ASSESSMENT OF ALTERNATIVE ENERGY POTENTIAL USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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Scientific Impetus

- To put in context the energy endowment of territories relative to global distribution, and to analyse what can potentially be exploited
  - Tropical Marine Science Institute (TMSI) developed tools for interactive visualisation of alternative energy resources, enabling spatial and statistical analysis

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The Role of Geographic Information Systems

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Geographic Information System

A geographic information system (GIS) is a computer-based data management system which consists of data capture, storage, retrieval, analysis and display of geographically referenced data.

To be more precise it is a linking of geographically referenced spatial and non-spatial data.

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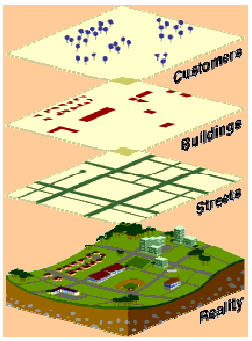
Layers of data

A GIS stores information about the world as a collection of thematic layers that can be linked together by geography.

This is simple but extremely powerful and versatile concept.

It has proven invaluable for solving many real-world problems.

Institutes have already begun to turn it to characterizing energy resources.



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Why use GIS?

- Links multiple disciplines into one system
- Allows examination and analysis of historical data, current data or future projections
- Present information in easily understood format
- Provides a common platform for distribution and information dissemination
- Supports decision making

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From Data To Resource Characterisation

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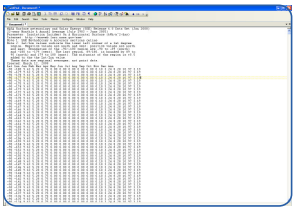
Input data sets describe different physical quantities

- Natural physical data can be collected by remote sensing methods
- Inclusive of or ground-truthed using direct measurements
- Subject to pre-processing by provider
- Important to know limitations of scale / resolution



e.g. NASA's Global Horizontal Radiation dataset takes monthly and annual averaged values over a 22-year period from July 1983 – June 2005, with base units of kWh/m2/day.

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Global vs Local Coverage

- Scale of datasets depends on type of analysis required
- Localised data (sub-national) allows for higher resolution
  - E.g. wind company looking at optimal site location

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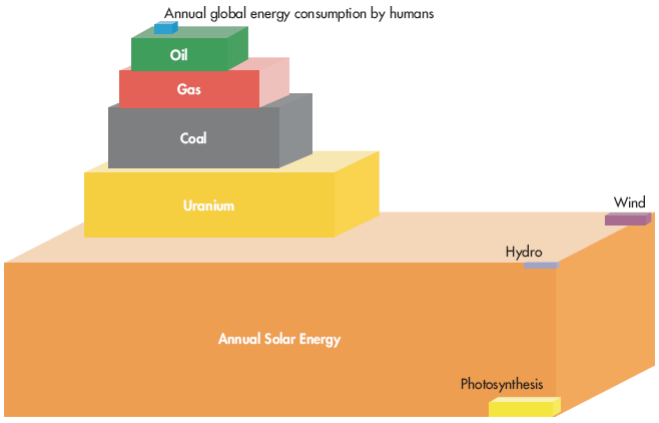
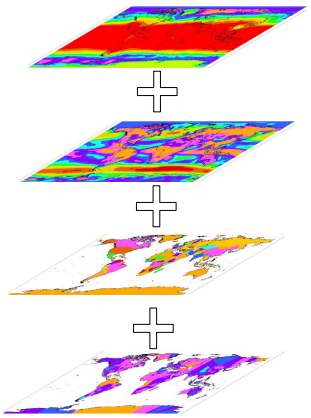


Source: National Petroleum Council, 2007 after Craig, Cunningham and Saigo.

- Taking stock of global energy resources
- Useful to compare endowments across different regions
  - E.g. comparing total solar insolation across desert and temperate regions
  - E.g. onshore vs offshore wind intensity in Asia

Alternative Energy Resource Characterisation

- Four main resources were considered for the present study
  - Solar
  - Wind
  - Hydroelectric power
  - Geothermal
- Source data were derived from NASA, NOAA, IHFC, WEC and other public domain
- Data sets were in native units e.g. Wind m/sec



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Methodology

Load into Geographic Information Systems (GIS) platform
- Convert source data into thematic layers
- Conduct spatial analysis using Statistical Interpolation techniques

Consider best-in-class technology and harmonise data values to common units of potential power capacity / unit area

Assess alternative energy potential

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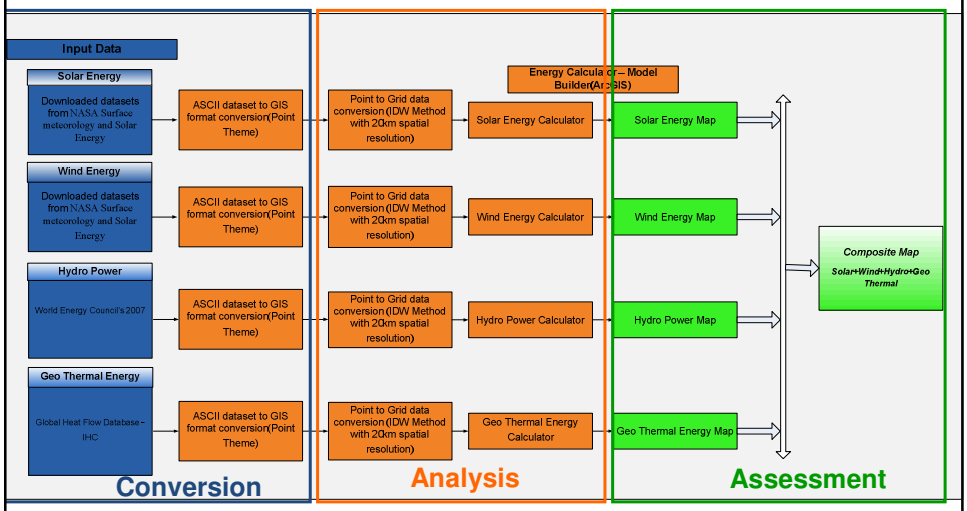
Overview of Workflow



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Result: Thematic Maps

- The maps show the distribution of alternative energy resources
- Global treatment allows harmonised assumptions and comparability
- A composite map allows rapid identification of regions with high / low potential for exploiting alternative energy, and encourages further exploration
- Allows user to consider whether one or more alternative energy technologies can be deployed

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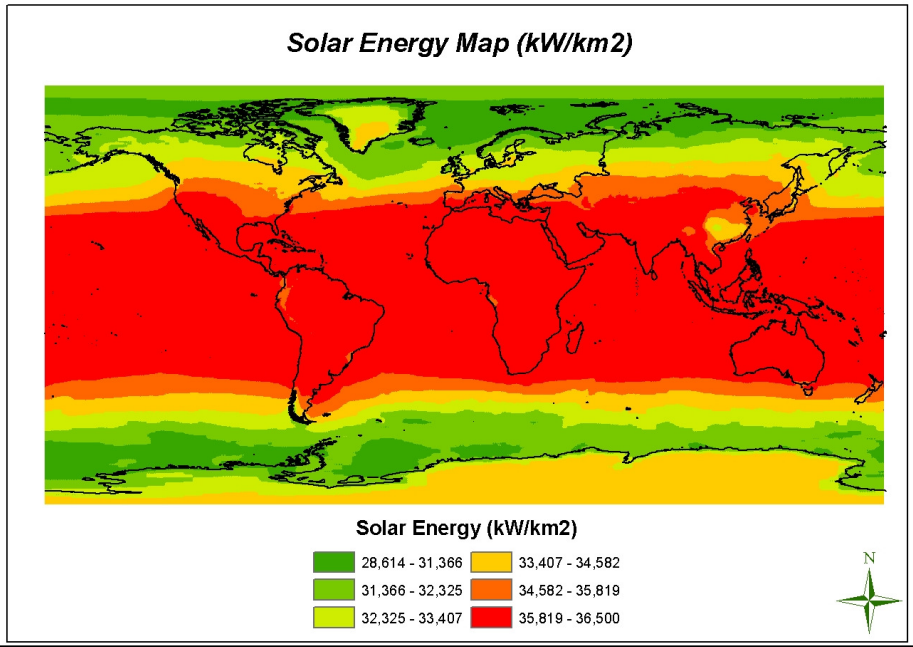
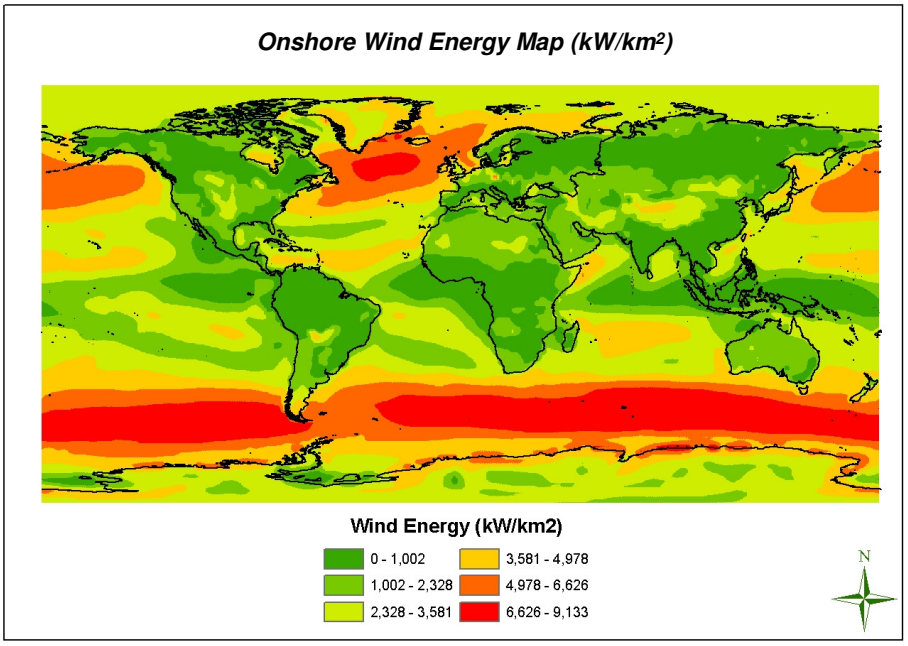
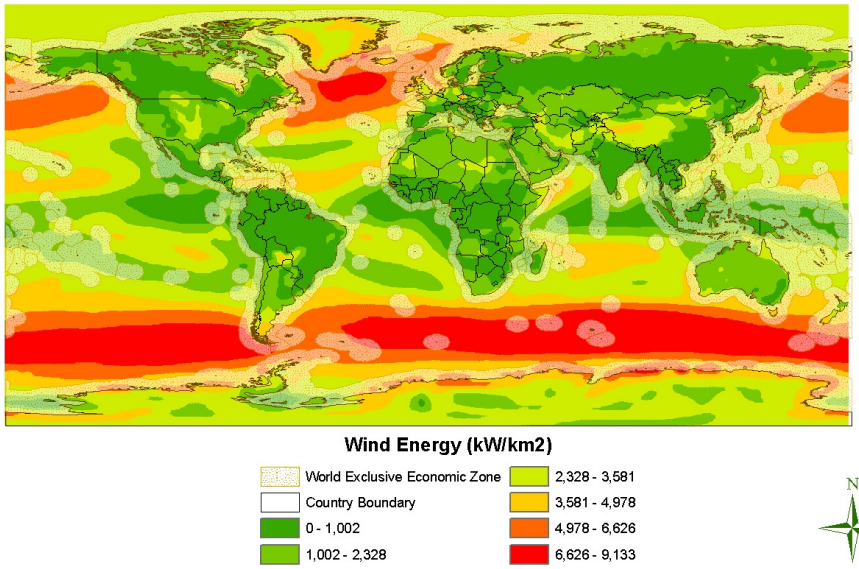
Spatial Analysis Results

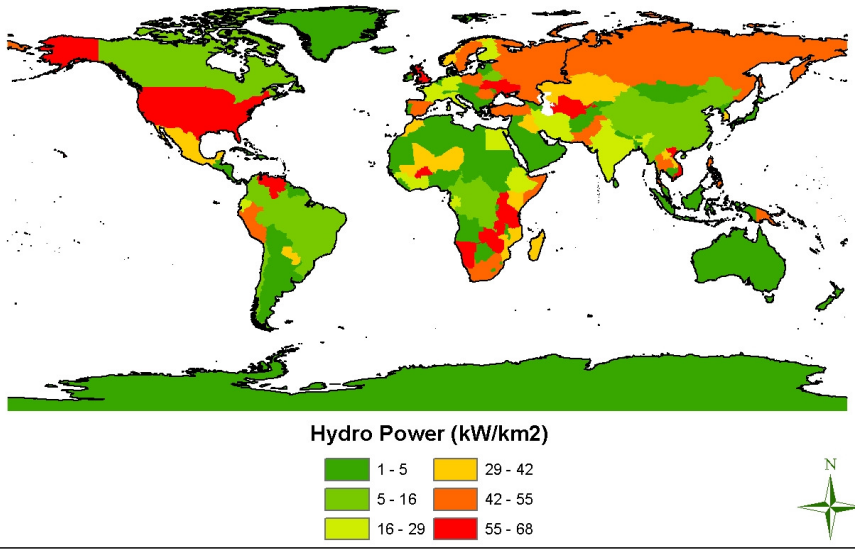


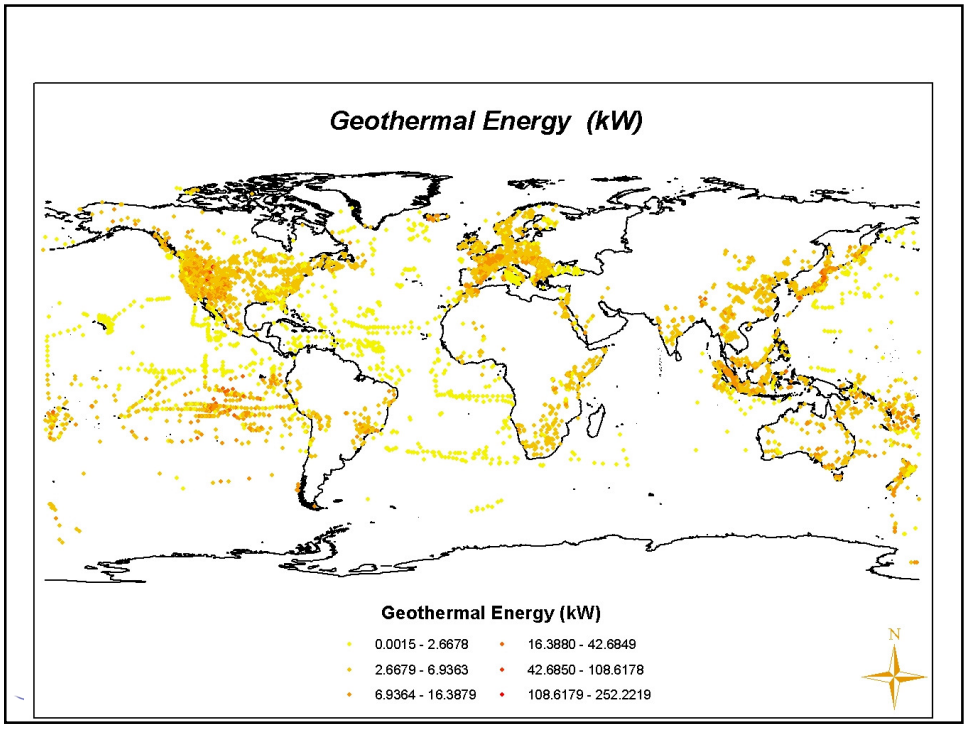


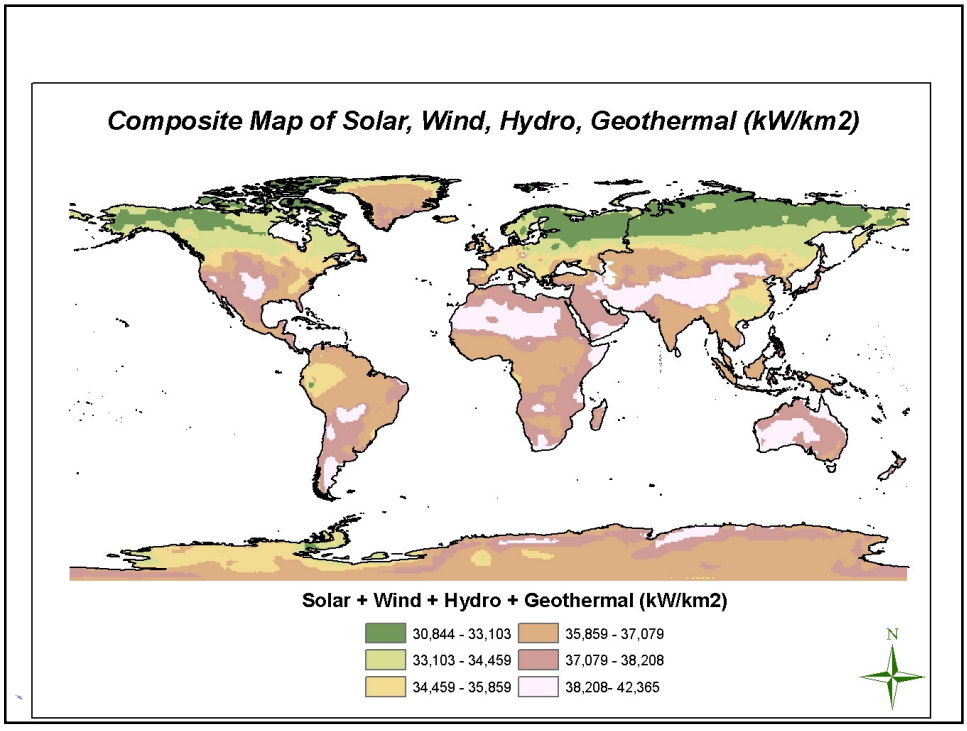
Offshore Wind Energy Map (kW/km²)



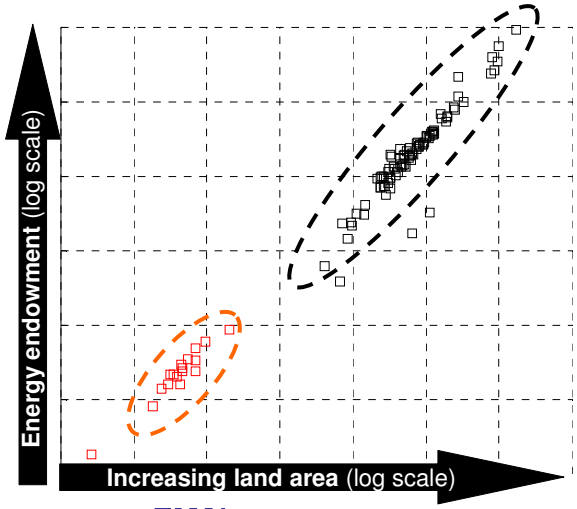
Hydro Power Map (kW/km2)




Geothermal Energy (kW)
Geothermal Energy (kW)
0.0015 - 2.6678
2.6679 - 6.9363
6.9364 - 16.3879
16.3880 - 42.6849
42.6850 - 108.6178
108.6179 - 252.2219
N


Composite Map of Solar, Wind, Hydro, Geothermal (kW/km2)
Solar + Wind + Hydro + Geothermal (kW/km2)
30,844 - 33,103
33,103 - 34,459
34,459 - 35,859
35,859 - 37,079
37,079 - 38,208
38,208- 42,365
N

Potential with respect to land area



- Bulk of countries have a certain land area and energy endowment

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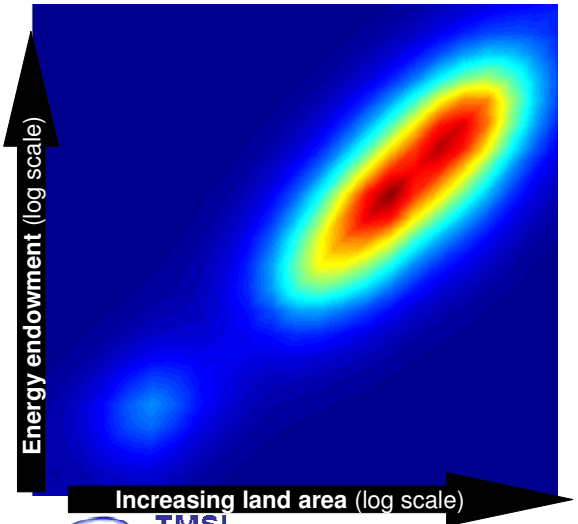
Potential with respect to land area



- Density plot shows where the main weight of the cluster lies

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Conclusions

- Alternative energy resources are unevenly distributed across geographical regions
- This leads to varying energy endowments
- An upper limit is imposed by natural constraints

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On-going Work

- Fully integrate additional thematic layers for the potential assessment:
  - Land use
  - Elevation
- Explore links between impacts of climate change / adaptation pressure and capacity to mitigate
- Consider the opportunities and problems associated with nuclear power
- Set up of a GIS database with geospatial data standards and data sets
  - Catalogued for easy retrieval, query, for interactive visualization and analysis
  - Online visualization of energy datasets using ArcGIS Server

- Alternative Energy Resource Data Centre?
  - A central hub providing access to an extensive collection of renewable energy resource data, maps, and tools to support activities related to energy potential assessment at Global, Regional and National level

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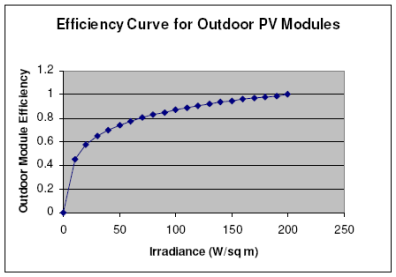
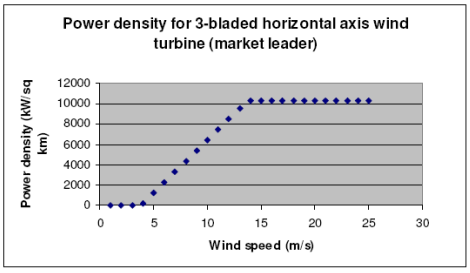
Supplementary Info: Power Density Calculation





- The fundamental unit of energy endowment is based on ***energy potentially exploitable per unit area***

- For each energy type, we conducted a scan of best-in-class technology being deployed and technology close to commercialisation/deployment. These provide the basis for assigning power output and footprint of hypothetical power plants. Units were harmonised to kW/km^2.

- Technology types are not intended to be prescriptive.

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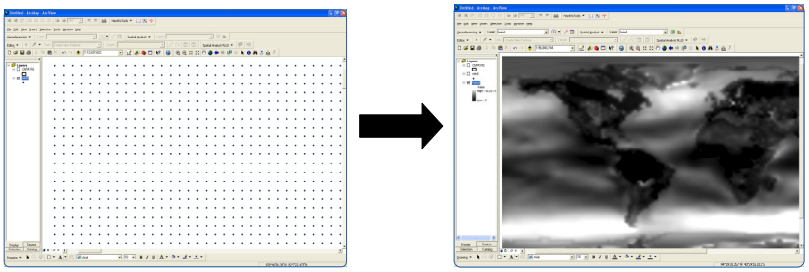
Supplementary Info: Spatial Analysis

- Point themes were spatially interpolated to GRID's using a method based on Inverse Weighted Distance (IDW)

- Spatial Resolution – 20 km

- Energy data corresponding to a region or country could be extracted using a mask theme



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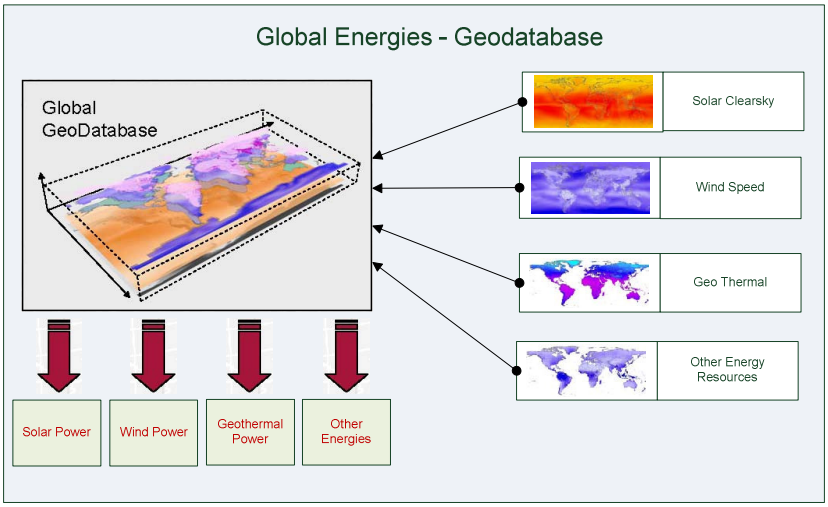
Supplementary Info: Geo-database



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Supplementary Info: Development of Geospatial Toolkit

- To develop a geospatial tool kit; a map-based software application that integrates resource data and geographic information systems (GIS) for analysing renewable resources
- The development tasks include creation of new algorithms for analysis, to illustrate overall energy distributions and assess regions' potential
- The tools include spatial analysis to perform geo-processing, raster calculation etc., to create energy grids, as well as the aggregation of these grids to produce composite maps

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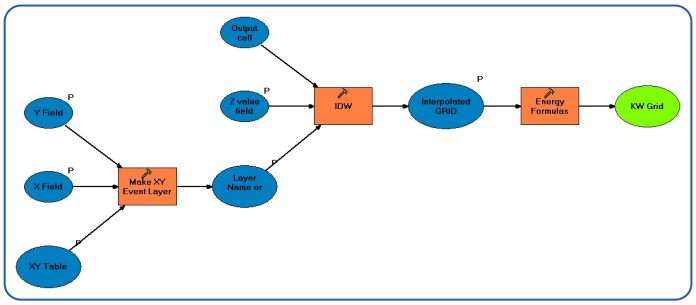
Supplementary Info: Spatial Toolkit – Model Builder



Model Builder
- Automated generation of energy maps
- Power density formulas are built in
- Tool kit provides the KW map as output

Composite Map Creation
- Each energy grids are added using Map Algebra technique
- Solar+Wind+Hydro+Geothermal = Composite Map
- Provide the regions with high/low energy potential
- Land use and elevation inputs yet to be built

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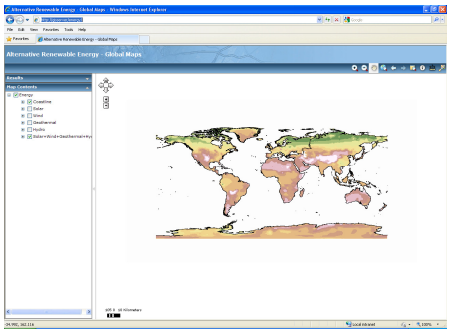
Supplementary Info: Web map visualization

- The dataset can be visualized online using web mapping interface created using ArcGIS Server. This facilitates viewing of the energy potential maps for each country/region.



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We welcome suggestions for
further work and collaboration.

Please contact

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ESI: Dr Felicia Shaw
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End of Part 2
Next:
Discussion of implications for energy planning and UNFCCC

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