Integrating biodiversity and energy in spatial planning

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Abstract: The low carbon energy production paradigm can represent higher spatial demands in environmentally sensible areas such as river courses or protected areas, potentially affecting their valorisation and use. These issues must therefore be addressed throughout energy planning and development in order to achieve a correct practical implementation of the new energy production paradigm.

In this context, energy production development and planning can benefit from using a methodological approach already implemented in water resources management. With integrated geographical information planning tools and models, subjects such as water resources, protected and biodiversity sensible areas or climate change can be easily incorporated into the decision process.

These tools are based on geographical data models that incorporate geoprocessing and cadastral capabilities, providing an integrated scope of all the issues relevant to energy planning. Examples of these tools have been implemented in compliance with the Water Framework Directive, namely in the Alentejo and Algarve regions.

Keywords: Integrated planning, Water Framework Directive, River Basin Management Plans, geographical information systems

1. Introduction

In recent years a significant energy production paradigm shift has been taking place, mostly motivated by energy resource scarcity, geostrategic tensions and, to some extent, environmentally-driven energy policies. From highly concentrated forms of energy transportation and production, energy production mixes have evolved to favour more context-dependant and spatially extensive technologies.

Technologies such as hydro power, wind power, solar power or biofuel/biomass have a much more profound dependence on the characteristics of its surroundings than their power plant counterparts, underlining the growing importance of integrated spatial planning. In order to effectively contribute towards better planning, transdisciplinary factors and criteria must be considered, spanning all areas of relevant technical expertise and regulatory impositions that influence energy productivity, predictability and usefulness.

The Portuguese National Action Plan for Renewable Energies (DGEG, 2012) exemplifies this strong spatial dependence for the National Electricity Transmission Grid planning and development (REN, 2008). These processes are base on technical criteria that include strategic guidelines transmitted by regional planning and development, nature conservation, water resources protection, tourism and archaeological protection.

Other sectors of activity are also strongly related to spatial analysis and management and may contribute towards enriching the energy production planning, management and assessment processes. Recent developments in water resources management led to the implementation of integrated methodological approaches that include subjects such as hydrology, water quality, protected areas, biodiversity sensible areas and climate change. These developments include database architecture, integrated cartographic solutions and web mapping applications for data presentation and decentralized collaboration.

This communication will describe the conceptual and methodological characteristics of the model developed for water resources management and provide insight that can be useful for the development of equivalent tools applicable to energy production planning, management and assessment processes.

2. Motivation and Study areas

The Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council of 23 October, hereinafter referred as WFD) establishes a framework for European Community action in the field of water policy.

The WFD aims to protect and enhance all water (surface and groundwater) quality, in order to achieve a "good status" for all water bodies by December 2015. It introduces the concept of water resources management based on river basins and promotes public participation, intending also to contribute to streamline legislation and management programmes (Nemus-Ecossistema-Agro.Ges, 2011a, 2011b; Nemus-Hidromod-Agro.Ges, 2011).

In order for these goals to be achieved, the WFD requires the identification of River Basin Districts (RBD) which must be subject to individual River Basin Management Plans (RBMP) that: identify responsible authorities; characterize the RBD; report on monitoring networks, environmental objectives and programs of measures; register protected areas and provide a summary of public participation activities undertaken to support RBMP preparation and their subsequent implementation.

The RBMP represent a pivotal tool in European water resources planning. For the RBD described in this communication, this planning effort depended on the development and implementation of an integrated geographical and alphanumerical data model. This data model was meant to register and store all relevant information and results, considering its production, presentation and transmission, and to allow data documentation and updating.

Hence, the developed data model comprises several analytical, cadastral and representational tools that support the planning and subsequent decision-making processes, contributing towards water resources management.

The methodological approach was separately applied to the RBMP for the “Sado e Mira” and “Guadiana” RBD and the “Ribeiras do Algarve” RBD, according to their administrative boundaries, particular conditions and identified priorities for each RBD.

3. METHODOLOGY

Conceptually, the developed model was meant to combine, articulate and communicate both the physical and abstract elements of the RBMP, supporting its analyses and characterization. The methodology applied to model development is based on a data modelling process using schematic Unified Modelling Language (UML), in compliance with the applicable International Organization for Standardization (ISO) standards and with INSPIRE (Infrastructure for Spatial Information in the European Community) technical specifications. The use of UML allows for database conceptualization from a schematic approach, which improves structural consistency and architecture.

The model is centred upon a geographical and alphanumerical database that groups data according to themes such as underground and superficial water bodies, hydrology, protected areas, anthropogenic pressures, economic analysis, risk analysis, environmental classification, monitoring and follow-up programmes. By centralising all relevant information, the database can function as a basis for any cross-thematic analysis or assessment and also be used for developing modelling scenarios.

The database includes relational tables and feature classes, several topology rule sets, a uniform reference coordinate system, metadata in accordance to the 22 ISO 19115 core metadata fields and attribute description, in order to strengthen data quality, usability and traceability.

Beyond facilitating resource management, this level of data production and storage systemization provides a reliable structure for evaluation and assessment procedures implementation and fine-tuning. In the RBMP implementation, such procedures include water mass conservation status, hydraulical infrastructure risk modelling, climate scenarios stipulation, hydrological vulnerability to pollution and anthropogenic pressures.

By congregating all relevant information, the developed geographical data model also serves as the main source for the cartographic elements of the RBMP and the web mapping application designed to support the promotion, monitoring, control and evaluation of the implementation of the Plans. This application is exemplified for the “Sado e Mira” and “Guadiana” RBD in Figure 1.

Figure 1 – Web mapping application for “Sado e Mira” and “Guadiana” RBMP.

These graphical outputs of the data model are primarily fed by the model’s database, allowing for permanent updating of data.

Moreover, steps have been taken to allow database integration with more sector-specific data sources such as licensing applications and hydraulic infra-structure inventories, which generate and/or manage geographical or alphanumerical entities present in the model.

This level of data integration and automated spatial representation provides an invaluable aid to planning and decision-making processes and facilitates further characterisation and study, also allowing for RBMP follow-up activities and reviews.

The model also supports integrated analysis such as anthropogenic pressure assessment, water balance estimation and simulation, and evaluation of protected area conservation status. Figure 2 exemplifies the cartographic output for protected areas in the Arade basin, “Ribeiras do Algarve” RBD, produced using data stored in the modelled database. This cartographic output results from a technical workflow that incorporates protected area status evaluation and local water mass conservation statuses and monitoring procedures, effectively integrating all relevant criteria.

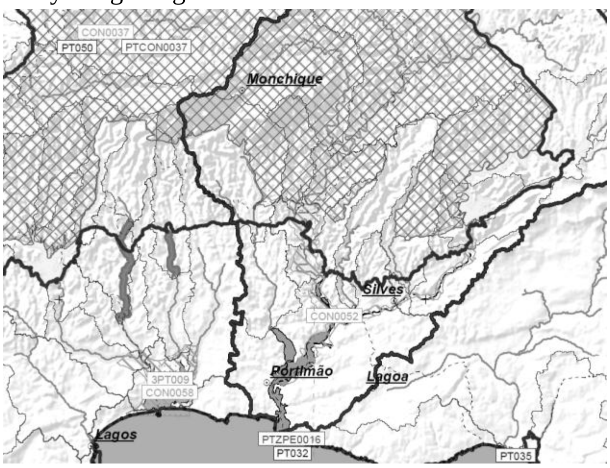

Figure 2 – A cartographic example from the “Ribeiras do Algarve” RBMP: protected areas in the Arade basin.

4. CONTRIBUTIONS TOWARDS BETTER PLANNING

Energy production planning, management and assessment processes have an indelible connection to space and spatial criteria and analysis. Consequently, the integration of these factors in the decision-making process is a necessary measure for the sector's good governance. In order to combine all the relevant factors, such as the potential impact on environmentally sensible areas, protected areas, and water resources, integrated spatial and analytical tools must be employed.

There are some strong synergies between energy planning and water resources management, given the significant overlap between some of the spatial and analytical criteria decisive to both matters. Subjects such as environmental sensibility, water resource balance, protected area identification and evaluation, and monitoring are pivotal factors for energy planning and assessment.

These subjects can be represented and updated in an integrated spatial planning tool with the use of feature datasets and relational tables, which allows for integrated workflow procedures, historic recording, scenario modelling and topological and consistency control, which contribute towards facilitating and concentrating planning process workflows.

Energy production planning and assessment processes can therefore benefit from the level of formal normalization and data integration that the presented methodology enables. Model's metadata documentation contributes towards improving its reliability, being also an important input for promoting data hygiene and reducing redundancies.

Furthermore, the associated outputs and tools for data presentation and dissemination – cartographic integration, web mapping application and the fully documented database itself – represent valuable inputs for the decision-making process, as well as its ability for scenario consideration.

The implementation of a fully functional geographical data model, including its associated tools and documentation requirements, can prove to be an important progress in the context of energy production management and assessment. Not only does this type of methodology provide a pre-modelled normalized structure that can be enforced upon the data, assuring high-quality information, but it also assists on streamlining processes with its easily accessible presentation tools and cartography.

In more practical terms, it should be noted that the implementation of a fully functional geographical data model is dependent upon model conceptualization, data loading and tool development and implementation.

Data model conceptualization is a crucial step that must take into account management and assessment objectives and all relevant data in terms of geometry, content/attributes, format, update frequency, and type of relation and integration with other data elements.

The developed conceptual guidelines must then be used to generate data structure and normalization in order to fully respect the model's characteristics and requirements and ensure correct data loading.

This step involves the implementation of any model-embedded analytical tools and relational structure, the imposition of a coordinate reference system, the validation of datasets with topology rules and metadata documentation, as well as the development of cartographic and/or web mapping applications intended to communicate and/or share data model contents and results.

5. CONCLUDING REMARKS

A complete geographical and alphanumerical data model can provide crucial technical and analytical support for planning, management and assessment processes. The energy sector, given its strong spatial interactions with its surrounding, can benefit greatly from methodologies being applied to the water resources management sector. These methodologies facilitate integrated planning processes based upon broad-spectre tools and methodologies, improving data quality and documentation and assessment accountability.

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