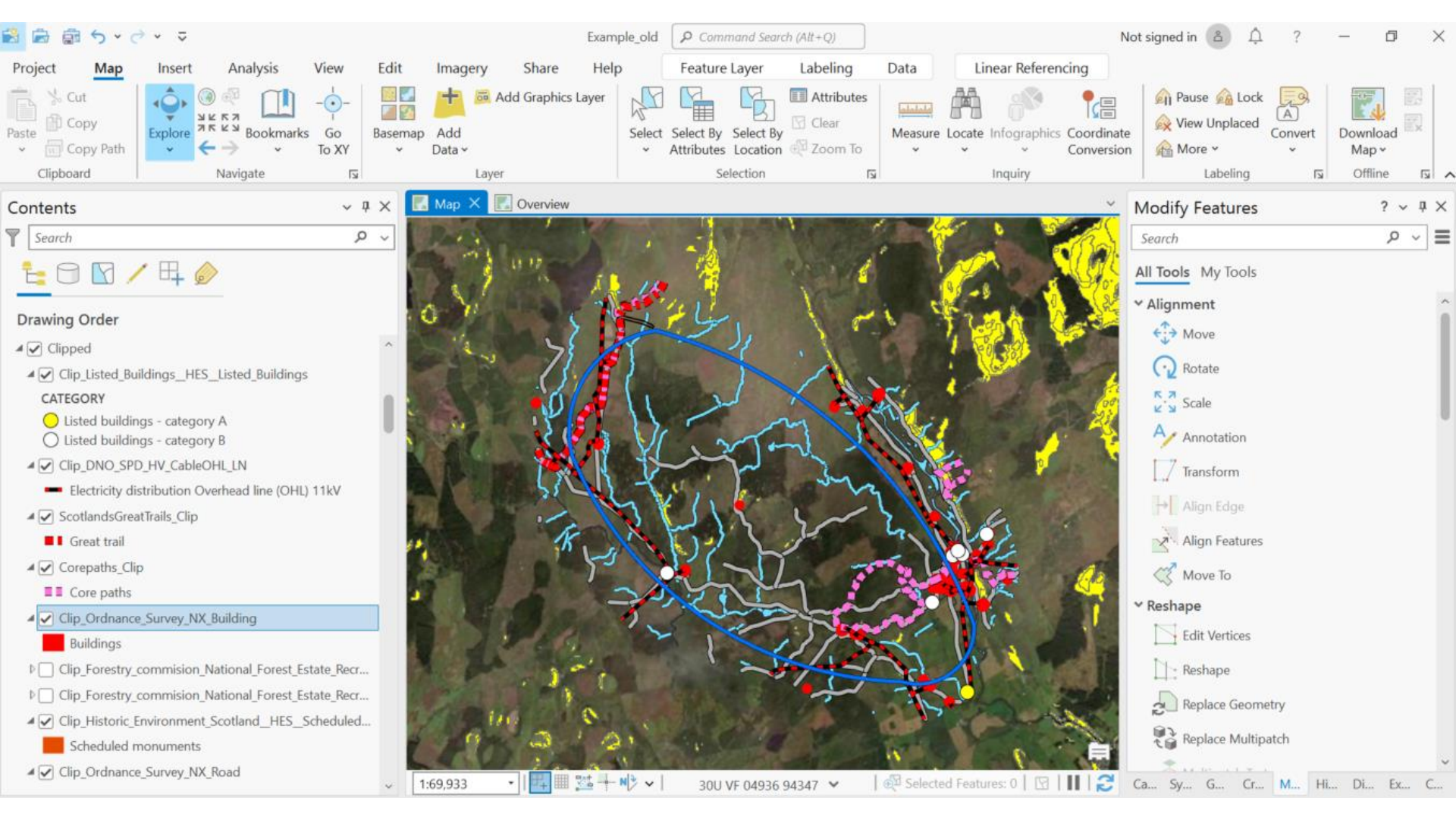
Low resolution DTM data available worldwide

Specific national data

Additional environmental, social, geophysical designations within the country websites organisations



An example…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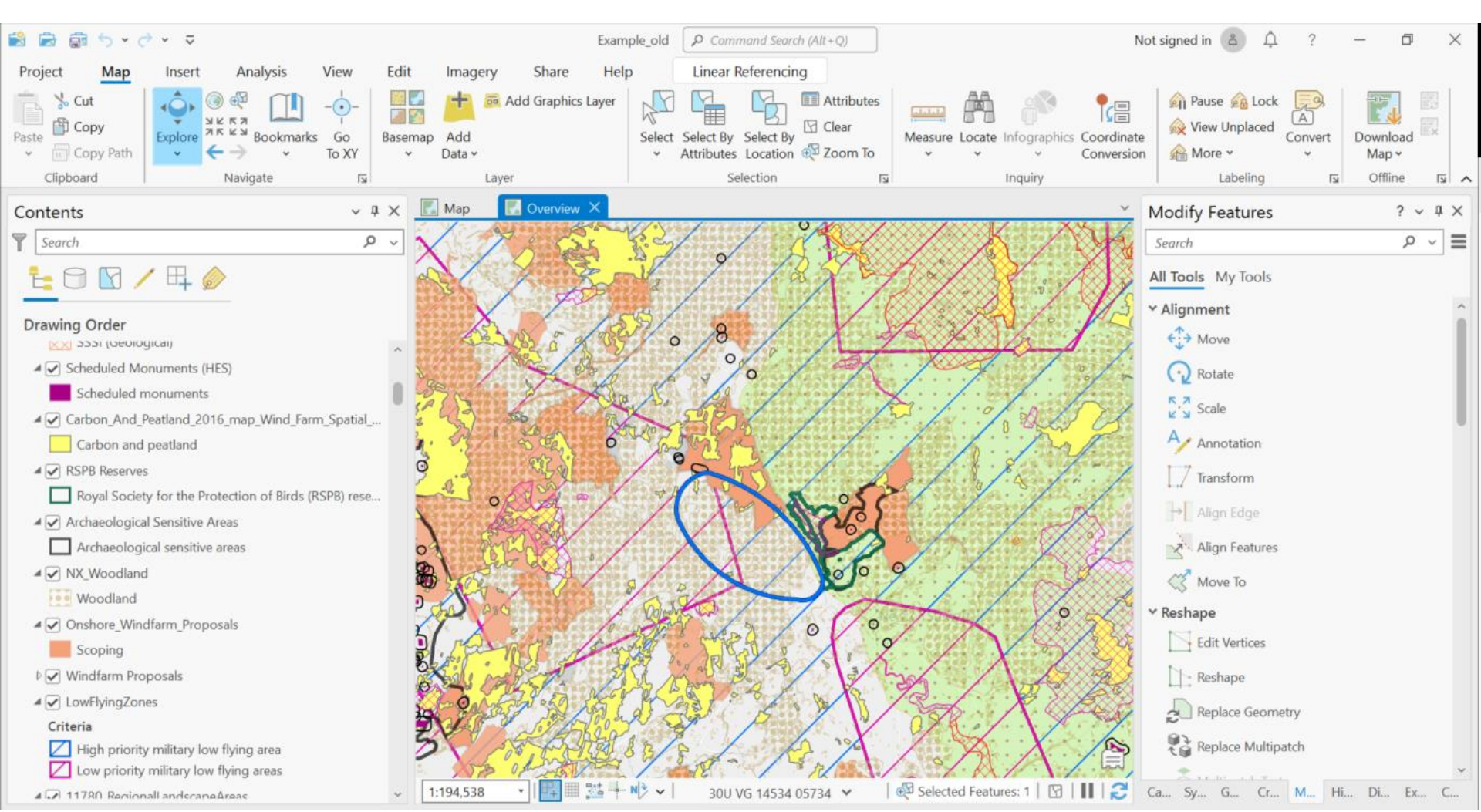
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Scheduled monuments
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RSPB Reserves
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NX_Woodland
Woodland
Onshore_Windfarm_Proposals
Scoping
Windfarm Proposals
LowFlyingZones
Criteria
High priority military low flying area
Low priority military low flying areas
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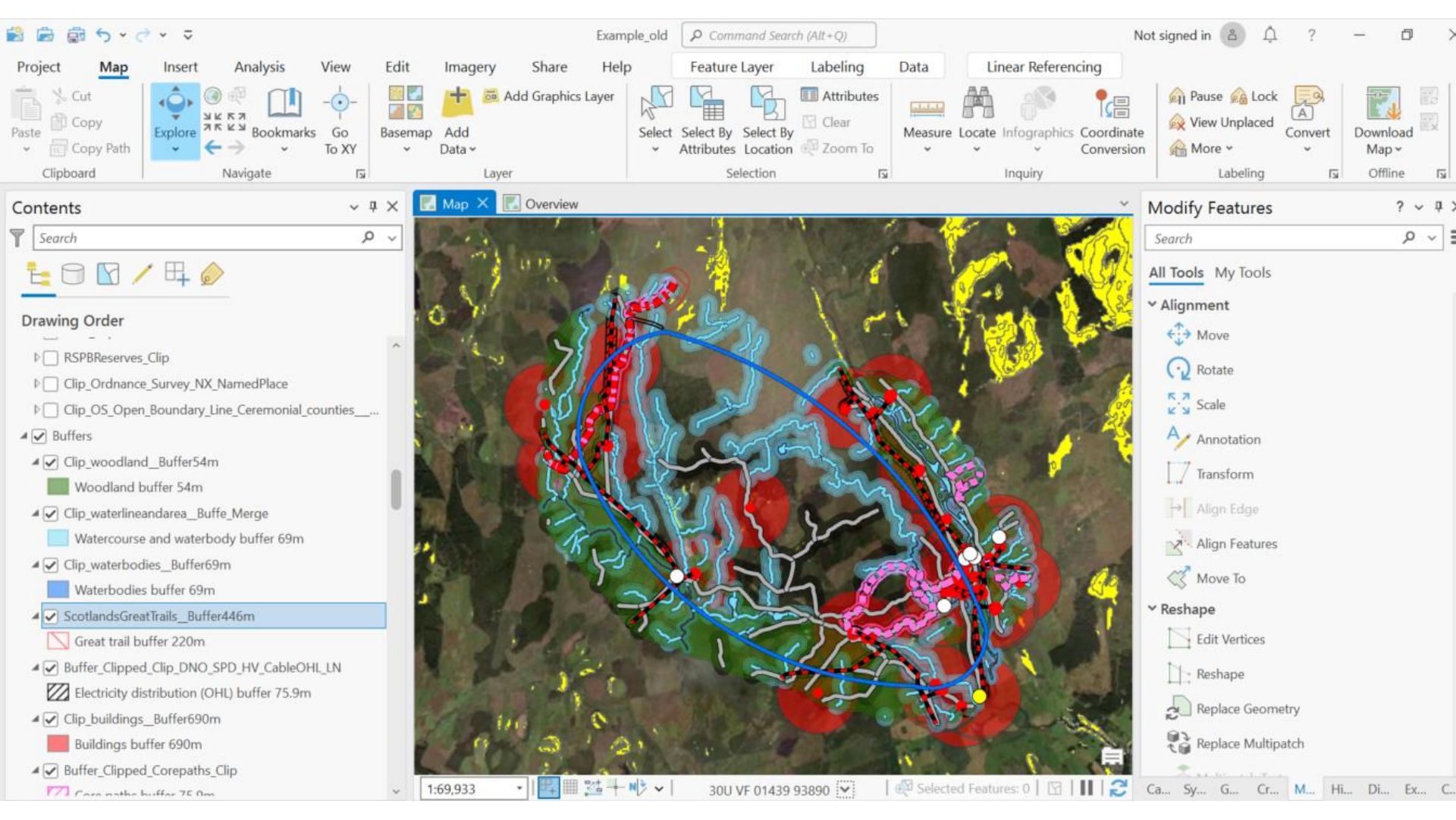
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Woodland buffer 54m
Clip_waterlineandarea__Buffe_Merge
Watercourse and waterbody buffer 69m
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ScotlandsGreatTrails__Buffer446m
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Clip_buildings__Buffer690m
Buildings buffer 690m
Buffer_Clipped_Corepaths_Clip
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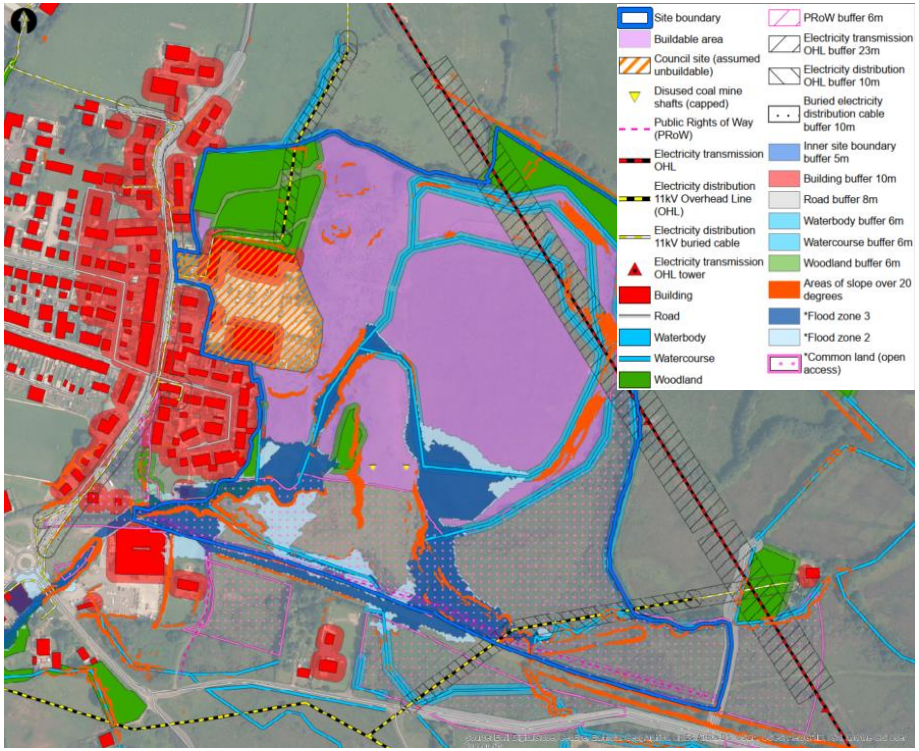
Constraints buffers

Minimum distance required from an identified constraints to the proposed development

- Minimum buffers are usually defined according with local policy and client instructions.

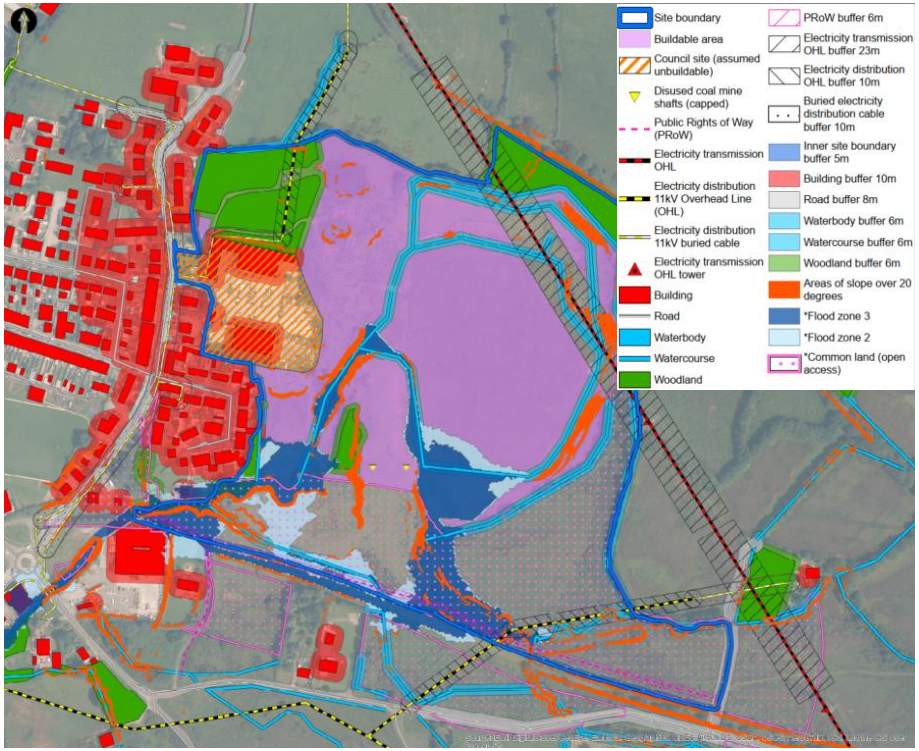
Buffers are country and client specific



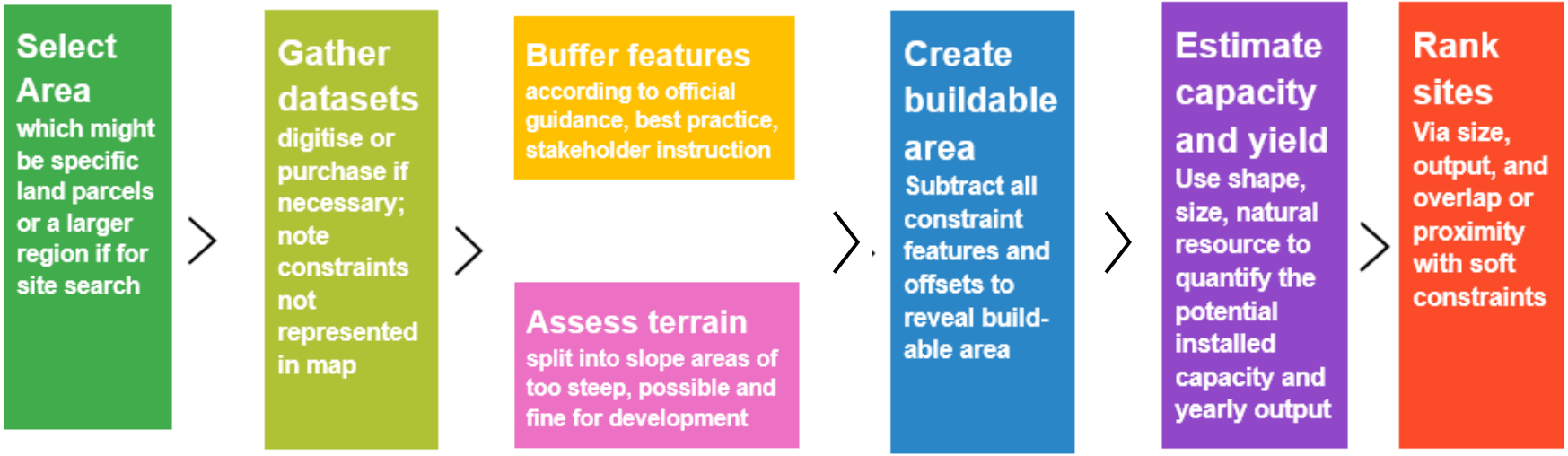
Constraints buffers

By who?

- Local and national government (town) planning departments - might have requirements for housing, water, road or similar
- Local and national environment authorities - might have requirements for ecology, woodland etc.
- Infrastructure owners/operators e.g. gas, electricity, water, telecoms towers
- Renewable energy industry or political organisations may provide guidance



Summary – What have we done in this exercise



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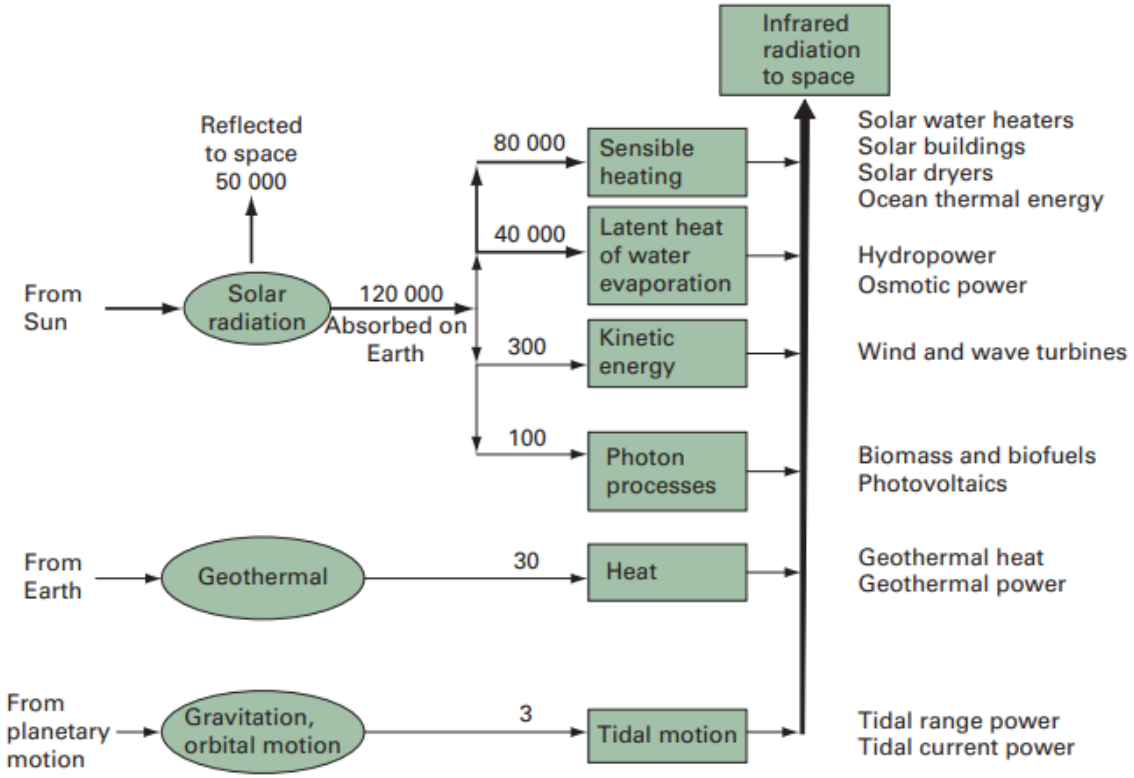
Solar resource assessment

Natural Currents of Energy on Earth

in TW (10^{12}W)



Source: Twidell & Weir, Renewable Energy Resources, 2015

Maximum solar flux density (irradiance) perpendicular to the solar beam is about 1 kW/m²

To compare: Global final energy consumption in 2021 corresponded to ~13.2 TW

Source: IEA, 2024

Atmospheric Extinction

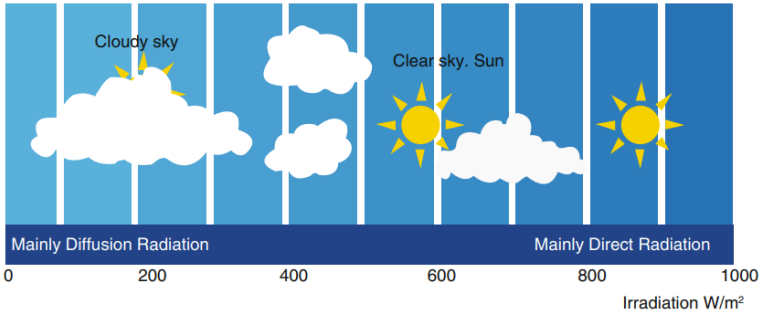
Extraterrestrial Radiation → **Atmospheric Extinction** →

- Surface irradiance
- Spectral effects
- Temporal & spatial variability of solar irradiance (and solar power)

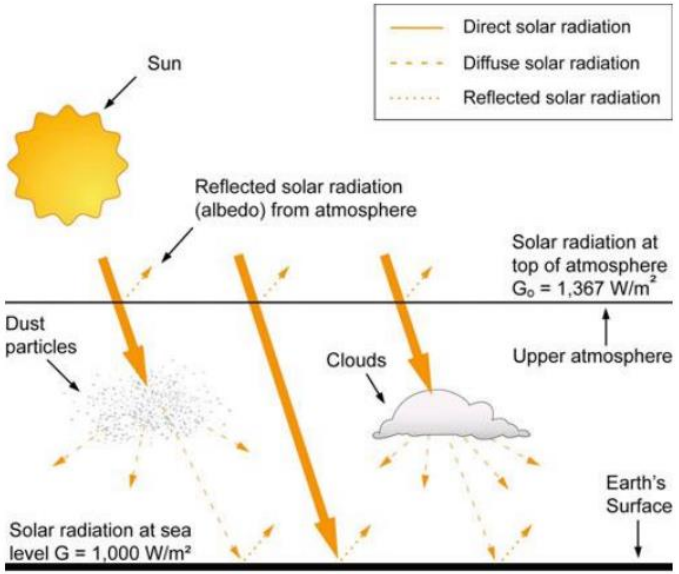
- Radiation laws (Solar spectrum)
- Solar geometry

- Absorption
- Scattering
- Atmospheric constituents (gases, aerosols, clouds)

The difference between the solar constant and the peak irradiance value at the Earth's surface is due to the Earth's albedo



Source: C. Stapleton & Neill, Grid-connected Solar Electric Systems, 2012



Source: C. Stapleton & Neill, Grid-connected Solar Electric Systems, 2012

Solar Resource Assessment (SRA)

How is solar irradiance modelled?

Ground-measured data

Advantages
✓ High quality data (if constant maintance)
✓ High temporal resolution (< 1 min)

Limitations
○ Great cost of maintenance and calibration.
○ Not-uniform distribution of weather stations
○ Coarse spatial coverage of long-term data.

Applications
▪ Model development / validation
▪ Site's monitoring
▪ Final site irradiance characterization

Satellite-derived data

Advantages
✓ High temporal and spatial resolution
✓ Large spatial coverage

Limitations
○ Extremely limited high-quality data for long-term time frames.
○ Well-regarded satellite datasets for the most part do not include historical events (e.g. volcanic eruptions)

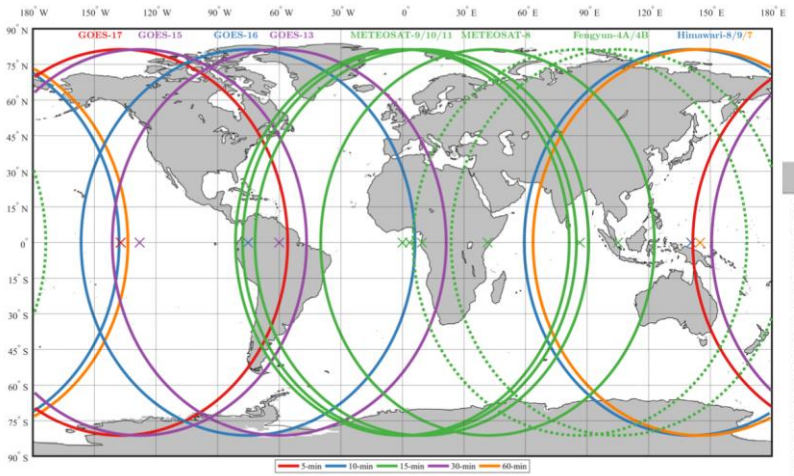
Applications
▪ Identification of potential PV sites.
▪ Managing of PV plants into national grids.
▪ Ideal for markets in developing-countries.

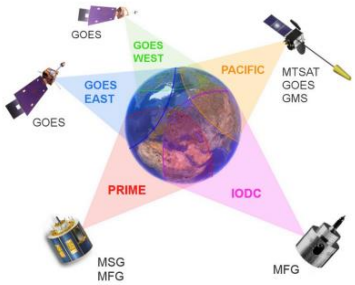
Source: SolarGIS. Validation Report, 2019

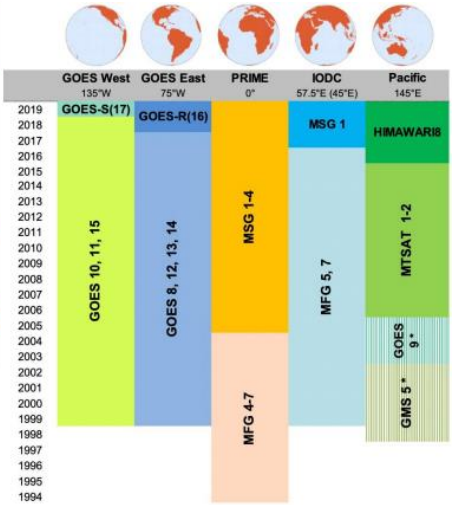
Solar Resource Assessment (SRA)

How is solar irradiance modelled?

- Geostationary meteorological satellite data to cover the globe
- Integration of data to provide local atmospheric conditions
- QC and validation of satellite data
- On-ground solar irradiance and other atmospheric parameters







Source: SolarGIS. Validation Report, 2019

Good Quality data: Up to 60°N and up to 60°S

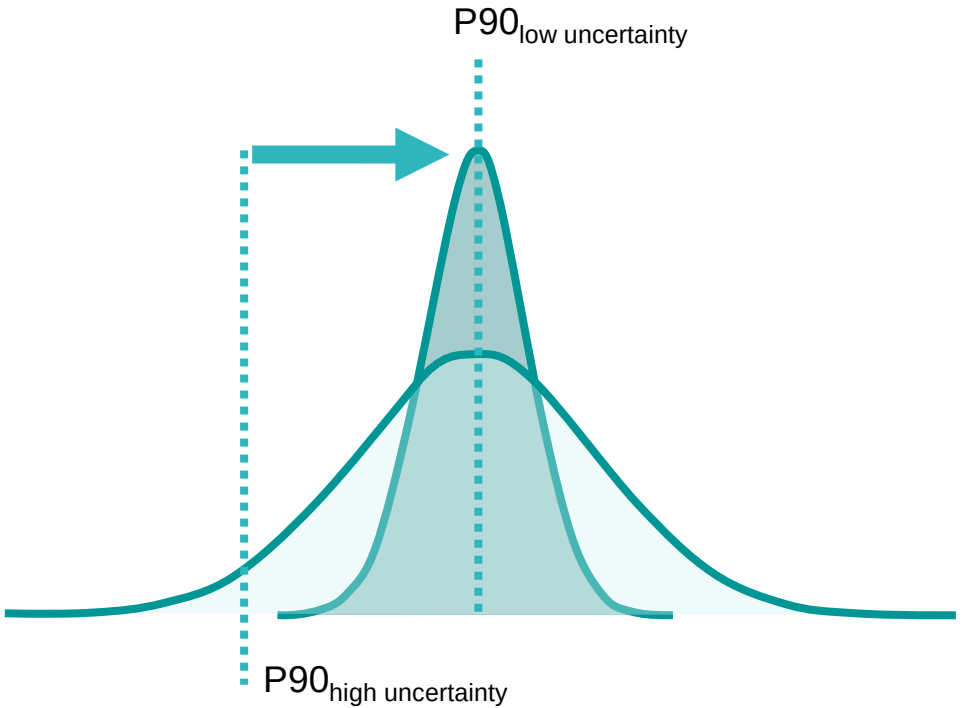
Solar Resource Assessment (SRA)

Client needs for SRA and EYA?

EYA: Detailed loss analysis and design-specific assumptions allow for accurate and reliable EYA

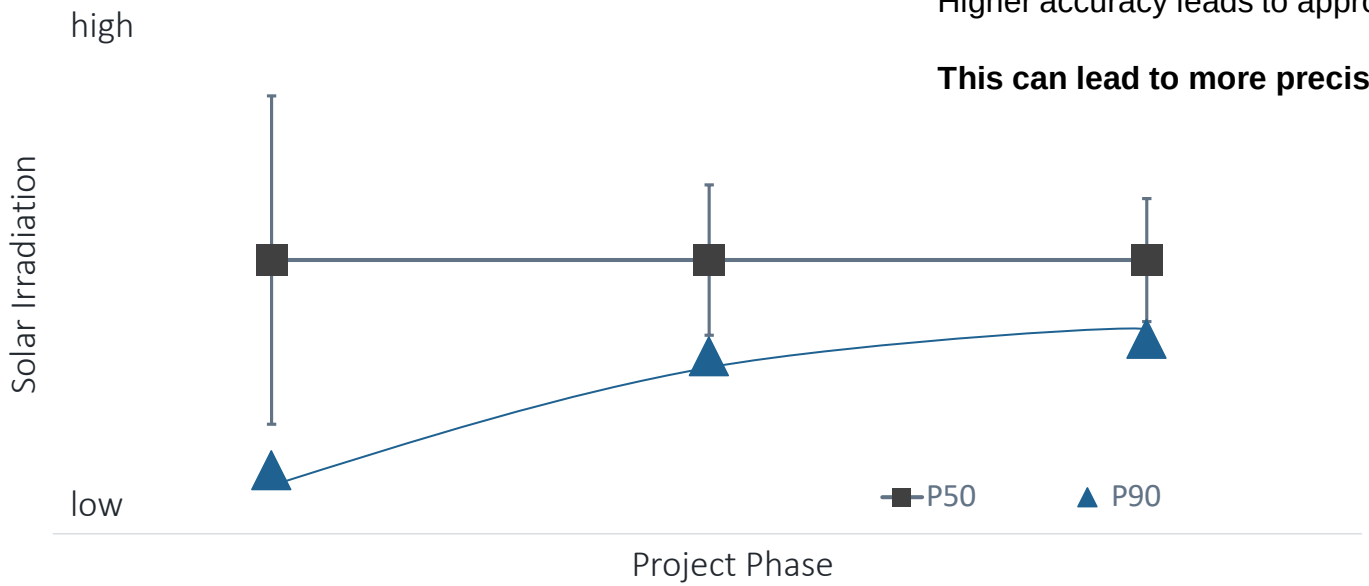
SRA: Reducing uncertainty will lead to an increase in solar resource and subsequently in potential yield.

Lenders and banks commonly rely on P90 values to determine project finance.



Solar Resource Assessment (SRA)

Client needs for SRA and EYA?

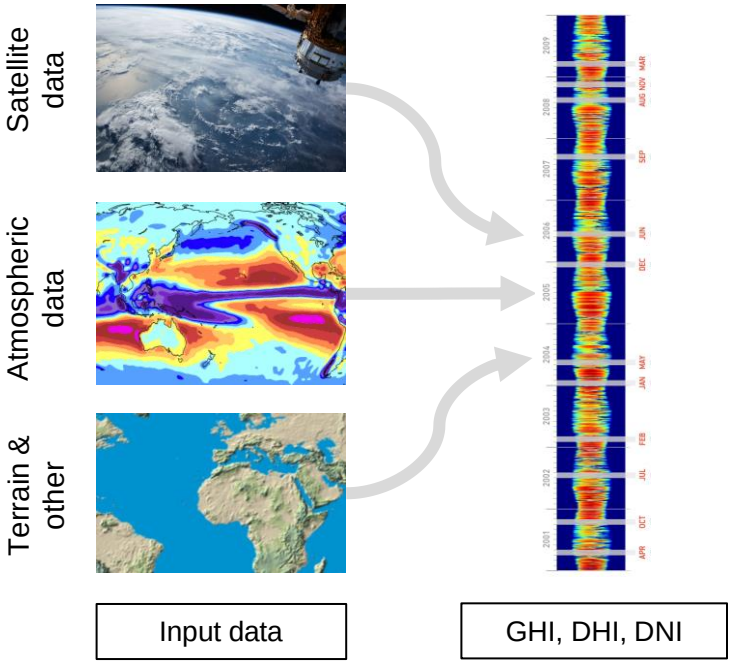


Higher accuracy leads to approx. 2.5 % higher yield (P90).

This can lead to more precise revenue estimation.

Solar Resource Assessment (SRA)

How is solar irradiance modelled?



Solar Resource Assessment (SRA)

How is solar irradiance modelled?

Source: SolarGIS. 2022

Solar Resource Assessment (SRA)

Satellite ground validation

Source: SolarGIS. Validation Report, 2019

Solar Resource Assessment (SRA)

Solar Resource Uncertainty

Expected range of bias outside validation sites (P90 uncertainty)

GHI: **±4% to ±8%**

DNI: **±9% to ±14%**

Depends on specific analysis on geography and availability of ground measurements

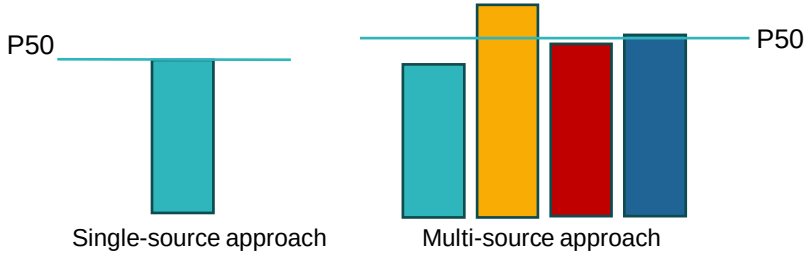
Location	GHI uncertainty	DNI uncertainty
80% occurance	±4%	±9%
90% occurance	±5%	±10%
Complex geography and extreme cases	±8%	±14%
Lower uncertainty regions Most of Europe, North America below 50°N, South Africa, Chile, Brazil, Australia, Japan, Morocco, the Mediterranean region, the Arabian Peninsula (except the Gulf region) and regions with good availability of high-quality ground measurements	Around ±4%	Around ±8%
Higher uncertainty regions Latitudes higher than 50°N and 50°S, high mountains regions with regular snow and ice coverage and high-reflectance deserts, urbanized and industrialized areas, high and changing aerosols (India, West Africa, Gulf region, some regions in China), coastal zones (approx. up to 15 km from water) and humid tropical climate (e.g. equatorial regions of Africa, America and Pacific, Philippines, Indonesia and Malaysia), regions with limited or no availability of high-quality ground measurements	Higher than ±4%	Higher than ±8%

Source: SolarGIS. Validation Report, 2019

Solar Resource Assessment (SRA)

How to reduce uncertainty?

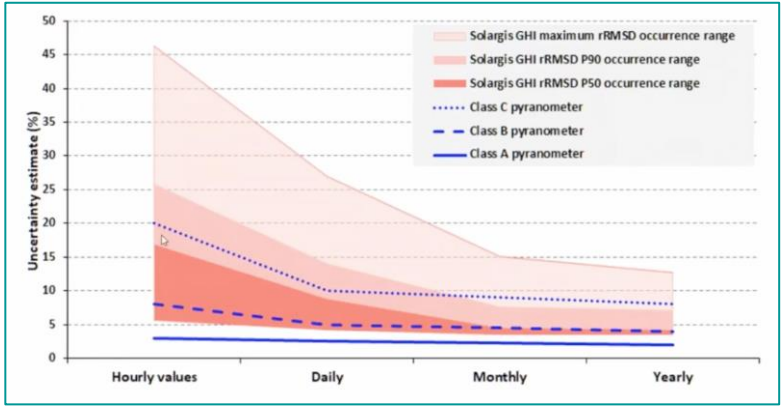
- High-res satellite data
- Multi-source approach to identify sources which over- or underestimate solar resource
- Ground-correlation: solar measurement campaigns



➢ **Reduce an initial uncertainty of 4 – 8% down to 3% or lower**

Ground measurements may deviate from satellite data, because of:

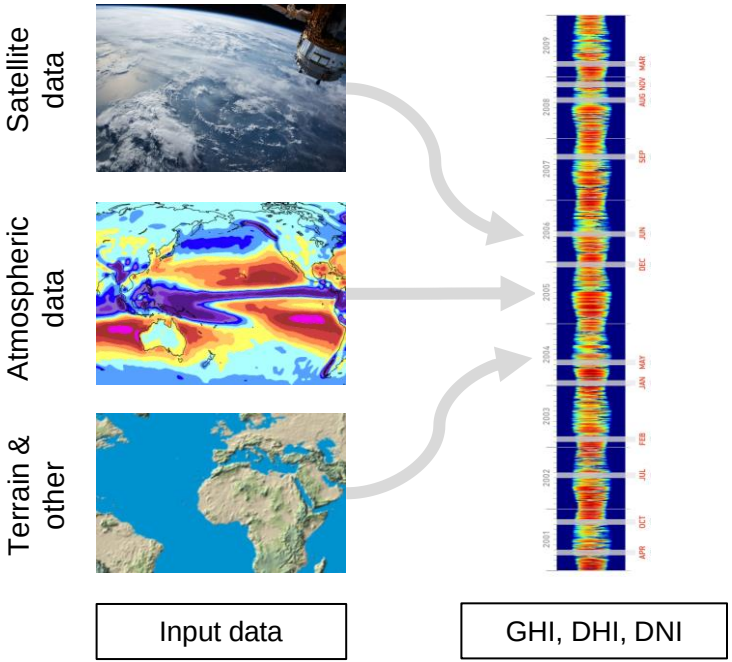
- Size of the satellite pixel and sampling rate
- Resolution and limitations of the input atmospheric data Imperfections of the models
- Site specific microclimate
- Issues in ground measurements



Source: SolarGIS. 2015

Solar Resource Assessment (SRA)

How is solar irradiance modelled?



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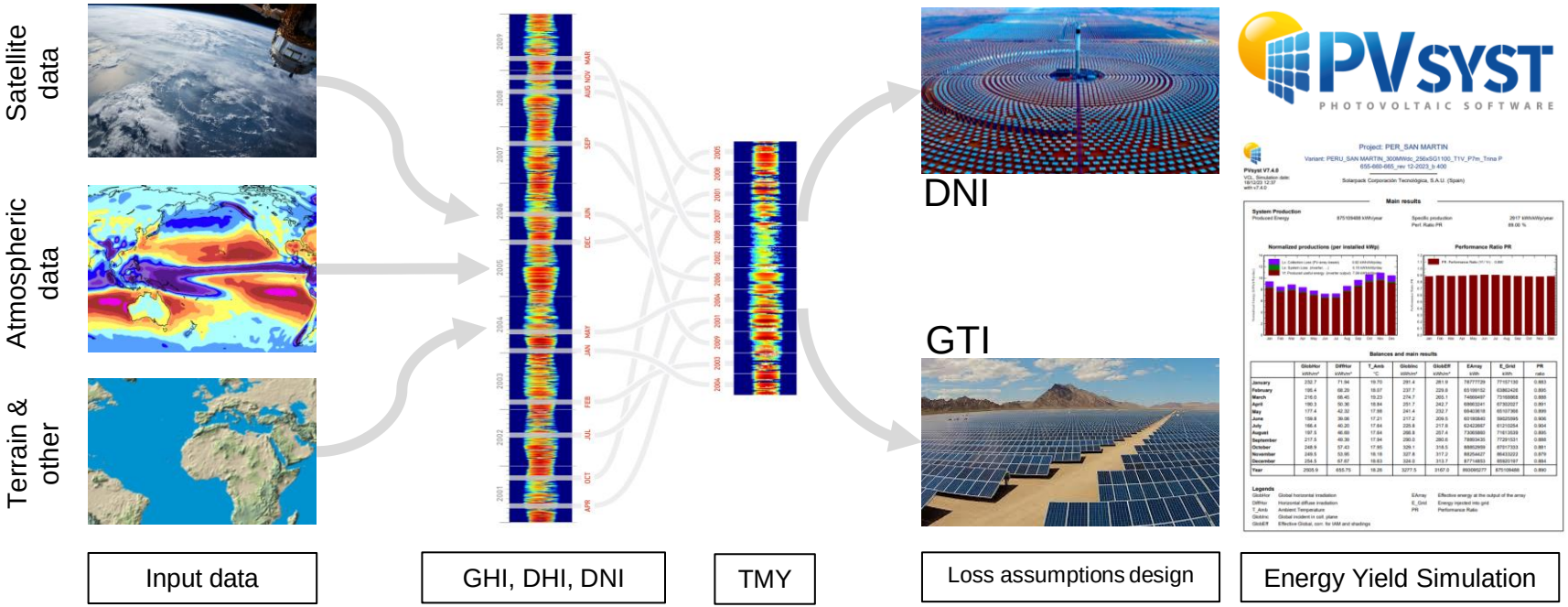

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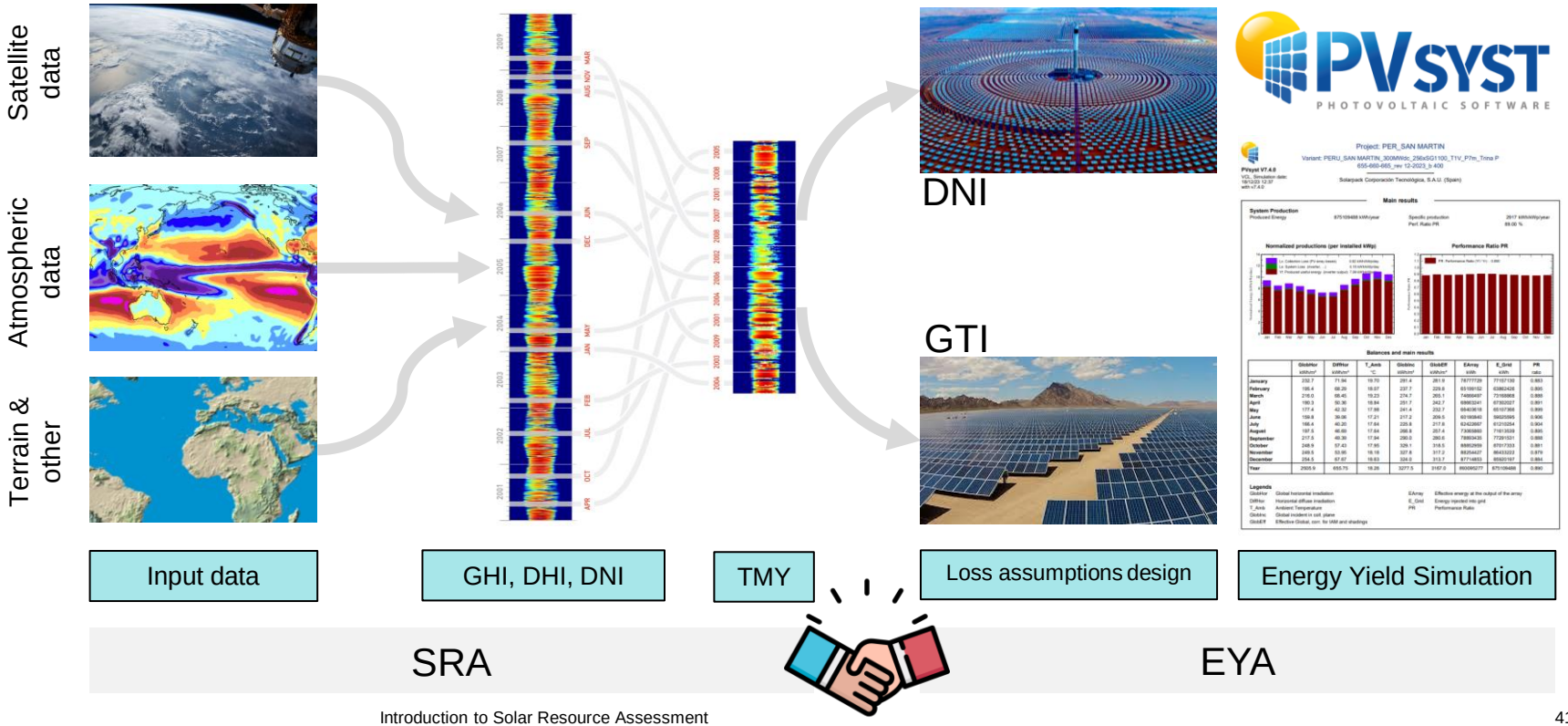


Solar Resource Assessment (SRA)

Irradiance dataset types (Solargis)

Data Type	Coverage	Purpose	Number of values per parameter
Time Series	Access to historical data (1994/1999/2007 to last month)	Project development & operational performance monitoring	Hourly: 8760 values x 26/21/13 years. 15-minute: 8760 values x 26/21/13 years x 4
Monthly Average	Access to monthly and yearly averages from 1994/1999/2007 to 2020	Prospecting	12 values
Typical Meteorological Year (TMY)	Access to historical data (1994/1999/2007 to last year)	Project development	8760 values

Solar Resource Assessment (SRA)

Open-source irradiance data (data series and TMY)

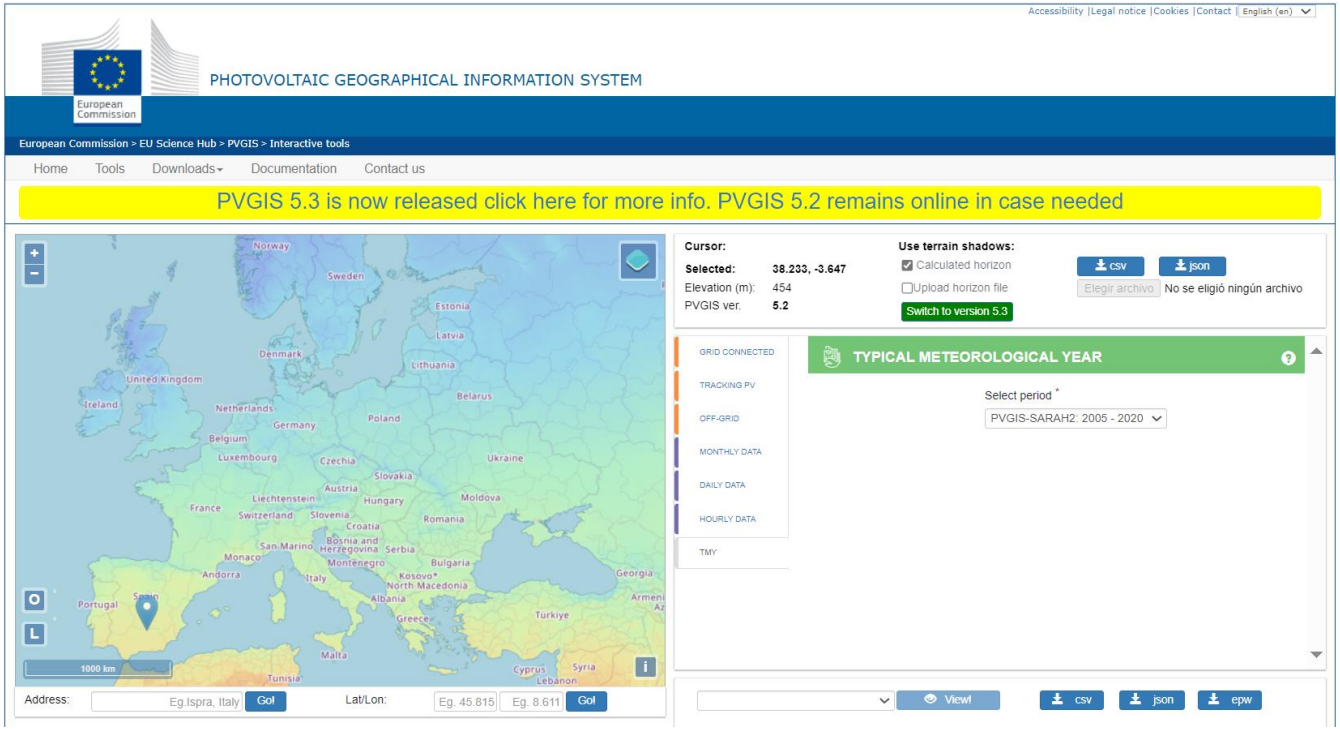
CAMS solar radiation time-series (copernicus.eu)

NASA POWER | API Pages

JRC Photovoltaic Geographical Information System (PVGIS) - European Commission (europa.eu)

Solar Resource Assessment (SRA)

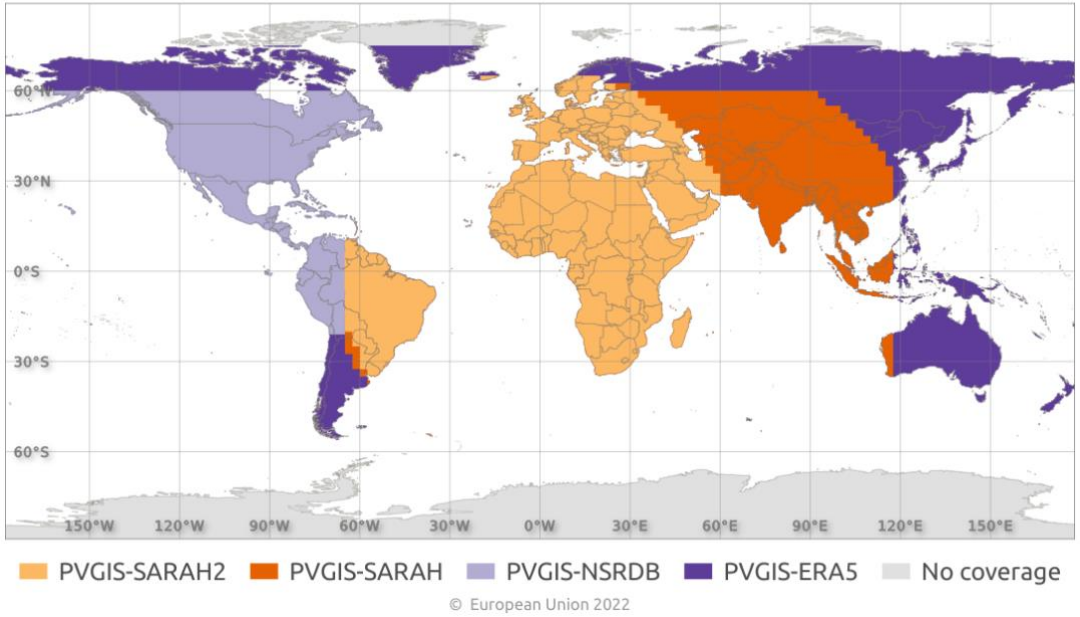
Open-source irradiance data (data series and TMY)



Solar Resource Assessment (SRA)

Open-source irradiance data (data series and TMY)

Database	Start year	End year	Spatial Res.
PVGIS-SARAH2	2005	2020	0.05° x 0.05° (~ 5 km)
PVGIS-NSRDB	2005	2015	0.038° x 0.0.38° (~ 4 km)
PVGIS-ERA5	2005	2020	0.25° x 0.25° (~ 25 km)



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Thank you

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