timbre

Tailored Improvement of Brownfield Regeneration in Europe

TIMBRE
Final publishable summary report

PROJECT FINAL REPORT

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1 Executive summary

Brownfield renewal is an essential element of sustainable land management. After more than three decades of research, a wealth of instruments has been developed to support brownfield regeneration – even addressing large-scale and complex contamination. However, an immense diversification of (sometimes not visible) tools with little connection to each other as well as a lack of consideration of regional and cultural specificities deter end-users from application of the most effective measures. Hence, problem owners, managers, regulators and other stakeholders do not use the best technologies and planning tools available. Additionally, emerging challenges call for the development of new and integrated solutions. The ambition of the EU project Timbre – Tailored Improvement for Brownfield Regeneration in Europe – was to support stakeholders in overcoming these barriers. Between 2011 and 2014, Timbre aimed with 15 partners from science, SMEs, industry and regulation at supporting brownfield regeneration by providing best-practice and case-study proven, customised problem- and target-oriented packages of approaches, technologies and tools for the assessment, investigation, remediation and integrated planning of reuse options. Timbre offers comprehensive support, easily available via web-based tools, for those interested in the regeneration of general and in particular complexly beset brownfields, so-called megasites, via its website www.timbre-project.eu.

Timbre analysed socio-cultural patterns that underlie decision making in brownfield revitalization by investigating administrative possibilities and site specific attitudes of stakeholders. Key actors of case study sites were classified and regional or national drivers and barriers that influence decision-making in Poland, the Czech Republic and Romania were identified. The critical role of constrains, stable goals and the accumulation of knowledge and trust were pointed out informing the design of Timbre tools.

The web-based Timbre tools were developed with significant stakeholder engagement. The Timbre Information System for Brownfield Regeneration supports a wide range of end-users in accessing available information about brownfield regeneration and thus in identifying, case by case, the best strategies and approaches to be applied in the different phases of the redevelopment process. The Prioritization Tool, which is based on multi-criteria decision analysis methods, supports stakeholders being responsible for wider territories (regions, districts, cities) or clusters of brownfields (portfolios) to allocate available resources to those brownfield sites that are assessed to be most critical, urgent or profitable to regenerate. The Site Assessment Tool supports participatory planning and assessment of re-use options for large contaminated brownfields by providing invited users access to data about a specific site and allowing them to get involved in the planning process. Applications of all tools to sites in Germany, Poland and Romania demonstrated the usefulness and transferability.

Timbre screened and monitored pollution at selected sites by an innovative combination of methods – phytoscreening, soil gas, direct push, and sample analysis.

The main pollution at Hunedoara, Romania, is heavy metals – removal after soil-flushing is a treatment option. At Szprotawa, Poland, jet-fuel and aromatic pollutants are in soil and groundwater. Here, remediation options include air sparging or in-situ chemical oxidation of hot-spots with phytoremediation for larger areas. Timbre, moreover, analysed the potentials and status quo of deconstruction and re-use options of buildings and structures at brownfields. For this purpose cost- and environmentally friendly strategies were identified to recycle building rubble and technical guidelines were provided for the prediction and minimization of emissions and for occupational health and safety in the deconstruction process.

The Timbre project claimed a high level of stakeholder engagement in the design and dissemination of its results, e.g. through publications (e.g. articles, reports, brochures, guidelines), and the organisation of a considerable number of stakeholder events (including conferences, focus groups, questionnaires, summer schools, specialist workshops and training events). The project was supported by an international advisory board and was coordinated at the Helmholtz Centre for Environmental Research – UFZ, Germany.

2 Summary description of the project context and the main objectives

General project context

In the last half century, economic restructuring has led to a growing number of brownfields – derelict or underused areas that have been affected by their former industrial, military and commercial uses or surrounding land and require intervention to bring them back to beneficial use – in all industrialised countries. Restoration, revitalisation and redevelopment of such artificial landscapes is often hampered by real or perceived environmental contamination, high costs for cleaning up to sufficient levels and also due to divergent interests of actors that are to take part in or are affected by the design and form of re-use (Bartke 2011, 2013, Morio 2013, Schädler et al. 2011, 2012, 2013a/b, Thornton et al. 2007).

In 2006, almost 100,000 km² or 2.3 % of the EU's territory were actually sealed and each EU citizen was on average stocked with 200 m² sealed surface (Prokop et al. 2011). Moreover, rising demands for biofuels, food and feed cause land use conflicts at the expense of natural ecosystems (Bringezu et al. 2012). The last decades showed an increased perception and understanding of unpolluted and pristine land as a scarce and non-renewable resource, especially in densely populated and highly industrialised parts of Europe, stressing the need for more efficient soil use and innovation in land management (De Sousa 2008, Howland 2007, Thornton et al. 2007). The objective to considerably reduce land consumption, e.g. by avoiding urban sprawl, has been implemented in European and national political strategies – although being challenged recently (EC 2006, 20012a,b, 2014, Leipzig Charta 2007). Still, the EU and many countries have granted an important place on the political agenda to the reuse and revitalisation of brownfields, as a strategic element for achieving a reduction in soil sealing or even offering a sustainable land-take alternative (Bartke 2013).

The European FP7 project Timbre – Tailored Improvement for Brownfield Regeneration in Europe – aimed to supporting end-users in overcoming existing barriers to brownfield re-use by developing and providing customised problem- and target-oriented packages of technologies, approaches and management tools for brownfield prioritization, re-use planning and remediation. In particular, Timbre focused on so-called megasites. These sites are characterised not only by their relatively large size, but also by their complexity of soil and groundwater contaminations, large residual above-ground and underground buildings and/or a heterogeneous mix of stakeholder interests. In Europe, there are over 20,000 large and complex contaminated sites with significant remediation costs (Bittens et al. 2009). These megasites threaten scarce soil and water resources and cause environmental and health risks as well as economic and social costs. Their effective and sustainable regeneration requires innovative investigation and remediation technologies and integrated evaluation approaches for optimised reuse options (Bartke et al. 2013, Morio 2013).

Megasites pose difficult technical and social challenges for risk-management, policy issues and reuse. Consequently, several research projects at the EU or regional levels have resulted in a lot of positive impacts at model sites and in model regions as well as awareness about major inputs towards successful brownfield development (Bartke et al. 2013). These projects have produced a variety of products intended to exert a wider impact, but so far their institutional and practical impact has been limited and transfer of results is difficult (Bleicher & Bartke 2013). In particular, innovative technologies and methods developed to investigate and remove soil contaminations were broadly applied only in a few countries of the European Union.

Since there is no single silver bullet to support the enhancement of brownfield regeneration, success can be expected only if improvements do specifically consider the social, economic and political context (including socio-economic possibilities such as economic, culturally and even site specific attitudes of stakeholders towards risks, coherent with the acknowledgement of ignorance and the legal appropriations for adaptive possibilities) that governs the entire process of decontamination and redevelopment (Alexandrescu & Bleicher submitted, Alexandrescu et al. 2014b, in preparation). Hence, brownfield regeneration is understood as an encompassing measure covering technical as much as societal and economic activities for brownfield revitalisation, recreation and recycling. Against this background, Timbre was to address the need to customise supporting instruments with respect not only to local, but also explicitly to the regional boundary conditions.

Main objectives of the Timbre project

In the last half century, economic restructuring has led to a growing number of brownfields – derelict or underused areas that have been affected by their former industrial, military and commercial uses or surrounding land in all industrialised countries. They require intervention to bring them back to beneficial use –. Restoration, revitalisation and redevelopment of such artificial landscapes is often hampered by real or perceived environmental contamination, high costs for cleaning up to sufficient levels and also due to divergent interests of actors that are to take part in or are affected by the design and form of re-use (Bartke 2011, 2013, Morio 2013, Schädler et al. 2011, 2012, 2013a/b, Thornton et al. 2007).

Against this background, the objective of Timbre's Working Package (WP) 2 was to provide knowledge on governance structures and decision processes. Of interest were also the reasons for the absent or tardy application of existing technologies, methods and tools. Learning about these reasons allows researchers and practitioners to understand if and to what extent decision-makers are interested in using certain technologies or tools, and what might prevent them from being interested. This creates the potential to suggest alternative options for decision makers and, in general, to support stakeholders on the ground (Alexandrescu et al. 2014, Bartke & Schwarze in preparation).

The specific objectives of WP2 were defined as: 1) developing an analytical framework for identifying stakeholders, for analysing decision/governance structure in brownfield revitalisation as well as for the identification of hindrances and unused potential for use of technologies and tools; 2) identifying the central stakeholders in decision making on brownfield revitalisation in the three case study countries Czech Republic, Poland and Romania; 3) interviewing stakeholders in Poland and the Czech Republic; 4) organising focus group meeting and analysis in Romania; and 5) identifying driving factors and criteria of decision making in sustainable brownfield development as well as hindrances for the application of technologies and tools based on the interview and focus group data.

A further aim of WP 2 was to deliver bottom-up social information for the Timbre work packages dealing with the development of technologies and tools. More precisely relevant stakeholders in brownfield revitalization should be identified and analysed concerning their role in decision making with regard to technologies and tools – in order also to inform the design of Timbre instruments tailored to end-user needs.

By now an abundance of strategies, regulations, tools, documented case studies and guidelines to deal with brownfield regeneration have been produced in Europe, but too often they are not applied their entire potential due to their diversification or scarce visibility (Bartke et al. 2013). Furthermore, the lack of awareness about the actual information needs of stakeholders dealing with brownfield regeneration is one of the reasons why the potentially useful information is not exchanged among stakeholders in the most effective way. This situation makes the success in brownfield regeneration unsatisfying in terms of financial, eco-efficiency or social acceptance.

In order to overcome this problem, WP 1´s main objective was to develop the “Timbre Information System for Brownfield Regeneration” (IS). This expert system is aimed at supporting stakeholders in sharing, accessing and selecting the most suitable information for the different phases of the brownfield regeneration management process. The IS is taking into account users’ specific requirements, using the evaluations provided by previous users, and hence, answering to stakeholders’ information needs (Rizzo et al. in preparation).

To this end, the specific objectives of WP1 were 1) the development of an EU-wide inventory of practicable solutions, technologies and tools supporting economically and socially beneficial brownfield regeneration, including data, information, strategies, tools and relevant national and international projects, programs and initiatives related to the process of brownfield regeneration; 2) the design of a Timbre web database, which systematically organizes the future consultation of the available information collected in the previous step; 3) the development of a ranking methodology for the evaluation and classification of the collected information through the active involvement of the stakeholders of the Timbre case studies; and 4) the development of the functionalities and interfaces of the web-based Information System.

The WP 3 research activities were focused on developing a prioritization tool, which was to help stakeholders being responsible for wider territories (regions, districts, cities) or clusters of brownfields (portfolios) to allocate available resources to those brownfield sites that are evaluated to be most critical, urgent or profitable to regenerate. Towards this goal, the following specific objectives were addressed in WP 3: 1) the collection and preparation of data and the information analysis as the start-point of research activities (reporting on results of a survey on brownfield regeneration and statistical analysis); 2) testing a pilot version of the Prioritization Tool at brownfield databases from four Timbre countries (Czech Republic, Germany, Poland and Romania) and for different types of datasets (urban, regional, national and private databases); 3) the creation of a stand-alone version of the web-based Timbre Prioritisation Tool – the programming (and technical improvement) of the web-based tool to be based on stakeholders' feedbacks; 4) the creation of dissemination materials (brochure, presentations, leaflets, internet pages) based on results of; and 5) the distribution of dissemination materials among potential end-users by means of special dissemination workshops and meetings with stakeholders and potential end-users.

A third web-based support tool was to be developed in Timbre's WP6. Building up on research on integrated site assessment and re-use planning tools (Schädler et al. 2011), the main objective in WP6 was to develop a customisable web-based site assessment and re-use planning tool (SAT), which enables end-users to develop and evaluate their own ideas of the future uses of brownfield sites in terms of a decision support system (DSS). The objective of this tool is to provide better support to projects in the screening stage, where possibilities with regard to future use of the sites need to be explored, holistically evaluated and communicated. In order to provide European-wide use and benefit of the tool, the goal was to provide a user friendly web based graphical user interface (GUI). The interface comprises diverse models and methods (also denoted as 'modules') and provides the necessary geographic information system (GIS) functionalities, e.g. for creation of land use allocation maps, definition of use-oriented and risk-based remediation targets, analyses of conflicts between environmental quality targets/thresholds, and existing contamination level, remediation cost and market value estimation, sustainability assessment, etc. Further reasons for developing a web-based tool were seen 1) in the unlimited availability to stakeholder round tables by serving the functionality to any PC/laptop with an internet connection via a web browser, and without the need of having the tools or the respective site data available on one or a number of desktop computers, and 2) the option to involve as many people as is desirable into the planning and decision process including laypeople. The development of the Timbre SAT was to be built upon existing assessment tools and modules developed in previous projects and research programmes (e.g., WELCOME, SAFIRA II, REFINA) in order to guarantee that the provided funding is not used to re-invent strategies that already exist and that have proven successful. Further developing existing methods

should also make sure that a significant step ahead from previous achievements can be provided during the limited scope of the project.

Timbre did not merely focus on decision support instruments, but also was to enhance strategies and technologies for integrated site characterization and remediation. In its WP4, four novel screening methods, namely tree coring (phytoscreening), soil gas measurements and two direct push technologies (MIP – Membrane Interface Probe and LIF – Laser Induced Fluorescence) were compared with each other, and with soil and groundwater samples. The combination of these measures allows an effective and rapid site characterization. Moreover, also forested areas and areas with risk of explosives were investigated.

WP4's analysis focused at two test and demonstration sites in Romania and in Poland. The former steel works site Hunedoara, Romania, has high concentrations of toxic elements and heavy metals in top soil. But thanks to the large amount of materials like illite and Fe(III) oxides with high sorption capacity and inertness and due to high pH (7.65 to 8.97), heavy metals were not detected in the groundwater at Hunedoara. The high Kd values limit plant uptake of heavy metals, and calculated clean-up times with phytoremediation are thousands of years. A treatment option is the removal of top soil, after volume minimization by flushing (SSWRS). At the Polish site Szprotawa, a former military airbase, jet fuel and BTEX in >2m depth in soil and groundwater are the major pollution. Hydrocarbons are rapidly degraded under aerobic conditions, and it was predicted that jet fuel and BTEX in top soil will degrade quickly. Phytoremediation is a suitable option to support the naturally occurring degradation of contamination at the site. Hot spots should be treated separately, e.g. with air sparging, in-situ chemical oxidation and excavating and composting at site. An efficient, cost-effective solution will require combining the techniques (treatment train).

In WP 5, practitioners-led and -focused analyses were to improve deconstruction and re-use of structures and materials at brownfields supporting the assessment of re-use options of buildings vs new developments, and elaboration of strategies to recycle building rubble on-site in order to avoid unnecessary dumping of materials and raw material use for more environmentally friendly site preparations. The work was in particular to focus on achieving the following objectives: 1) report on knowledge status on recent projects and practice in the EU on regulations regarding decontamination measures, working safety, re-use and or disposal; 2) develop cost- and environmentally friendly strategies to recycle building rubble, to avoid and minimize dump materials and the consumption of raw materials, including tools for estimation of costs and environmental as well as socio-economic impact of possible re-use or deconstruction of buildings on brownfields; 3) elaborate a technical guideline for the prediction of emissions during deconstruction measures (building, contaminants, noise, vibration, dust / particulates) and for the minimization of these emissions; and 4) provide a technical guideline on the working safety during the deconstruction of buildings and structures. The work was to be supported by field

investigations and laboratory tests on test sites in Poland and Romania as well as on intense exchange with relevant stakeholders.

In order to enhance a widespread acceptance and utilisation of the Timbre results from WPs 1-6, WP 7 “Web platform, outreach, dissemination, and transition” was to develop a concept for a series of tailored supporting measures for specific end-users. For results emerging in Timbre, adequate packages were to be designed according to the requirements of the different target groups to be identified. The measures were to facilitate the stakeholder engagement in the design of Timbre instruments in as much as their dissemination. Moreover, WP 7 was to increase the visibility of the Timbre project results throughout Europe and beyond and as such support the application of the developed tools beyond Timbre. The final objective was to link the Timbre tools and databases on the Timbre web-platform.

Coordinated by the Helmholtz Centre for Environmental Research – UFZ, the project management objectives in WP8 were to ensure an appropriate general management structure to safeguard that all aspects of the project were well integrated and coordinated and that deliverables were completed in a timely manner. Furthermore, WP8 coordinated the collaboration with EC officers, an encouraging international advisory board and with a considerable number of external partners and projects, especially the EU project HOMBRE.

For further information, project results including the Timbre web-tools and data-bases, references and links, visit the Timbre website www.timbre-project.eu.

3 Description of the main S & T results/ foregrounds

The activities of all work packages in the Timbre project are directed towards a steadily growing contribution to (i) the enhancement of sustainable brownfield regeneration through the development of economically and sociologically sound frameworks that help fostering the set-up of tailored approaches, technologies and tools; (ii) the contribution to a common strategy for brownfield regeneration in Europe that will lead to accelerated and eased policies for large-scale projects in regions with an urgent need for ecological and economic development; (iii) the integration and adjustment of already existing technologies in order to provide solutions being accepted and applied by end-users throughout all European regions; and (iv) the improvement of the accessibility of existing state-of-the-art knowledge via a web based platform in order to harmonise European brownfield regeneration procedures.

The Timbre project strived to overcome existing barriers to brownfield regeneration by developing and providing customized problem- and target-oriented technologies and tools for enhanced brownfield regeneration in Europe. The Timbre objectives have been dealt with by focusing on single sites, their regional scale or on registers of sites. In total, six different sites and two registers (Tab. 1) were chosen based on their applicability to test and elaborate the Timbre instruments. Instead of having merely one case study site, this more diverse portfolio of test fields was selected to provide the consortium with the benefit of the ability to ground its research on a broader information basis. This was fundamental to support the Timbre objective of taking into account different national and regional characteristics and determinants that were assumed and found to influence brownfield revitalisation in Europe (e.g. Alexandrescu et al. 2012/2013, Frantál et al. 2012, Hagemann et al. 2012, submitted). Furthermore, by following this approach it was acknowledged that in general test sites are not equally appropriate to analyse their socio-economic setting and any type of remediation or investigation technologies at the same time in a given project duration.

In general, on the one hand, elaboration of approaches, technologies and tools at different levels of application were tested and developed further at specific case study sites. New technologies for investigation and remediation or testing the combinations of instruments were applied at selected sites (e.g. Fatin-Rouge et al. 2013, Hagemann et al. 2013a/b, Martac et al. 2013/2014, Mohamed et al. in preparation a/b/c/d, Trapp et al. 2014). Moreover, Timbre also focus on the regional scale of selected sites to study stakeholder settings and interests as a constitutional part of brownfield regeneration activities at these case study sites (e.g. Alexandrescu & Bleicher submitted, Alexandrescu et al. 2013, Frantál et al. 2012, Klusáček et al. in preparation, Rizzo et al. in preparation). Additionally, to rank sites in a specific region of interest, the regional determinants of successful regeneration were surveyed and compiled. On this basis the prioritization tool was developed identifying the areas with a high economic and ecological relevance for the region or portfolio (Bartke et al.

2014b, Frantál et al. 2012, Klusáček et al. 2013a/b/2014, Kunc 2014, Pizzol et al. in preparation).

Tab. 1 and Fig. 1 provide an overview of Timbre's application areas. The areas are situated in Central and Eastern European countries characterised by a long history of industrial development, which has led to derelict lands and brownfields after the economic restructuring beginning in the early 1990s (cf. Alexandrescu et al. 2014a/b, Frantál et al. 2012, Kunc 2014). Policy makers and stakeholders are still struggling to solve the resulting problems especially in these countries due to a lack of experience in the regeneration of heavily contaminated brownfields. Therefore, Timbre's project activities were focussing on this region. Nevertheless, the outcomes of the project in terms of technological and tool solutions were to be designed to be transferable to other European countries.

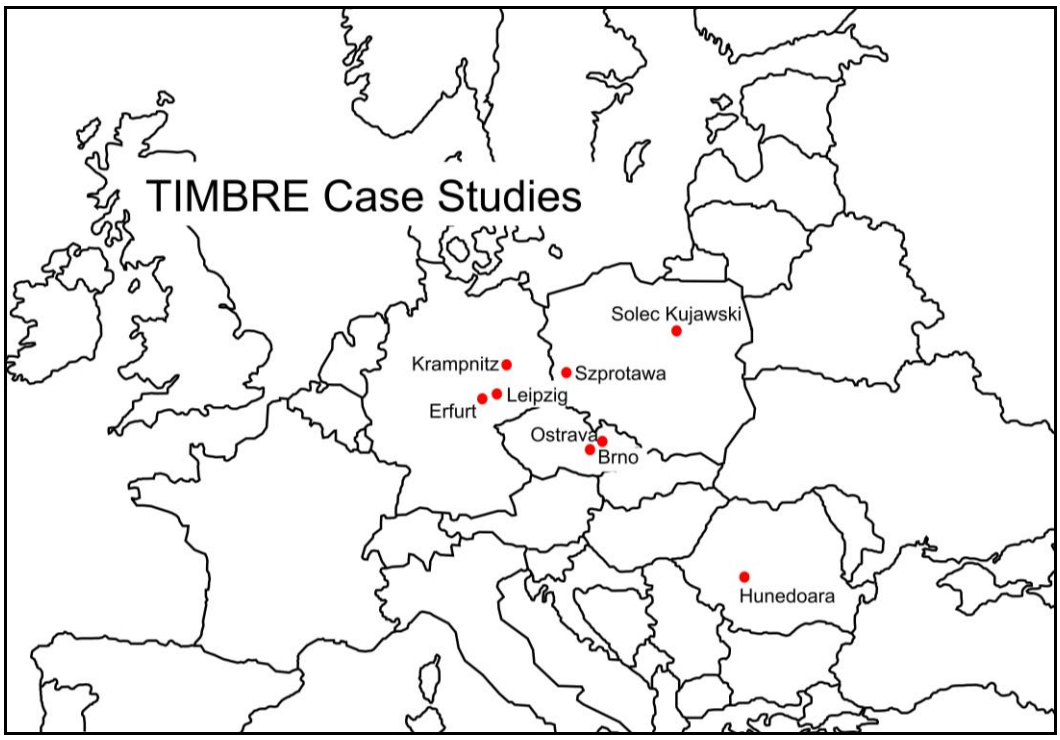
In the following, the main S & T results/ foregrounds of the project are presented in order of the Timbre project's Working Packages (WPs).

Tab. 1: Timbre application areas

No.	Type	Name	Location	Former usage	Size
1	Site	Hunedoara - ECO SID	Romania, Hunedoara County, Hunedoara City	Coke production, ironworks, steelworks, recycling materials	138 ha
2	Site	Fuel storage in Szprotawa	Poland, Lubusz Voivodeship, City of Szprotawa	Airbase	> 200 ha
3	Site	Former wood impregnation site in Solec Kujawski	Poland Kuyavian-Pomeranian Voivodeship, City of Solec Kujawski	Post-Industrial site	80 ha
4	Site	Ostramo Oil Lagoons	Czech Republic, Moravian-Silesian Region, City of Ostrava	Refinery of oil until 1980, then factory for regeneration of used oils	7 ha
5	Site	Brno – Vaňkovka	Czech Republic, South Moravian Region, City of Brno	machinery plant and metal foundry	2 ha
6	Site	UFZ-BBG	Germany, Krampnitz, City of Potsdam	Military base	120 ha
7	Re-gister	GESA	Germany, East Germany	Commercial and industrial	2,980 ha
8	Re-gister	LEG	Germany, State of Thuringia	Former military sites of the Soviet Army & state wide survey of brownfields	1,800 ha & 6,800 ha

Source: Timbre Grant Agreement Annex I - DOW part B, p 8.

Fig. 1: Location of Timbre application areas



Source: Timbre Grant Agreement Annex I - DOW part B, p 8.

3.1 WP 1: Expert system as information platform for innovative and widely applicable strategies, technologies and solutions

The main objective of WP1 has been the development of the Timbre Information System for Brownfield Regeneration (from now on “Information System”). This tool is aimed at supporting a wide range of stakeholders/end-users in accessing available up-to-date literature and information about brownfield regeneration and thus in identifying, case by case, the best strategies and approaches to be applied in the different steps of the redevelopment process. Development of the Information System encompassed the following tasks.

Task 1.1. Development of an EU-wide inventory of data, information, strategies and tools for brownfield regeneration. A screening of all accessible literature on data, information, strategies and tools related to the process of brownfield regeneration has been performed by all WP1 partners. In the review, the most relevant national and international projects, programmes and initiatives realized in the field (e.g., CABERNET, Common Forum, Consoil, etc.) have been taken into account as sources of data, as well as professional forums and consortia (e.g. Sustainable Remediation Forum – UK, SURF – USA, Green Remediation – USEPA, etc.). In the review process each WP1 partner paid special (but not exclusive) attention to materials and case-studies concerning its own country (e.g. Czech Republic, Germany, Italy, Poland, Romania etc.) and its field of expertise (e.g. risk assessment, remediation technologies, decision support, etc.). The collected information was to be stored in an appropriate database – as developed in Task 1.2.

Task 1.2. Implementation of the Timbre web database. The design of the database is based on the framework for the collection, analysis and future consultation of material gathered in Task 1.1.The framework resulted from a participatory process that involved Timbre partners, members of the projects International Advisory Broad (IAB) and stakeholders of the Timbre case studies and beyond. Within the framework, the main phases of the risk-based regeneration process are identified and correspond to thirteen “information categories”.

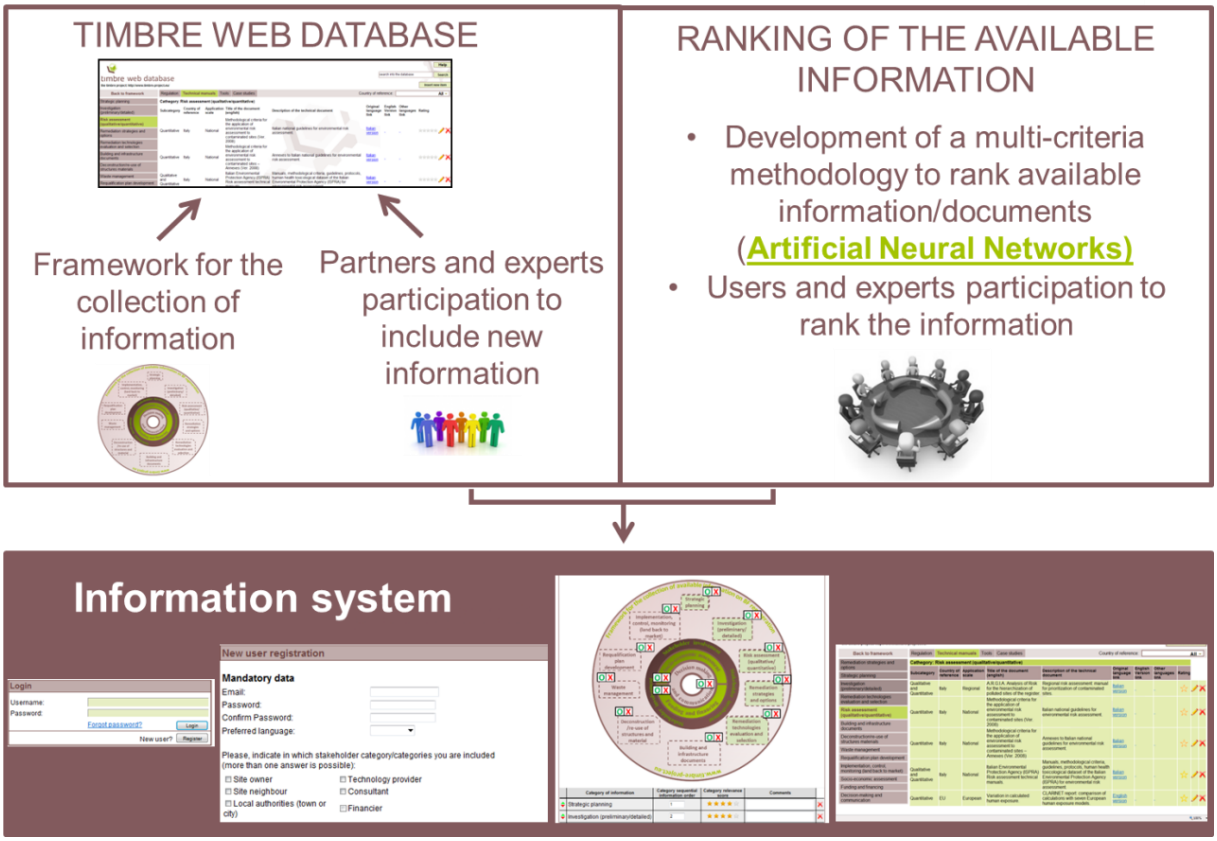
Task 1.3. Evaluation and ranking of the collected approaches, methods and tools for brownfield regeneration. A multi-criteria methodology for the classification and ranking of the materials/information included in the database has been developed which provides, for each phase of the brownfield regeneration process, the most suitable approaches and tools according to end-users specific requirements.

Task 1.4 - Identification of methodological and technological gaps. This task is aimed at providing a preliminary analysis of the contents of the Timbre web database in order to contribute at the identification of methodological and technological gaps for each phase of the brownfield regeneration process.

Task 1.5 - Development of the Timbre web-based Information System. In this task, the development of the Timbre web-based Information System (IS) for end-user friendly provision of meta data and customizable information and tools for brownfield regeneration has been performed.

Going into detail, the Timbre Information System for Brownfield Regeneration (IS) is composed of the Timbre web database, where the web links to relevant information on brownfield regeneration are stored, and by the ranking methodology that allows to classify those web links according to users' characteristics and information needs. As shown in Fig. 2, these two components are integrated into the tool and users can benefit from their features through user friendly functionalities and interfaces.

Fig. 2: Information System components and structure



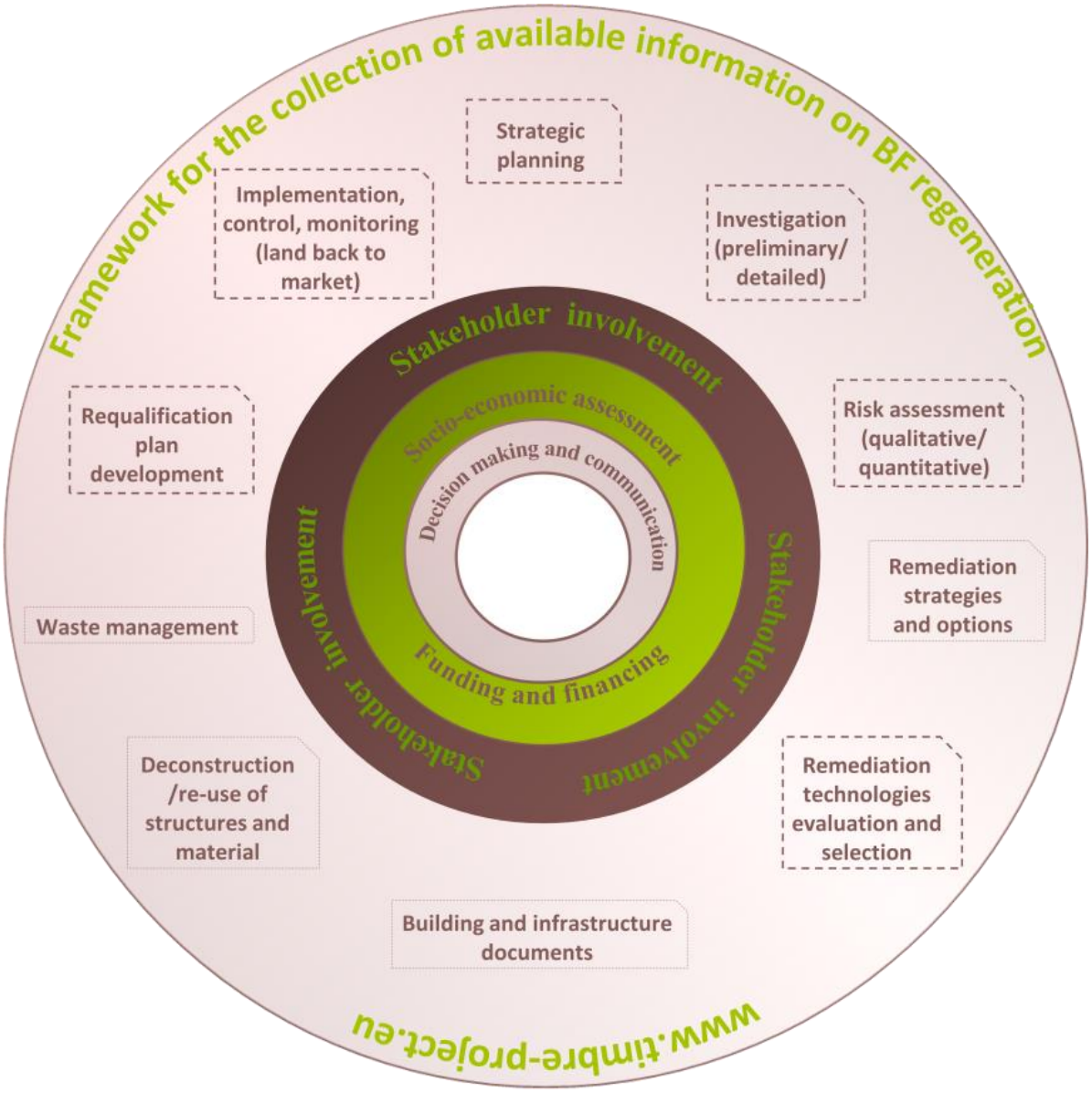
Timbre web database

The Timbre web database is the main component of the Information System, and is aimed at containing a wide collection of web-links to information on brownfield regeneration. The structure of the Timbre web database has been developed on the basis of a framework for the collection of information on brownfield regeneration (Fig. 3), which is the result of a participatory process that aimed at involving Timbre partners, Timbre case studies stakeholders and external stakeholders. The process

for the development of the Timbre web database is reported in Deliverable 1.1 “Web database with a structured site related inventory of European brownfield information and data” deliverable to the European catalogue for available brownfield regeneration tools (including tools for planning, decision support, regeneration technologies, economic evaluation, sustainability assessment) and in Milestone 1.1 “Decisional framework developed during the two workshops organised for the involvement of experts” (cf. Pizzol et al. 2012).

Within the Information System, web-links are classified according to the information categories of the framework and to the typology of documentation they represent (i.e., regulations, technical manuals, tools and case studies).

Fig. 3: Framework for the collection of available information on brownfield regeneration



Timbre Information System ranking methodology

Different stakeholders may have different specific needs when they look for specific information about the various phases of the brownfield redevelopment process—not least depending on their work tasks, their experience, the regulatory context they are operating in, and so on. The distinctive objective of the Timbre Information System is to provide each end-user with the most suitable instruments, approaches and information for each phase of the brownfield regeneration process, meeting his/her specific characteristics, requirements and needs.

According to this objective, the Information System is meant to be a user-friendly search tool automatically proposing to the user a tailored list of web links. The latter are ordered by relevance on the basis of specific criteria set by the user when performing his/her search.

The analysis and ranking methodology implemented in the Information System exploits a set of “criteria” related to the end-user (e.g., category of stakeholder, language) and to the specific features of his/her search (e.g., country of interest, specific search aim) with the purpose of providing the end user with those web links that best satisfy his/her expectations and needs.

Moreover, the Information System is thought to be an interactive system, where the end user will be able to evaluate the outputs provided as result of his/her search session(s). This evaluation is then used to refine and better tailor the outputs of future searches performed by other users.

The developed ranking methodology makes use of Artificial Neural Networks (ANN) (Mehrotra et al., 1997) which are mathematical nonlinear regression models, which, after a so-called “learning phase”, are able to infer the model underlying a set of given inputs and outputs used as a “training set” (Giubilato et al. 2013).

An ANN is inspired by biological neural networks and consists of an interconnected group of artificial neurons, which processes information using a connectionist approach to computation. The proposed methodology is based on the idea of developing a system with the ability to continuously learn from past search sessions in order to improve the provided results. The methodology makes use of a set of information collected during each search session and divided in 4 groups:

Group 1. “User related” inputs are data provided by the users during registration to the Information System, such as:

- “Preferred language”: the user is asked to indicate the preferred language when searching for information. According to this selection the system provides a list of web links where documents are written in the user’s preferred language. The subsequent links refer to material written in English, and afterwards in other languages.

- “Stakeholder category/ies the user belongs to”: this information is used by the system in order to provide the user with the most visualized web links by previous users belonging to the same category of stakeholders.

Group 2. “Session related” inputs are provided by the user during each search session and depend on the specific tasks he/she is using the Information System for. These inputs are the following:

- “Aim of search”: for each session the user is asked to indicate his/her search aim when using the Information System. This information is used to provide tailored information to the user. A list of search aims is provided and the users can choose one option from the list or indicate a new particular search aim.
- “Country of reference”: for each session, the user is asked to indicate the country where the needed information is intended to be applied. This information will affect the results (ranking of web links), which will be provided in the following order: first the links related to the selected country (including links to documents/materials written in the selected country’s language), then web links referring to the language indicated by the user as the preferred one, then links to material written in English, and finally in other languages.
- “Selected information categories”: in each session, the user is asked to select the information categories of the framework that are related to his/her search aim.
- “Scores of information categories”: after selecting the information categories, the user is asked to evaluate them, assigning a score according to his/her personal preferences and expertise.
- “Typology of information”: after the selection of the information categories the user can select also the typology of information of interest, choosing among “Regulation”, “Technical manuals”, “Tools” and “Case studies”.

Group 3. “Scores” inputs refer to the evaluation of the web links contents (i.e., associated documents) provided by each user at the end of a search session according to the following criteria:

- “Pertinence”: the user is asked to specify if a specific web link’s information is pertinent and related with his/her previously defined aim of search;
- “Appropriateness”: the user is asked to indicate if a specific web link’s information is appropriate for the previously indicated information category/ies;
- “Usefulness”: the user is asked to evaluate the level of usefulness of the web link information in achieving the specific aim of search;
- “Clarity”: the user is asked to evaluate the level of clarity of the web link information, considering how understandable and properly communicated the information is;
- “Reliability and accuracy”: the user is asked to evaluate the level of reliability and accuracy of the information that can be evaluated considering the quality and the trustworthiness of the source of information;
- “Updating”: the user is asked to evaluate the level of topicality of the information and the compliance with the latest regulatory frameworks.

Group 4. “Statistics”:

- Number of clicks received by a web link from users belonging to the same stakeholder category: it indicates the level of interest from the same stakeholder category for that web link.
- Total number of clicks: it indicates the level of interest for a particular web link.
- Detailed information on the proposed ranking methodology are reported in Deliverable D1.2 “Timbre Expert System Prioritisation Methodology & Preliminary Identification of Methodological and Technological Gaps”.

Timbre Information System interfaces and functionalities

The Information System (Pizzol et al. 2014) integrates the web database and the ranking methodology and provides suitable results on user friendly interfaces that have been developed according to stakeholders' suggestions gained during dissemination activities (i.e. Berlin workshop on 27th November 2013, Brno workshop on 29th November 2013, Bucharest workshop on 11th March 2014 and Katowice workshop on 28th May 2014).

The Information System can be accessed at the following link (http://www.timbre-project.eu/informationsystem.html) and is integrated within the Timbre Tools suite (see Deliverable 7.5 "Web based tool suite" – Bartke et al 2014a). It includes the following functionalities:

- registration and log in;
- search for information in the tool;
- definition of the search aim and selection of the country of interest;
- selection of the information categories related to the pre-defined search aim;
- visualisation of results;
- evaluation of information;
- add/upload new information to the tool;
- modify or delete information;
- update of not active web links;
- password recovery and modification;
- procedure to become an Expert user;
- help;
- log out.

A user manual of the Information System (Ca' Foscari University & Timbre 2014) has been developed and made available within the tool in the following languages: English, Czech, German, Polish and Romanian.

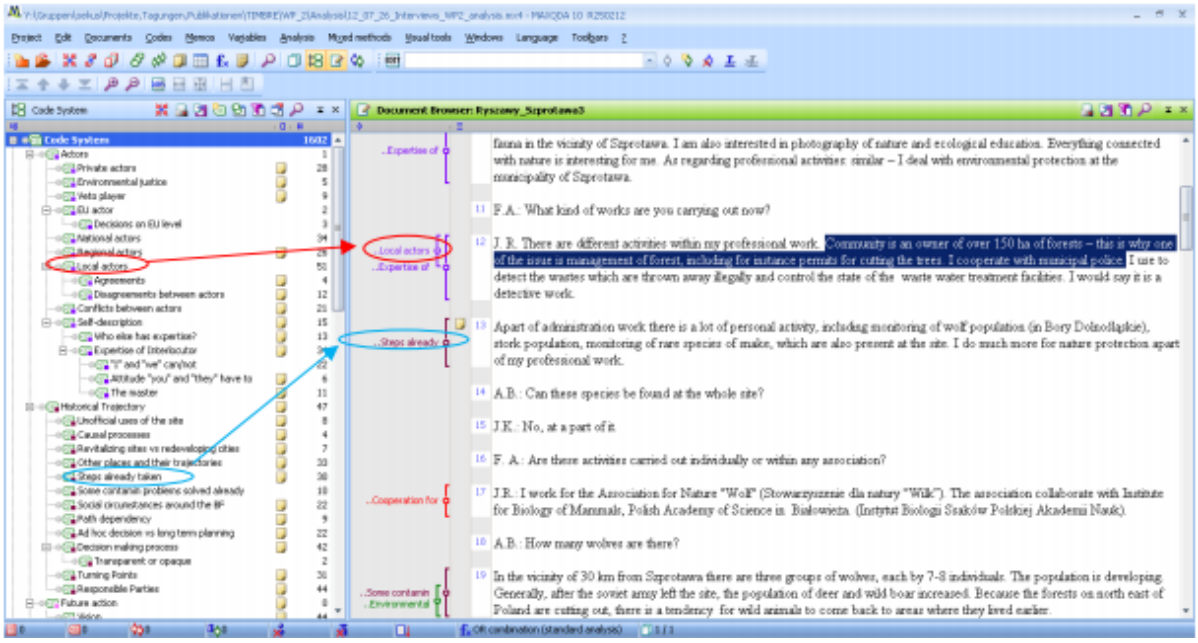
The tool and relevant information can be accessed via http://www.timbre-project.eu/en/information-system.html.

3.2 WP 2: Decision structures and local culture: Investigation of administrative possibilities and site specific attitudes of stakeholders

The research of WP2 has been carried out based on qualitative methods of social science research. This included the identification of main actors based on the expert advice of Timbre partners from the Czech Republic, Poland and Romania. Further actors were identified through snowball sampling, by asking interviewees about further stakeholders that could be available for interviews. With the actors identified in this way, the WP2 researchers carried out expert interviews and focus group discussions.

Fig. 4: Data gathering and interaction with practitioners in focus group discussions

Fig. 5: Developing a coding system for analysing qualitative data, and integrating the results into the deliverable D2.1 and D2.2.



The discussion of the results is structured according to the two main WP2 outputs: deliverables 2.1 and 2.2. Deliverable 2.1 deals with actors and decisions at a site-specific level (Alexandrescu et al. 2012), while Deliverable 2.2 outlines a framework to characterize drivers and barriers in decision-making at the national and state level (Alexandrescu et al. 2012).

Classification of actors and analysis of decision making structures at site level.

The classification of actors and analysis of decision making structures were carried out in relation to the specific Timbre test sites. The specificities of each site play thus an important role. Based on expert interviews we identified opportunities used or missed by actors in the past as well as the barriers, which they have circumvented (or failed to overcome) in pursuing their goals. Every form of human organisation can be said to exist through a variety of narratives (Maines & Bridger 1992) – that is, activities, which depict other activities or the actors who perform them. These narratives are inherently plural so that the history and future development of a brownfield are always interpreted in different ways by different actors. This variety of interpretations is important as it reveals the real social context in which brownfield revitalisation does or could take place.

Based on the reconstruction of the development of the three test sites, turning points of the development were identified. Such turning points shed light on the structural changes that affect a site, on decision making structures, and on controversies regarding future developments. Turning points are important because they often indicate if a site is set on a path of regeneration or whether, on the contrary, it is likely to remain undeveloped for some time.

Three (analytical) categories of actors have been identified:

Primary actors have an important role to play in the regeneration of brownfields, due to their full-time involvement in regeneration activities, their current expertise and future vision on the regeneration of the sites as well as their networks and resources. At the local level, primary actors can be seen as central hubs, which set goals and mobilise their own means as well as the expertise and resources of other actors (so-called secondary actors) in carrying out regeneration activities. They are the ideal addressees of tools and approaches for brownfield revitalization.

Secondary actors also play an important role in regeneration, provided that they have expertise and set their goals in the area of brownfield regeneration. Secondary actors, who only pursue economic goals, are unlikely – without the aid of actors committed to the regeneration of brownfields – to achieve the revitalisation of complex contaminated sites.

Veto players are important to the extent to which they can foster or, more often, hinder the efforts of primary and/ or secondary actors.

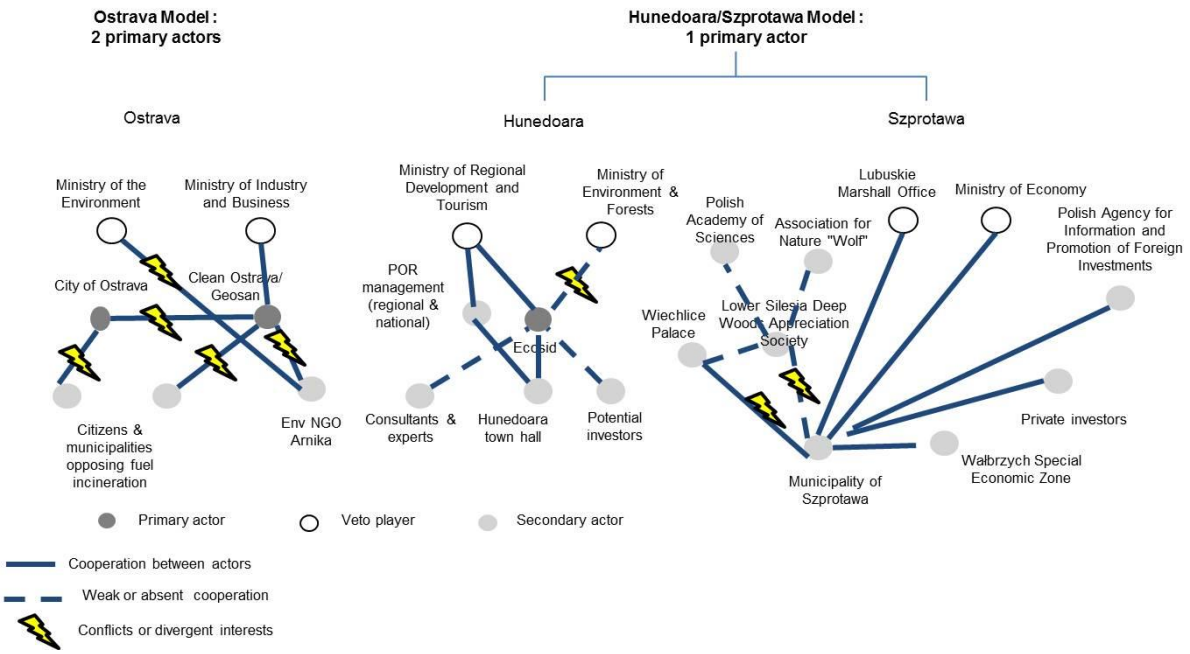
Especially in undeveloped brownfield markets – as the one in Romania at present – national and also local veto players can exert pressures on primary actors. In some cases, these seem to prevent primary actors from acting towards the regeneration of brownfields, either by blocking the availability of financial resources or making brownfield resources valueless. In any case, veto players have an important role to play.

The Timbre case studies display two configurations linking primary and secondary actors as well as veto players. From the point of view of these configurations, the three sites can be succinctly characterised as follows, based on data collected in 2011 and 2012:

The Ostrava model: two primary actors. As primary actor, a national company consigned with clean up the site is well advanced in the regeneration process of the site, although its relationships with the secondary actors (e.g. local NGOs) are often ridden with conflicts. The municipality of Ostrava is an emerging primary actor aiming to regenerate part of the area surrounding the lagoons. As a first step, it needs to secure ownership over this area and is currently involved in this process. On the other hand, it has a troubled relationship with the national clean up company, because the local authority sometimes becomes the target of criticism for problems in the lagoons (which they do not own).

The Hunedoara/Szprotawa model: one publicly controlled primary actor. A company in charge with the clean-up process of the Hunedoara site is owned 99.99% by the Hunedoara local council and works closely with the Hunedoara city hall. It also works closely with the management authority of the Regional Operational Programme (POR) (a secondary actor) for a funding application to revitalise a 20 ha part of the whole site. The relationship of this local company with the Ministry of Environment and Forests (veto player) is weak and perceived negatively by local actors. In Szprotawa, the municipality is involved on a fulltime basis in the regeneration of the site. It is actively engaged in attracting investors and it has established a network with secondary actors (including the Wałbrzych special economic zone) and veto players to promote the area among potential buyers.

Fig. 6: Two models of interaction between actors at the Timbre test sites (deliverable D2.1)



Several aspects turned out to be influential as driving forces or barriers in revitalization processes at site level. The existence of visions for further development of a site and the agreement of relevant actors on such strategies often stimulates activities concerning a site. Contesting visions need to be dealt with and are part of decision making in democratic societies.

In the case of a megasite with high stakes such as the one of the oil lagoons in Ostrava, ensuring a transparent decision-making process is vital to ensure the timely completion of regeneration. Contested technological approaches as were seen for example in Ostrava need to be dealt with but may in the end improve the result of cleaning up processes. The continuous engagement of stakeholders and two-way communication with them are important lessons for Timbre in ensuring the acceptability of its tools and approaches.

The symbolic value of a future site use could function as driver in revitalizing that site. Such a value comes into play for example in Ostrava, where the future land use of the site should be that of a forest park. However, to ensure that the future site use works as a motivating force in the present, the current discontents with the clean-up methods should also be addressed. Symbols can, however, also function in a negative way. For example, the fateful closure of the Siderurgica plant in Hunedoara, which led to high unemployment in the city, influenced the debate on future land use options at the site.

Uncertain political circumstances (e.g. legal responsibilities in decision making), which are seen especially in Hunedoara, are a clear hindrance for revitalization.

The availability of expert knowledge on revitalization in all three case study countries is limited as only few domestic specialized engineering companies do exist. Domestic companies usually bring together specific technical knowledge and knowledge on domestic culture and decision making processes. The latter might facilitate decision making processes.

Fig. 7: Different actors claim uses for contaminated sites. Here the example of steel thieves at the test site in Hunedoara. Negotiation between different claims of usage is needed

Country and State Level Specific Characteristics

Country and state level characteristics – regulatory, economic and institutional factors – are analysed as regards their roles as drivers or barriers in decision making. The most important precondition for any action in brownfield revitalization is the perception of brownfields as problem-areas (i.e. as sets of interrelated environmental, economic and social problems) and the translation of these problem-areas in national policy and regional decision making structures and clearly defined responsibilities.

By employing the conceptual approach of project ecologies, we address the following question: in which areas of human activity do the drivers and barriers to regeneration tend to cluster? The answer is that the focus should be place on four areas: the institutional context, the achievement of swift trust, the organization of project networks and the management of knowledge. The central findings for each of these are the following:

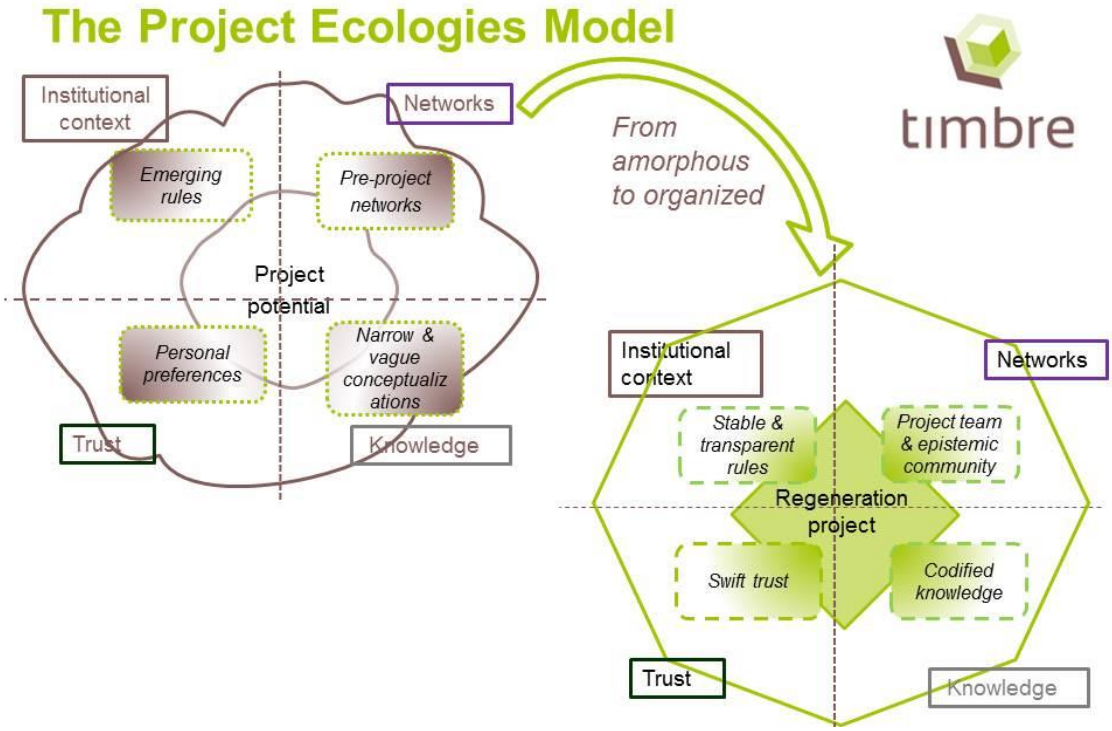
The *institutional context* indicates that the coherence of actions within a revitalization process and the stability of rules within a project are desirable characteristics. The identified barriers often are not barriers in themselves but occur when drivers are absent. For example, a barrier occurs as soon as different actors jointly involved in regeneration at different levels (for example local and national) cannot have coherent or stable expectations with regard to each other's roles in revitalization. Researchers should also be prepared for unexpected outcomes, for example when pursuing a particular set of drivers at one point in time that may create new barriers in the future.

Swift trust is category-driven trust (Grabher 2001), meaning that actors trust each other based on their roles (as engineers or managers, for example), rather than based on personal relationships. Swift trust enables complex networks of actors to cooperate even in the absence of long-standing interpersonal trust, and thus enables and facilitates interaction in BF revitalization. The creation of swift trust is essential for gathering the skills and expertise needed for an effective network for regeneration.

The *organization of project networks* means that actors get organized according to specific functions, which include a core team, an enterprise and an epistemic community. A stable core team led by a primary actor is central for the organization of project networks. Clear goals, available resources and agreement on time limits facilitate the development of a project.

Finally, it is important that the *knowledge* acquired by actors in regeneration projects is not lost for subsequent projects. Knowledge can be relatively inchoate and thus take the form of vague stories about what brownfield regeneration should achieve. When actors reach the higher stage of brownfield culture, they have agreed on the basic terms of a regeneration process (for example, they shared visions of future land uses). Finally, the highest stage of knowledge acquisition is that of tools, which means that actors can codify acquired knowledge and pass it on to others for use. Useful examples of tools are the databases of brownfields at regional or national level, which offer a good basis for informed decisions among actors. The experience of Timbre at the Szprotawa site in Poland has shown that creating brownfield cultures among local actors can be fostered by the skilful application of tools (e.g. for land planning).

Fig. 8: The project ecologies model indicates the key areas where national and state factors (drivers and barriers) are likely to cluster (deliverable D2.2)


The Project Ecologies Model
Institutional context
Networks
Emerging rules
Pre-project networks
Project potential
Personal preferences
Narrow & vague conceptualiz ations
Trust
Knowledge
From amorphous to organized
timbre
Institutional context
Networks
Stable & transparent rules
Project team & epistemic community
Regeneration project
Swift trust
Codified knowledge
Trust
Knowledge

3.3 WP 3: Success metrics and prioritization tool

Building on the more locally and site specific focus of WP 2, WP 3 was to deliver a multi-criteria comparative analyses via quantitative means (statistical correlation analyses, questionnaire surveys) as well as further expert interviews. The findings of WP 3 were to allow both specific and general conclusions. Being specific when coming from the main Timbre case study areas in Central and Eastern Europe, being general when using many several sites coming from property registers (such as from GESA).

The main scientific and technical WP 3 results are described in the three deliverable reports.

Survey on brownfields regeneration

The first WP 3 Deliverable (D3.1 – Frantál et al. 2012) has been designated the ´Report on results of survey on brownfields regeneration and statistical analysis of responses from three Central European countries (Czech Republic, Germany, Poland), one Eastern European country (Romania), and the sites from the registers provided by TIMBRE partners'. The report D3.1 consists of the following parts:

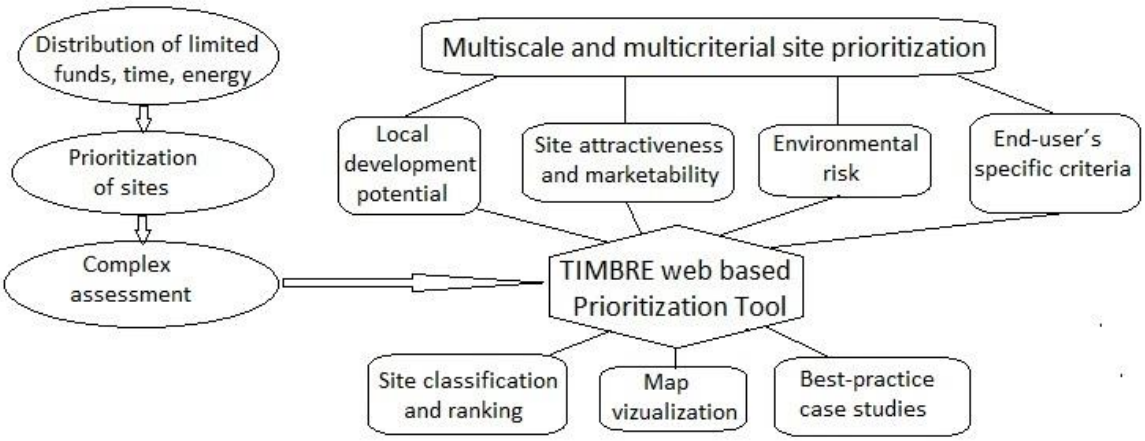
- Introduction - the introductory part summarizes WP 3 objectives as defined in the Timbre project's Description of Work and depicts the structure of the report.
- Theoretical-conceptual background - in this part, there is discussed the current "state of the art" concerning the problems of brownfield regeneration based on the literature retrieval, with a special emphasis on topics related to the WP 3 objectives and tasks. Subsequently the WP 3´s key concepts and terms are defined.
- Brownfields in selected European countries: current reality - there is a comparative analysis of general legislative and political frameworks of the brownfield regeneration in the selected five countries (Czech Republic, Germany, Italy, Poland, Romania) and a basic spatial analysis of existing brownfields in these countries (based on the availability of data and options to publish them).
- "Best-practices" survey – there is a draft of the international dataset of successful brownfield regeneration case studies (so called ´Best Practices Data Room´), including examples from various European countries. Cases of differ for spatial, land-use and functional contexts (i.e. urban and rural, industrial, agricultural, military, residential, recreational, etc.). The result of the best practices survey is not just a descriptive inventory of specific case studies but also an analytical report exploring patterns and factors of the successful regeneration.

- Questionnaire survey - this part presents selected results of the international questionnaire survey of stakeholders´ perceptions and attitudes. The survey which was carried out primarily in the four selected countries (Czech Republic, Germany, Poland, Romania) have included questions about the assessment of success factors and barriers of brownfield regeneration in different geographical contexts and from the point of view of different stakeholders, their preference of the future use of brownfields in different geographical contexts, and the assessment of positive impacts of brownfield regeneration.
- Conclusions – in the final part, the report summarizes the main findings of conducted surveys, identifies the common points and main divergences concerning the legislative frameworks, political-institutional practices, stakeholders´ perceptions, etc. Furthermore, there are described the relations of the achieved results for other WP 3 tasks and deliverables and how the findings of these surveys are important for Timbre main outputs (the Prioritization Tool, best-practices data room, demonstration studies, manuals, etc.)

Prioritisation Tool

The Prioritization Tool helps stakeholders being responsible for wider territories (regions, districts, cities) or clusters of brownfields (portfolios) to distribute available resources to those brownfield sites that are assessed to be the most critical, urgent or profitable to regenerate; the tool provides an assessment of classification of sites according to sites redevelopment potential, marketability, environmental risk or other perspectives specified by end-users. The Prioritisation Tool, which calculates the score for 3 pre-set dimensions (Local development potential, Site attractiveness and marketability and Environmental risks) and a global score for all three dimensions, supports effective decision-making processes related to brownfield regeneration. The tool was tested with different types of brownfields databases (urban, regional, national and private databases) from four Timbre countries (Czech Republic, Germany, Poland and Romania).

Fig. 9: The general concept of the Timbre Prioritization Tool



The report to the second Deliverable D3.2 (Klusáček et al. 2013) comprises the documentation of the "Prioritisation tool, software and manual" consisting of:

- The description of the conceptual and technical framework of the web-based Prioritisation Tool, (available at the following internet address http://www.dais.unive.it/~timbre/PrioritizationTool/)
- Report describing the process of prioritisation tool development and tailoring
- Annex I contains a glossary with definitions of selected key terms related to the prioritisation concept
- Annex II contains the Manual for End-users

All information is available via http://www.timbre-project.eu/Prioritization-Tool.html.

The tool for brownfields prioritisation had been developed and widely discussed with end-users and experts on the issue of brownfields since the beginning of WP 3 research activities. Every advancing step that was made was presented to groups of stakeholders during some of the Timbre events. Feedbacks were carefully taken into account while the continuous development of the tool enabled the better applicability of the Timbre project results to praxis (cf. Klusáček et al. in preparation). Based on experiences from existing brownfield tools and applications developed in previous projects and their acceptance and applicability by end-users, the Timbre team perceived communication with stakeholders as a crucial point for the success of designing an end-user tailored tool. This is the reason why cooperation with the initiative titled Partnership for Czech Brownfield (organized by the Technical University of Ostrava, Ass. Prof. Barbara Vojvodikova) has been developed from the early stages of the Timbre project. To enable wider audience and participation of different groups of stakeholders, the majority of the Timbre stakeholder events in the Czech Republic were organized in cooperation with this initiative, which brings

together experts from both the private and public spheres involved in various stages of brownfields regeneration projects.

Fig. 10 and 11: Pictures from the Timbre stakeholder events in Zielona Góra, March 29, 2012 (Poland) (left) and in Ostrava, March 1, 2012 (Czech Republic) (right)

As an initial step, the factors of successful brownfield regeneration were firstly identified during the Timbre stakeholders workshops in Hunedoara, Romania, in Ostrava, Czech Republic and in Bucharest, Romania in 2011 and 2012 by means of qualitative research methods (questionnaire survey, interviews, focus group). Wide discussions have risen regarding the weighting of each factor, which were used as pre-set weights in prioritisation tool. For identification of these weights, the opinions of more than 370 experts from seven European countries were gathered by means of a questionnaire survey (Klusáček et al. in preparation). The majority of respondents came from four EU countries that are the target areas of the TIMBRE project (347 experts form the Czech Republic, Poland, Germany, and Romania). Questionnaires were gathered both during events with stakeholders organized by the Timbre project (see Bartke & Brückmann 2014b, Bartke et al. 2012a) and via personal contacts that were kindly provided by members of the TIMBRE research consortium.

To make an effective and relevant prioritization requires providing the prioritization tool with detailed and reliable data and complex information about brownfield sites. A precise mapping, identification, analysis, and inventorying of brownfields is the first step towards a successful prioritization. Brownfield inventories (databases, registers) may have the form of a table database (with basic descriptive data), info-sheets with more detailed information about sites and on-going regeneration stages, and/or GIS layers (maps with coded sites and additional information) – (cf. Timbre, 2014).

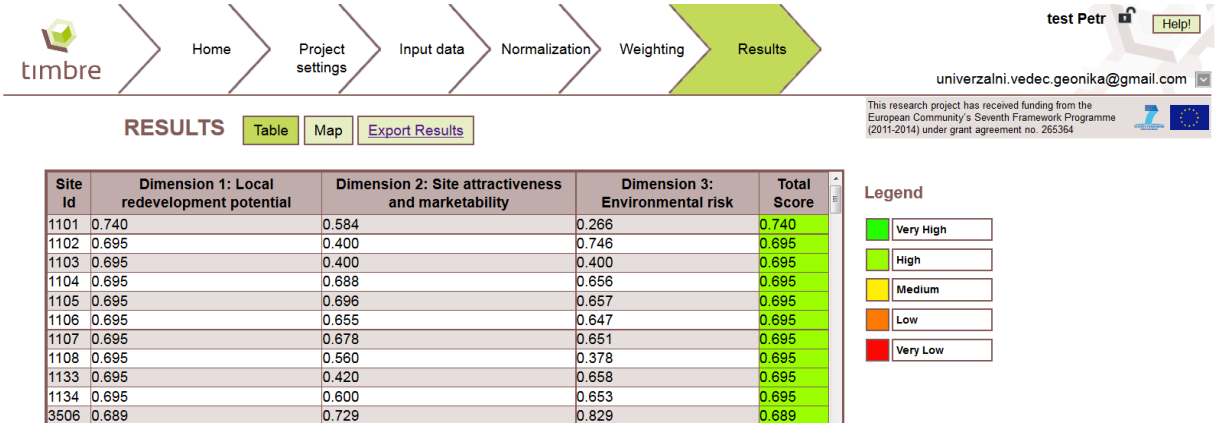
The tool was tested with different types of brownfields databases (urban, regional, national and private databases) from four Timbre countries (Czech Republic, Germany, Poland and Romania). Tests included include a database created by the Regional Development Agency of South Moravia for South Moravian Region in the Czech Republic, one by Timbre partner GESA for Saxony in Germany and one by LEG – Thüringen for Thuringia, Germany and others more – for the latter two cf. Bartke et al. (2014b). In the development, the tool was modified both according to feedbacks from project partners and according to feedbacks received from end-users during workshop in Ostrava in 2012 and March 2013, in Ústí nad Labem in March 2013, in Berlin in November 2013 and in Bucharest in March 2014.

Figures 13 and 14 illustrate the results of applying the Prioritization Tool, i.e. either a table displaying the ranked order of the sites in a region or portfolio – here for the case of South Moravian Region) – and as Google Maps® linked cartographic output.

The tool and relevant information can be accessed via http://www.timbre-project.eu/en/information-system.html.

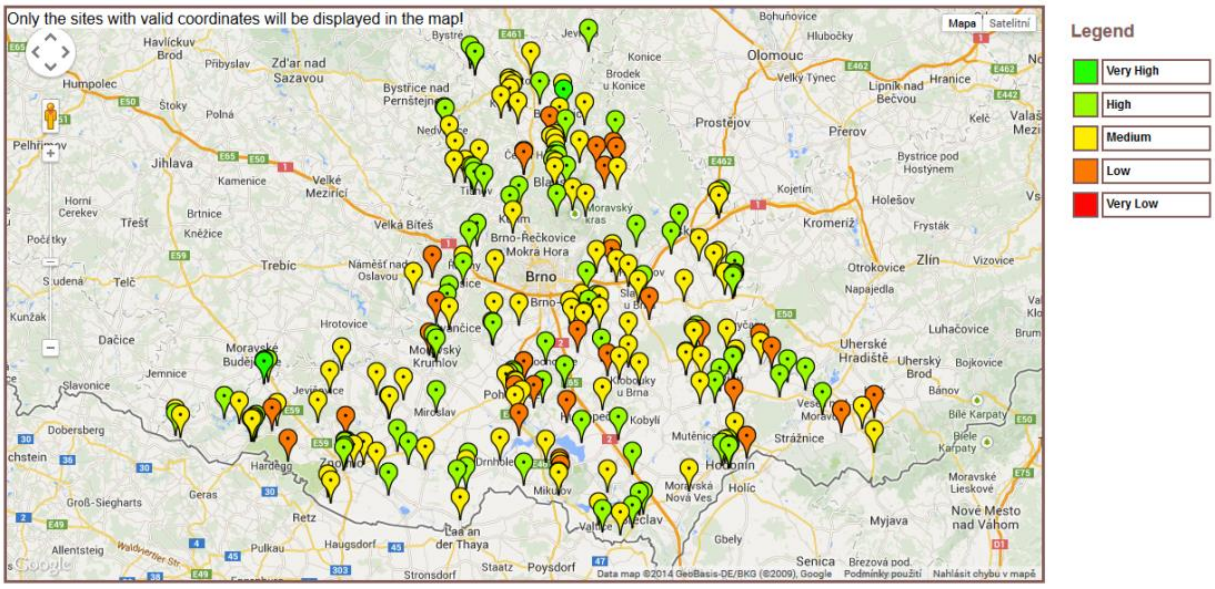
Fig. 12: Pictures from the TIMBRE stakeholder event in Ústí nad Labem, March 26, 2013

Fig. 13: Timbre Prioritization Tool: Exemplary tabular output on information about location of brownfields sites with different redevelopment potential (case study area of South Moravian Region). On top, the Prioritization Tool's navigation bar and respective assessment steps are visible.



Site Id	Dimension 1: Local redevelopment potential	Dimension 2: Site attractiveness and marketability	Dimension 3: Environmental risk	Total Score
1101	0.740	0.584	0.266	0.740
1102	0.695	0.400	0.746	0.695
1103	0.695	0.400	0.400	0.695
1104	0.695	0.688	0.656	0.695
1105	0.695	0.696	0.657	0.695
1106	0.695	0.655	0.647	0.695
1107	0.695	0.678	0.651	0.695
1108	0.695	0.560	0.378	0.695
1133	0.695	0.420	0.658	0.695
1134	0.695	0.600	0.653	0.695
3506	0.689	0.729	0.829	0.689

Fig. 14: Timbre Prioritization Tool: Exemplary cartographic output on information about location of brownfields sites with different redevelopment potential (case study area of South Moravian Region)



Demonstration studies and outreach material

The third Deliverable 3.3 (Klusáček et al. 2014) with full tittle "Prioritisation Tool: Results of demonstration studies and outreach material" is divided in the following chapters:

- Methods of testing and tailoring the web-based prioritization tool – this chapter briefly describes the methods used for testing and tailoring the pilot version of the web-based prioritization tool
- Results of demonstration studies – this chapter describes the testing of the prioritization tool based on selected brownfield databases from the four TIMBRE-studied countries (the Czech Republic, Germany, Poland, and

Romania), and on different types of brownfield databases (urban, regional, national, and private databases),

- Tailoring of the prioritization tool – this chapter contains the most important feedback from stakeholders, which were collected either through direct contacts with the stakeholders (at workshops and meetings with stakeholders organised in Ostrava, Brno, and Berlin) or by means of indirect contacts, such as personal and electronic communication; the chapter has the structure of Questions and Answers and it will be part of Frequency Asked Questions (FAQ) page related to the on-line prioritization tool
- Prioritization Tool – SWOT analyse – this chapter offers conclusions and contains descriptions of Strengths, Weaknesses, Opportunities and Threats identified during previous research activities.

The last deliverable report is accompanied with attachments, which are part of the so called outreach and dissemination materials. There are the following attachments:

- Extended documentations – feedback on the prioritization tool, obtained in written form, describing perceptions of the on-line prioritization tool from the perspectives of stakeholders in the different Timbre research countries
- Cartographic outputs – these illustrative cartographic outputs show that the web-based prioritization tool is able to work at different hierarchical geographical levels (national, regional, municipal) and describes the advantages of using the Google Maps® system
- Dissemination materials:
    - Brochure – this is a kind of a publicity material, containing a description of the web-based prioritization tool (cf. Timbre 2014),
    - Product flyer – it is another kind of a publicity material, bringing only basic information, which should capture the attention of the potential end-users,
    - Two publicity presentations – the first short version contains only the most important information, focusing on the objective, target user group, basic functionality/approach, exemplary application, and links to further information; the second, larger version contains more detailed information (this large version was distributed to participants of dissemination workshops) - the information is available via http://www.timbre-project.eu/Prioritization-Tool.html.

The selected results of all three WP3 deliverables were used for creation of further materials for stakeholders. Next to those mentioned in D3.3, the most note-worthy is the Web-based European Data-room of Regenerated Brownfields, which is available at http://www.timbre-project.eu/Cases.html

3.4 WP 4: Strategies and technologies for integrated site characterisation and remediation

Objectives

In WP4, emerging strategies and technologies for effective site characterisation and remediation were adapted, further developed and tested, addressing: (i) feasibility testing of phytoremediation and specific soil washing with recycled solutions (SSWRS), (ii) novel strategies for effective site characterisation and monitoring of subsurface contamination and remediation, (iii) evaluation of remedial options using site models, based on adaptive site characterisation.

Feasibility testing of phytoremediation was to comprise laboratory studies on plant uptake and phytotoxicity of common soil and groundwater pollutants as well as mathematical modelling to quantify and simulate phytoremediation. Feasibility testing of SSWRS was to include field (in situ and on-site) and laboratory experiments on process robustness, performance and suitable target compounds. Pollutant transfer by SSWRS was to be assessed by mathematical modelling. Tree core sampling and direct push/shallow soil probing were to be applied adaptively at selected sites and assisted by numerical modelling in order to test feasibility, limitations and effectiveness of these technologies for site characterisation.

Studies on potentials, costs and associated risks of in situ remediation techniques were to point out which measures may, or may not, be successful and appropriate at a site. The evaluated set of methodologies was to provide tools for integrated planning and assessment of regeneration options.

Summary of results

Site investigation: Four alternative screening methods to traditional site characterization were applied at two Timbre test sites, Hunedoara in Rumania and Szprotawa in Poland. The research aimed at combining different techniques for screening purposes effectively for characterization of soil and groundwater contamination. Data have previously been presented in D4.1 (Martac et al. 2013) and D4.2 (Algreen et al. 2013b). Results obtained at the Szprotawa test site are in the process of publication (Kalisz et al. 2014). Because toxicity and risks are connected to contaminant mobility, leaching tests and soil buffer capacity were also carried out for the Hunedoara test site.

The different investigation/screening methods are: tree coring (phytoscreening), soil gas measurements and the two direct push technologies MIP (Membrane Interface Probe) and LIF (Laser Induced Fluorescence). Additionally, direct chemical analysis of the concentration of pollutants in groundwater and soil was performed.

For delineating the hydraulic features of the site, HPT (Hydraulic Profiling Tool) investigations were carried out as well.

Szprotawa, the Timbre site in Poland, is an area formerly used as Soviet military airbase located. The field is mainly polluted by aircraft fuel (benzines and BTEX compounds). The environmental conditions enabled to use this area as a testing plot for the various methods, which were then compared in terms of their efficiency. The objective was to identify the potential for their combination in an effective and cohesive strategy for site characterization – reducing the uncertainties and costs of establishing site knowledge needed for regeneration. The results show that various site characterization methods can be combined in a step-wise approach and in a flexible manner giving comprehensive information tailored to the needs at the expected level of accuracy and at reasonable costs. It was well demonstrated that the developed multi-method approach to site characterization is especially suitable for megasites.

Remediation strategies: The aim of the Timbre project was to develop and provide customized problem- and target-oriented packages of approaches, tools and technologies to overcome existing barriers to mega-sites regeneration. Soil washing and phytoremediation were investigated as possible remedial approaches to be applied at the Timbre sites.

The feasibility of **phytoremediation** in Hunedoara was evaluated (Trapp et al. 2014, cf. also Algreen et al 2013a, b, Martac et al. 2014). The former steel works site Hunedoara has occasionally extremely high concentrations of toxic elements and heavy metals in top soil. At these places, phytotoxicity is likely to occur and would inhibit or distort phytoremediation efforts. Moreover, the pH at site is rather high (7.65 to 8.97), which leads to very strong sorption (Kd) of several heavy metals (in particular, nickel and lead). These high Kd values limit plant uptake of heavy metals, and calculated clean-up times are unrealistic (thousands of years). In conclusion, phytoremediation is no option for Hunedoara.

Thanks to the large amount of materials like illite and Fe(III) oxides with high sorption capacity and inertness, heavy metals were not detected in groundwater at Hunedoara despite elevated concentrations in top soils.

The feasibility of **SSWRS (soil flushing)** was assessed in Hunedoara and in Solec Kujawski (Efligenir et al. 2013, Fatin-Rouge et al. 2013, Mohamed et al. 2013, in preparation). It was shown that SSWRS was able to manage the two situations despite their huge differences in contaminants, concentrations and soil geology. Shortly, it was shown that benefits balance operating treatment costs, mainly through the reduction of waste volumes, and new margins can still be expected in optimised conditions of use. Nevertheless capital costs for water treatment are high as compared to costs for chemicals which limits this strategy, despite the one-step

adaptable, robust and stable treatment offered by cross-ultrafiltration. Nevertheless, the technological tools developed and assessed within the project (mainly foams to improve soil-remediation and ultrafiltration for wastewater treatment and reuse) have shown to be very attractive to manage difficult situations met in soil remediation.

At the Polish site Szprotawa, the former military airbase, jet fuel and BTEX in >2m depth in soil and groundwater are the major pollution. Concentrations at Szprotawa are often higher than toxic thresholds to trees (up to 11,000 mg/kg), but the peak is deep below surface (2 m depth). Tree growth is possible but may be inhibited at longer periods of drought (when trees root deeper to get water supply). Stunned growth and early death of trees is observed at the former fuel station. Vividly growing pioneer vegetation has been observed at site, confirming this finding. Hydrocarbons are rapidly degraded under aerobic conditions, and the immediate reaction model with diffusion of oxygen as limiting factor was applied. The calculations show that jet fuel and BTEX in top soil will degrade quickly. Complete degradation under optimal conditions would occur in a bit more than a decade. Experience from real sites teaches however that hydrocarbons residing below the groundwater level will persist for longer periods. Taking all together, phytoremediation is a good option to support the naturally occurring degradation of contamination at the site. The hot spots with very high concentration of gasoline should be treated separately with a more rapid, more efficient treatment method. Options are air sparging, in-situ chemical oxidation and excavating and composting at site. An efficient, cost-effective solution will require to combine the various techniques (treatment train), as described in D 4.5 (Martac et al. 2014), Kalisz et al. (in preparation) and Westergaard Clausen et al. (in preparation). As remediation schemes were proposed for the Szprotawa site: (i) In-situ biological treatment with oxygen-enriched water and coupled vapour extraction case; (ii) ISCO & Biological remediation; (iii) Combination of soil-flushing and air-sparging.

The concepts are based on the knowledge status gained within the Timbre framework but not tested yet. Site specific pilot test are, therefore, strongly recommended in order to assess the efficiency of the proposed concepts and reveal the success time horizons. As short exemplary evaluation of remediation options for Szprotawa site, it can be said that Szprotawa site is a case with relatively low risks of further migration of contaminants in the groundwater and low risk for human. Selection of the remedial approach depends on the redevelopment scenario planned for the site. The following approaches can be taken into account: (i) Quick remediation based on ex –situ methods; (ii) Short term remediation; (iii) Long term remediation; (iv) Suspended usage.

A short evaluation of the approaches is presented in Table 2 (from Martac et al. 2014). The analyzed approaches differ with regard to time, costs and sustainability (low environmental burden). The most balanced is the soil vapour extraction or bioventing being positively evaluated in all aspects.

Tab. 2: Short exemplary evaluation of remediation options for Szprotawa site

Approach	Considered technologies	Criteria of evaluation		
		time	costs	sustainability
Quick remediation (based on *ex-situ* techniques)	Polluted soil replacement, eventual *on-site* soil remediation. Supporting techniques could be needed (ISCO)	+ + +	- - -	- - -
SHORT-term remediation	ISCO based techniques	- + +	- - +	- - +
LONG-term remediation	Bioremediation combined with ISCO techniques, enhanced bioremediation.	- - +	- - +	- + +
	Soil vapour extraction, and/or bioventing	- + +	- + +	+ + +
	Phytoremediation supported by humification, lime treatment (land farming)	- - -	+ + +	+ + +
Suspended usage	MNA, phytoremediation/ forestation, continuous risk control	- - -	+ + +	+ + +

Based on the spatial characterization of the contamination, specific remedial approaches might be appropriately assigned to particular areas: the former fuel base with BTEX contamination at the level of 150 - 240 mg/kg of d.m. and benzines 1,100 – 4,700 mg/kg d. m. respectively, and the engine heating area with BTEX being at the level of 50 - 80 mg/kg of d.m. and benzines 9,000 – 11,000 mg/kg d. m. for which all approaches can be considered, depending on the plans of future land use, the remaining areas with contamination of BTEX at the level of 2.3 mg/kg d.m. and benzines around 23 mg/kg d. m. for which natural attenuation and risk control are sufficient remedial measures taking into account current land use – forest and green area.

Air sparging. A remediation scenario was developed using bioventing and coupled vapour extraction at the Szprotawa site. The results have been published in the deliverable D4.5. A paper about the outcome is in initial progress.

During the TIMBRE project, the 3D-distribution of kerosene and BTEX pollution in the former fuelling area has been modelled from the direct-push data, showing that the main mass of contamination is situated at relative shallow depths both in the saturated and unsaturated zone. Soil gas investigations have shown that biological degradation of the kerosene is active with the development of carbon dioxide and methane in the central fuelling area. Biological degradation is, however, hampered by relatively static groundwater conditions and consequently a lack of oxygen as a

driving force. Vapour extraction tests in the central fuelling area have shown that significant concentrations of hydrocarbons can be removed in the gaseous phase by vapour extraction.

Taking into account the hydrogeological setting and the nature and distribution of contamination, an in-situ remediation by bioventing and simultaneous vapour extraction has been developed. The scenario envisages a series of gravel-filled trenches that are equipped with horizontal gas screens in the unsaturated zone. The latter are used for extracting the gaseous phase of the pollution. After extraction, the gas is treated by activated carbon and then released into the atmosphere. In the saturated zone, groundwater circulation is induced by pumping and infiltration of water from and to the gravel-filled trenches. The water is then enriched with oxygen and other nutrients (N, P) and pumped back to the system, thereby supporting the natural processes of degradation.

The results from soil gas investigations and vapour extraction tests have shown that the applicability of the process could best be tested on a pilot scale in the eastern part of the fuelling area. In this area, the hydrogeological prerequisites are favorable for coupled bioventing and vapour extraction. The pilot plant should as far as possible be constructed using local resources. The gravel for backfilling the trenches could be obtained from recycling unpolluted building rubble that is present on the site (see WP5).

Soil-flushing. The removal of the source zone in Szprotawa is limited by the low hydraulic gradient of groundwater and the high interfacial tension between water and the non aqueous phase liquid (NAPL) in the saturated zone. Despite most of contaminants are volatile and the soil porous, sparging is limited by low radius of dispersion around injection wells. In that situation, soil-flushing is interesting to dynamize the NAPL removal, because it uses surfactants at low concentrations to dissolve and break the NAPL. Moreover, the required hydraulic containment downstream with water treatment and upstream reinjection of treated water enhances the hydraulic gradient, hence helping for faster dissolution. Flushing treatment is advised to be combined with sparging as the air/water emulsification improves each technology by the enhanced viscosity, convection and dispersion of the remediation fluid. In addition, it has been shown to systematically increase the porosity of the contaminated zone by removing fine particles. This treatment should be done after limits of pump and treat have been reached, and low residual levels of contaminants compatible with a final bioremediation step should be reached after 3 months. The water treatment for reuse (mainly based on ultrafiltration and pervaporation) is explained in D 4.5. It favours the high reduction of waste volumes and their recycling in energy recovery.

3.5 WP 5: Deconstruction and re-use of structures and materials

In order to provide the basis for adequate decisions of investors and site owners concerning the destruction and re-use of existing buildings and structures on brownfields, WP 5 was to develop tools and instruments supporting decision makers in developing environmentally friendly strategies under respect of the existing different national laws.

Hagemann et al. (2012) provide an evaluation of selected European methods of decontamination, law and regulations for decontamination measures, occupational health and safety and re-use and / or disposal of deconstruction materials. Data have been collected by a detailed internet investigation on projects, national laws and practices and through expert interviews in France, Switzerland, Germany, Romania, Poland and Italy. The report summarises the key results of this investigation and points out the legal frameworks, approaches and special needs for methods, information and improvement concerning deconstruction of buildings and re-use of building rubble for these countries. Generally the acceptance of recycled building materials has to be increased by better information and advertisement. The distribution of recycled materials can be improved by easy accessible and broadly known databases and material exchanges on a regional level, where materials can be offered or ordered by interested companies or persons. For an easier handling and trade, EU-wide quality standards and alignment of approaches and requirements are useful.

Hagemann et al. (2013a) summarise the results of field investigations and laboratory analysis from two Timbre test sites and an example site from Germany that are informative for the further development of these sites, but also give general insights. Based on these results the opportunities of deconstruction or re-use were assessed and tailored strategies to handle building rubble in a sustainable way were developed. Generally applicable factors, which influence the decision process, progress and costs of a project, have been identified as "Hard Factors" and "Soft Factors". In case of renovation or deconstruction of buildings / structures the following, generally applicable strategies for an environmentally friendly and economic handling of building rubble have been developed and tested in practice: (i) Site investigations and laboratory tests of each material; (ii) Volume / mass estimations; (iii) Documentation of the results in a comprehensive register of materials and pollutants as appropriate. Based on this elaboration and according to European and national waste management and occupational health and safety standards, a detailed renovation / demolition concept has to be developed in cooperation with owner, planner, consultants and local authorities.

Hagemann et al. (2013b) discuss the most important emissions resulting from a deconstruction measure (dust, noise, vibrations, contaminants, sewage and exhaust from deconstruction equipment) and described their main sources. They give guidance to the qualitative prediction of emissions to be based on detailed pre-demolition investigations with result in a detailed list of building materials with volume

estimation and a catalogue of building contaminants according to possibilities of re use or disposal according to European and national legislation. A deconstruction concept, which considers the results of these investigations, is to allow a quantitative evaluation of emissions based on the material inventory and the applied deconstruction methods. The results are to be used for the assessment of the effect of emissions on the environment at different points of emission considering neighbouring buildings, land use and affected humans. The calculation and assessment of noise and vibrations was shown on an example from German practice according to European legislation. Based on the results of the prediction of emissions tailored measures for minimization and emission protection for the environment of a deconstruction site can be developed. The authors present a checklist for the development of emission minimization and protection measures.

Based on the results of the first field campaigns in Szprotawa and Hunedoara, which delivered basic information, a second field campaign for both test sites has been elaborated. For a more complete evaluation, a project of GeoExperts in Germany (together with the subcontractor Stricker), the evaluation and deconstruction of an office building in an urban environment has been added.

Szprotawa, Poland – The focus of the investigation on the Szprotawa site was on the assessment of existing abandoned buildings and infrastructures regarding their re-use or, in case of demolition, the properties of the resulting rubble. For this purpose, 30 representative samples of building materials were taken, 24 of these samples were given to chemical analyses to the IETU laboratories. The field campaign took place in September and November 2012. The site was further used as a model study for different scenarios of further development with re-use of buildings or partially or complete deconstruction and further use of the resulting rubble in the remediation process within the WP6 models for site redevelopment planning. For this purpose additional investigations on the structures and materials regarding chemical - physical properties and volume estimations have been done by IETU in July 2013. The focus of these investigations lay on different scenarios for site development including the estimation of deconstruction and waste management cost and the assessment of environmental impacts. All structures being still present at the site and not used up to date were classified according to the established typology. Buildings and constructions were listed and described. For each building type, the potential reuse, volume of deconstruction material and its usability were evaluated. Scenarios prepared during WP6 workshop were used as the basis for making decisions on further reuse or deconstruction and for appropriate costs estimations. Results of scenario analyses were put into excel table. The main results of the investigation in Szprotawa have been as follows: (i) A further use of the concrete buildings (Hangars, bunkers) seems to be possible. Problems to solve are their partially poor state of conservation and the lack of an intact infrastructure, e.g. supply lines and accessibility. (ii) In case of deconstruction most of the concrete is suitable for further processing according to the related Polish guidelines. In this case, about

66,800 m³ of concrete would be available, if the whole remaining structures would be removed. (iii) Most of the brick buildings cannot be re-used due to their state of conservation (partially destroyed, advanced state of weathering). A further use of the rubble for high quality recycled materials is not possible. A potential way of further use would be in terrain modelling. The results have been prepared and processed for the analysis of different scenarios of further development for processing in the WP6 tools – a transferable approach for other brownfields in Europe.

Hunedoara, Romania – In Hunedoara, where the buildings have been demolished completely to get iron, steel and other metals out of the rubble, the investigations were focussed on the different mixtures of building rubble. The aim was to separate and describe the different remaining materials and mixtures of rubble in order to find a way for a further use of those large amounts of material. The main problems on the site are how to deal with the rubble and what to do with remaining subsurface structures (foundations, cellars, drains, etc.). Due to a poor developed market for recycled mineral products in Romania, the solution would be removal and deposition of the rubble or, better, a further use on site e.g. for terrain modelling, soil improvement and filling of the subsurface structures in order to prepare the area for a further use. The related field investigations took place in October 2012. As a result, most of the investigated rubble (about 110,000 m³) can be used on-site under the premise of a hydraulic barrier (a layer of clay or silty clay between rubble and groundwater) and an impermeable cover on top. Tertiary clays in the underground of the site give the premise of the hydraulic barrier. From this point of view the opportunity could be a further use on site for terrain modelling, soil improvement and filling of underground structures related to future land-use plans. The current situation in Hunedoara can be summarized as follows: (i) The deconstruction took place under the focus of short term profit maximisation without consideration of the future development of the site. (ii) No separation of materials and pollutants according to European standards caused a mixture of materials which is difficult to handle in an environmental friendly way. (iii) There is an ongoing worsening of the situation due to the lack of supervision and occupational health and safety measures.

Dortmund, Germany – On the - already finished - project in Dortmund, Germany a complete investigation on building materials is demonstrated which lead to a detailed deconstruction and re-use concept. The situation can be described as follows: After an evaluation of several different concepts with partial deconstruction and new construction and re-use of the remaining building stock, the owner decided in cooperation with his planner and consultants for a complete deconstruction and new building. This decision was based on the following considerations: (i) For a re-use of the existing buildings, complete or partial, the following actions would have been required: a) Exchange of technical equipment (heating, air condition); b) Refurbishment of the security equipment (fire protection); c) Removal of obsolete and / or hazardous building materials in some parts (e.g. containing Asbestos, PCB, PAH); d) Refurbishment of the washed concrete front; e) Increase of energy

efficiency (isolation, windows, etc.); f) Adaption of the room layout to required workflow. (ii) The advantages of a partially or complete re-use can be summarised as follows: a) reduced costs in comparison with a complete new building (max. about 50% in case of complete re-use) even after refurbishment and decontamination; b) no complete evacuation and interruption of current workflow required; c) less consumption of raw materials and energy; d) reduced emissions; e) less influence on public traffic and neighbourhood; (iii) whereas the disadvantages are as follows: a) remaining functional and structural deficits due to the construction and position of buildings; b) efforts required for the removal of safety defects of the front not assessable; c) appearance not fitting to image and workflow of the company; d) despite of all measures remaining an "old building" with optional raised maintenance costs and risk of hidden defects. After evaluation of the listed points, various concepts with combination of re-use and partial demolition as well as a completely new construction were discussed. The focus point for the owner (user) was on a functional, contemporary design fitting to the workflow of the company, an appropriate promotionally effective and of architectural interesting appearance as well (understanding the site as an important "landmark" in the southern downtown) next to the reduction of the operating costs (energy consumption). After discussion of the advantages and disadvantages of each re-use option, the owner decided for a complete removal of the old building stock in favour of a new building. The planning of the deconstruction measure is influenced by the legal framework. Hagemann et al. (2013b) report on the investigations that have to be done as a basis for a deconstruction concept and as a result of the investigations, on the elaborated concept for a selective deconstruction.

Hesse et al. (2014) give a technical guideline on occupational health and safety during the deconstruction of buildings and structures. Apparently the risk of a lethal incident in deconstruction work is many times higher than in other construction branches. An unsustainable situation like this urgently requires appropriate improvement measures which are able to reduce the risk of fatal consequences for workers and non-involved third parties. Worldwide efforts to improve the occupational safety situation in general have led to the development of several tools, aids and standards. A very popular and widespread standard is the OHSAS series - a complex and comprehensive management system for occupational health and safety that is already used in many businesses. Those standards are pre-defined systems that represent a kind of basic framework for an intended safety and health organization in order to initiate a comprehensive consideration of occupational health and safety aspects during the entire deconstruction process. The implementation of a management system such as OHSAS 18001 in a given project needs a variety of adjustments to ensure the operational structure for the standard's purpose. Hesse et al. show how an adapted management system can be an integral option to improve the current safety and health situation in the context of deconstruction projects. However implementation and success of a management system depend on the provided resources and the participation of any person involved in the project.

3.6 WP 6: Web based tool for integrated planning and assessment of revitalisation options for brownfields

The major product of Timbre's Work Package 6 (WP6) is a customisable web based tool for integrated planning and assessment of revitalisation options for particular brownfields. Being accessible via internet (web browser), the tool enables diverse groups of end-users to participate in exploring the possibilities with regard to future use of the site, namely in developing and evaluating their own ideas of the future uses of the site. In order to provide European-wide use and benefit of the tool, the goal has been to provide a user friendly web based graphical user interface (GUI) comprising diverse models and methods ('modules') and providing the necessary GIS functionalities, e.g. for creation of land use allocation maps, definition of use-oriented and risk-based remediation targets, analyses of conflicts between environmental quality targets/thresholds and existing contamination level, remediation cost and market value estimation, sustainability assessment, etc.

Web based tool

The Timbre web based site assessment and re-use planning tool (SAT) is intended to serve the purpose of initiating and fostering communication among stakeholders with respect to several aspects or services: (i) Information: How is the situation at a given (contaminated) brownfield? (ii) Planning: Joint design of multiple alternative brownfield re-use options. (iii) Assessment: Appropriateness of the site in general for re-use and related measures or of the implementation of particular re-use options.

Fig. 15: Structure of the Timbre web based site assessment and re-use planning tool (SAT).

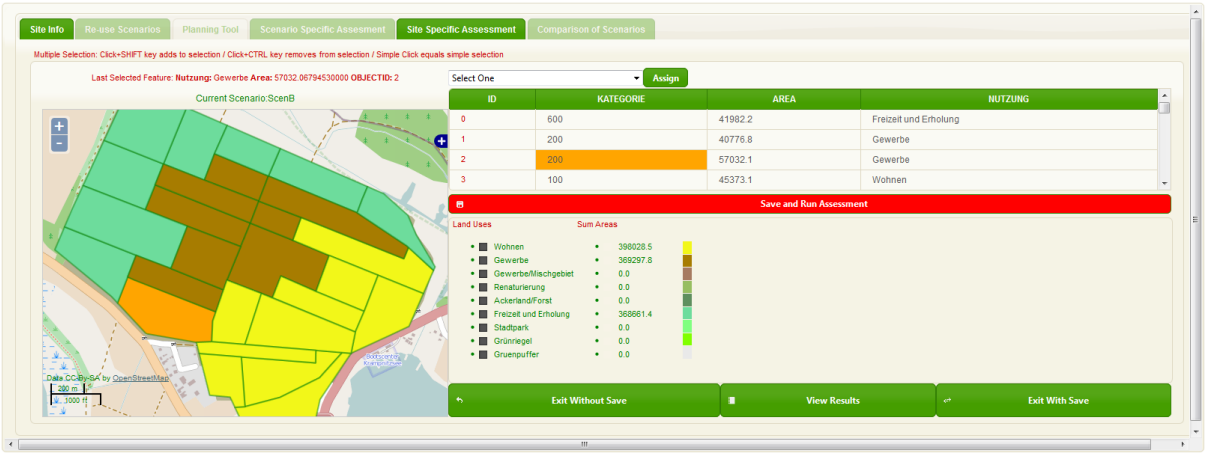
The structure of the web tool and implemented modules is illustrated in Figure 15. The structure reflects the intended services (see above). It is distinguished between (i) site-specific assessment modules that evaluate the situation/conditions at a site with respect to a particular aspect (e.g. bioenergy potential) in general (for the site but not specific to a certain re-use option), and (ii) option-specific assessment modules that evaluate the situation/conditions at a site with respect to a particular aspect and a particular re-use option (e.g. estimation of costs for remediation required to implement the re-use option)

The SAT is specifically designed for use by interested stakeholders including non-experts, e.g. laypeople as regards brownfield development. The web based tool is built upon existing assessment desktop software tools, which have been developed in previous projects (EU project WELCOME, BMBF funded projects SAFIRA II, REFINA, and Optirisk). While these tools rather have the character of expert tools, the purpose of the web based tool was to involve also interested stakeholder incl. laypeople in the planning and decision process. The web tool, therefore, is specifically designed for this purpose and represents a kind of “light” version of the existing expert desktop tools, making it accessible to a wider group of users via the internet. Another main advantage of the tool being web based is its availability to stakeholder round tables by serving the functionality to any PC/Laptop with an internet connection via a web browser, and without the need of having the tools or the respective site data available on one or a number of desktop computers. The “light” version provides limited capabilities to a wider group of users via the internet. Here, “limited capabilities” means that only a subset of input parameters is changeable by the (end) user, i.e. those kinds of parameters that can be reasonably specified also by non-experts. This principal concept applies to the tool as a whole as well as to the individual modules.

The main task for the regular SAT user is to shape his/her vision of the future re-use of the site by help of the ‘Planning Tool’. Through an interactive map (Figure 16), various land-use types can be assigned to any of the predefined planning units, in which the site has been divided as part of the project preparation.

Once defined, the re-use option can be automatically evaluated. In total, six existing methods and tools were implemented as modules of the current version of SAT to support the holistic evaluation of site redevelopment options with respect to: (i) risks to humans via intake of food stemming from agricultural areas on the site (developer: DTU), (ii) the site’s potential for energy crops plantation (developer: JG); (iii) the proportionality of risk mitigation measures (developer: JG); (iv) costs of implementing the planned re-use option, in terms of clean-up and site preparation (developer: TUB); (v) economic benefit: market-based evaluation of the site for the planned option (developer: UFZ (Bartke, 2011), and (vi) sustainability of the planned option within a pre-defined setting and time horizon (developer: TUB based on previous work of STADTREGION, a private planning office – cf. also Bartke and Schwarze in preparation).

Fig. 16: SAT's register tab 'Planning Tool' – for interactive creation of redevelopment scenarios



The latter three assessment aspects are integrated in a desktop tool called Megasite Management Toolsuite (MMT), which had been developed previously by TUB and UFZ (Schädler et al. 2011/2012, UFZ – TIMBRE 2013a/b). This desktop software served as 'methodological starting point' for the development of the web based SAT.

Application of the web based tool is only possible after preparation of required project data. This preparation is supposed to be done by experts grounded in contaminated site revitalization in order to guarantee a sensible use of the web based tool's capabilities. The preparation includes the application of the desktop software programs and results in a full project data set containing all relevant data: all types of maps describing the situation at the site (e.g. existing land use, distribution of contamination in soil and groundwater), values of input parameter of assessment modules, default answers to queries used in assessment, etc.

The SAT includes user and project management capabilities. So-called Power Users have access to a respective Administrator Panel. These Power-Users are supposed to be experts in charge of the site redevelopment project (e.g. an environmental consultant, a clean-up specialist, a planner). They decide about the 'regular' end users of the tool, e.g. key actors, important stakeholders, etc., which will be invited by the Power User.

The SAT was implemented by UTCB as a Java Enterprise 6 application based on the following main technologies. The main workflow is based on HTTP/AJAX request-response paradigm. Requests are usually generated through JSF and PrimeFaces frameworks and they are all AJAX based. After the security bridge is passed, requests are "received" by the JSF managed beans. When database interaction is required, managed beans utilised a CDI injection mechanism to "talk" with EJB components, which in turn handle, in a transactional environment (based on JPA),

the database queries. TIMBRE uses the object-relational database management system PostgreSQL and PostGIS to handle spatial data. SAT also exploits external applications (GDAL and Python).

It should be noted that the SAT, although any efforts have been made to develop it to a state that allows direct use in practical work, has not yet reached a mature state but should be seen a prototype, which needs to be further tested, revised and developed in further projects on national or European level.

Add-on Capabilities

In addition to the SAT itself, a concept for implementing additional modules ("add-ons") was developed by TUB and UTCB, in order to pave the way for a continuous expansion and adaptability to user needs of the web based tool in future.

The concept and required tasks for the implementation of further methods or models are described in a guideline, which was written by UTCB and TUB, taking into consideration the experiences made in the context of implementing modules from JG and DTU to the SAT. The guideline covers all steps necessary for the successful implementation of add-ons.

The required steps are illustrated by means of one detailed example for such an add-on implementation. A methodology that had been developed by JG to assess the proportionality of risk mitigation measures was chosen as an example. The module is a site-specific assessment module and was integrated accordingly (see Figure 16). JG developed a detailed input and output structure for the add-on's user interface that served as basis for its implementation. The tool is intended to serve as a nucleus for the implementation of further modules (add-ons to the tool). Additions to the tool can be made with respect to site-specific as well as option-specific assessment modules (see section 'Web based tool' above).

Major reasons for consideration of an add-on to the existing planning and assessment tool might be (i) the recognition of some deficit on the existing tool. This may refer to some aspect of brownfield re-use that is either not considered so far (e.g. discounted earnings for specific re-use options) or is considered only insufficiently (e.g. quantitative assessment of environmental impact, some aspects of which are only qualitatively considered in the existing sustainability assessment module; (ii) legal requirements that can be fulfilled only by application of a specific evaluation method, which is not yet implemented in the tool; (iii) institutional requirements, e.g. the initiative of extending the tool's functionality may be taken by a consultant, who wishes to see his/her assessment methodology integrated in the web based tool.

The addition to the existing tool might be made in the course of an ongoing project that is already being investigated by help of the web based SAT or it can be made in view of a future application of it, e.g. to account for requirements in a particular country, where the SAT has not been applied to so far.

The technical implementation typically consists of server side tasks (Web GUI development) and the programming of the processing unit (calculation engine), which is typically made externally and will make use of existing source code if available. The engine will be compiled for execution on the server platform (Windows). In case of 'simple' assessment routines or logics an immediate coding (JavaScript) may be considered.

To guide the add-on process, an adaption procedure (how-to) on the implementation of additional modules has been developed, which is documented in Deliverable 6.2 (Finkel et al. 2013). The guideline covers all steps necessary for the successful implementation of such add-ons. The second purpose is to provide one detailed example for such an add-on implementation. Here, a methodology that had been developed by JG to assess the proportionality of risk mitigation measures was chosen as an example.

Case studies

SAT and its 'twin' desktop tools or modules have been applied to four Timbre sites in Romania, Poland and Germany in order to provide support to these projects in the screening stage by exploring and holistically evaluating possible options with regard to future use of the sites.

The course of action for the application of the web-based tool is illustrated in Figure 17. In a first step, several site data need to be collected and prepared for application of the expert tools. The tool's data requirements are described in Deliverable 6.3 (Morio et al. 2014). The expert tools are then applied to assess the site or given re-use options, respectively, with respect to particular aspects (see section 'Web based Tool' above). The prepared site data as well as the results of the expert tools' application form the so-called full data set that was uploaded to the web-based tool platform.

Fig. 17: Course of action for application of Timbre web based site assessment tool.

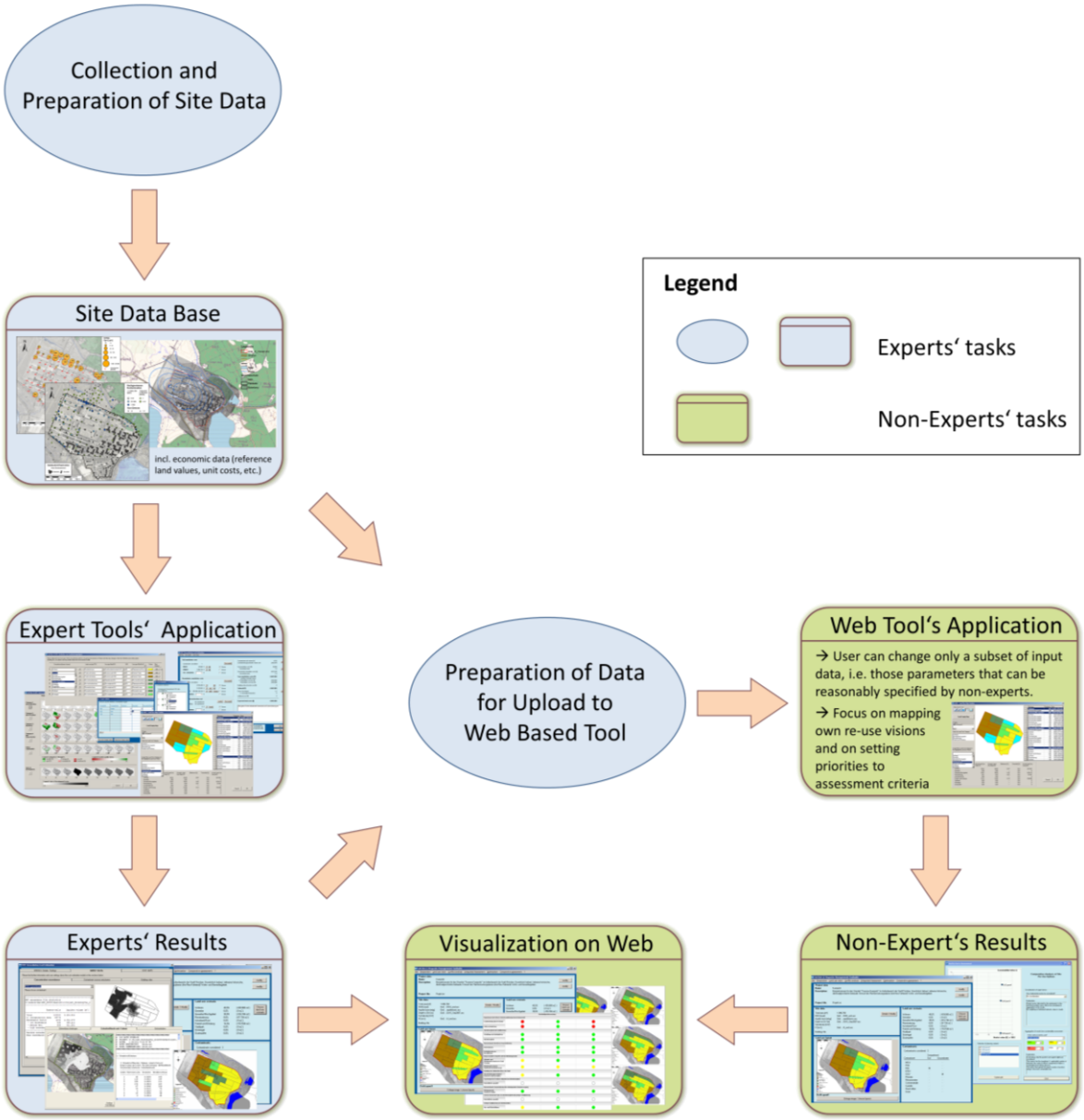


Table 3 summarizes the features of the four WP 6 model sites. The particular tasks and challenges at the individual sites as well as the results of the tools' applications are discussed in detail in Deliverable 6.3 (Morio et al. 2014). At each of the sites, several re-use options were designed and comparatively evaluated. Figure 4 shows an example of a future re-use plan for the Szprotawa site, which was created in a stakeholder group roundtable discussion.

All re-use options were evaluated using the SAT. Figure 18 illustrates the re-use plan recommended by stakeholder groups for the former military airbase at Szprotawa, Poland, Figure 19 gives an example for the results of the economic part of the integrated assessment at the Former glassworks site in Radeberg, Germany.

Tab. 3: Main features of WP 6 model sites

Model Site	Features
Former military site "Krampnitz" in Potsdam near Berlin (Germany)	- size: 113 ha (27 planning units) - situated in the outskirts of the city of Potsdam; nature reserve, lake and agricultural areas in direct neighbourhood; trade, industrial as well as residential zones close-by - groundwater contamination dominated by TCE and PCE Information about soil contamination is limited to the delineation of areas potentially contaminated by polycyclic aromatic hydrocarbons (PAHs) - 3 site re-use scenarios have been evaluated
Former glassworks site in Radeberg (Germany)	- size: 4.5 ha (31 planning units) - located within the city of Radeberg - soil contamination includes mineral hydrocarbons, PAH, Ammonium, BTEX, heavy metals and cyanides; due to incomplete site investigation high uncertainties with respect to extent of existing subsurface contamination - 5 site development scenarios were evaluated
Former steelworks site in Hunedoara (Romania)	- size: 234 ha (28 planning units) - located in vicinity to the city of Hunedoara - wide spread soil pollution with heavy metals, PAH and BTEX contamination at former chemical plant and the former phenol waste water treatment plant, thanks to a thick layer of clay the groundwater is not heavily polluted - four land re-use options were considered
Former military airport in Szprotawa (Poland)	- size: 1,400 ha (154 planning units) - located located in Wiechlice village close to Szprotawa main urban area - various potential sources of contamination (fuel depot, car park and workshops, area of fuel reloading, etc.) - redevelopment of the site is essential for the future prospects of Szprotawa town - since 1992 under revitalisation - two predominant redevelopment scenarios (economic-centred development for trade and industry vs. recreation-centred development) plus three alternative scenarios were evaluated

Further Achievements

In addition to the work related to the development and application of the SAT, the existing desktop software "Megasite Management Toolsuite (MMT)" has been adapted and tailored in work package 6 to be applicable to the Timbre model sites. Tailoring included the creation of two full MMT versions in Polish (used at model site in Szprotawa) and Romanian (used at model site in Hunedoara), diverse improvements and new functionalities (in particular the data upload to the Timbre web tool) as well as site specific adaptations.

3.7 WP 7: Timbre web based tool suite

The Timbre tool suite platform is an open platform that makes available the access to the suite of tools and methods (and their documentation) that were developed in Timbre, namely to (i) the web based site planning and assessment tool "SAT" (from WP6); (ii) the Timbre Information System – a web database expert system (from WP1) as information platform for innovative and widely applicable strategies, technologies and solutions, (iii) the site prioritization and selection tool (from WP3), and (iv) further methods and information, as have been compiled by Timbre. The latter include in particular the Timbre European brownfield regeneration databases. These are comprehensive databases that are easily accessible on the project's website for information on European brownfield regeneration approaches and tools. The databases have been partly integrated into the above mentioned tools and include the following elements: (i) An European catalogue for available brownfield regeneration tools (including tools for planning, decision support, regeneration technologies, economic evaluation, sustainability assessment), (ii) An European Brownfield data room (including a brownfield inventory for different scales, socio-economic data, contamination status, regeneration costs, market values), (iii) Best practice examples, that is, successful examples for brownfield regeneration on different scales and regions, e.g. rural, industrial, urban areas. The first database was integrated into the Timbre Information System (cf. Pizzol et al. 2012). The second database has been published through the formats of reports (cf. Frantál et al. 2012). The Timbre web based tool suite consists of two parts: a report serves as accompanying document to the tool suite, which is available directly at http://www.timbre-project.eu/outcomes.html and forms the other part. The report explains the conceptual background of the web based tool suite and gives an overview on capabilities, limitations and data requirements of the tools within the tool suite. Second, the report describes the tools and its modules, including (i) the general structure, which partly builds upon and modifies existing assessment modules, (ii) the provision of access via internet, (iii) the integration and interlinkages between the specific tools.

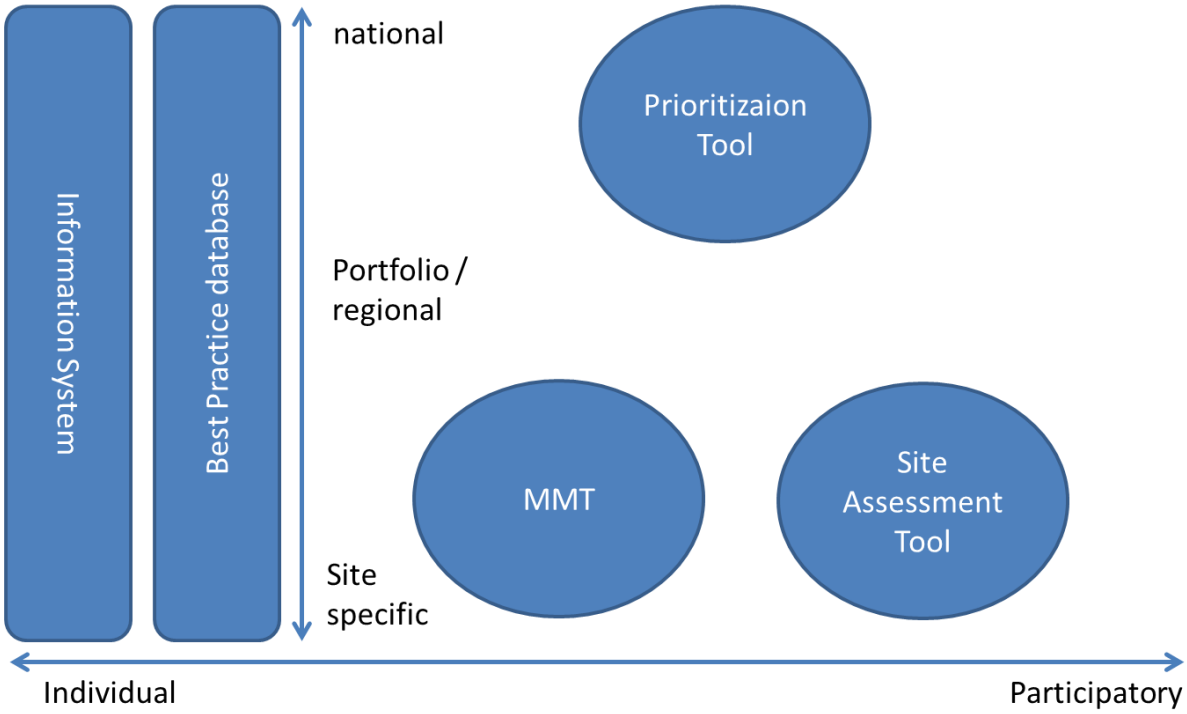
Concept: The Timbre web platform is of key significance to deliver the project's results to brownfield regeneration stakeholders. It provides several tools (i.e. the Timbre web based tool suite) and information (incl. data) aimed at improving the process of revitalising brownfields in Europe. Both tools and information (incl. data) were to be developed in the project's WPs and were intended to be tailored (or customisable) in order to enable a high degree of practicability and applicability. Inherent to this aim has been 'user specificness', i.e. individual information and tools may have specific and different target users.

Level of integration: Levels of integration can be described in different terms: Integration is either possible with respect to content or to technological implementation (software, platform) or from the end user usability point of view. The latter includes the easiness of application and common language since end users stem from different disciplines or have different expertise in the context of brownfield redevelopment. Within the Timbre project, several efforts have been undertaken with respect to integration of the web tools.

Within the Timbre project, the key challenge was to find an effective level in the trade-off of efforts needed and potential benefits that could be achieved. Whereas full integration might be deemed desirable at a first glance, from an efficiency rationale and economic point of view, we rather had to strive for identifying the highest level of integration, where marginal costs of an additional step of integration efforts are not rewarded or at least equalized by the marginal benefits in terms of additional usefulness of content integration as perceived by Timbre stakeholders. Having reflected on this internally, with members of the International Advisory Board of the project and with selected end-users, we choose to go for a medium level of integration – safeguarding at least a common understanding and availability of outcomes, but not going for the efforts of detailed technical integration. Hence, the tools and further accompanying measures, like a common glossary of terms, information about trainings and events, project outcome documents (deliverables) and so forth, were partially integrated on a common landing page with respective documentation. Further integration is possible, but was not performed within the limited scope and resources of the Timbre project. This further integration would include the technical linkage of the specific tools' in- and output as well as the full technical integration of the tools into one technological web-platform. The challenges and opportunities of further integration are discussed in the D4.5 report.

The goal of conceptual connection of the Timbre web tools is sketched in Figure 20, which includes the spatial scale (local, regional, national) as well as the scale of addressees (i.e. individual stakeholder of participatory stakeholder groups).

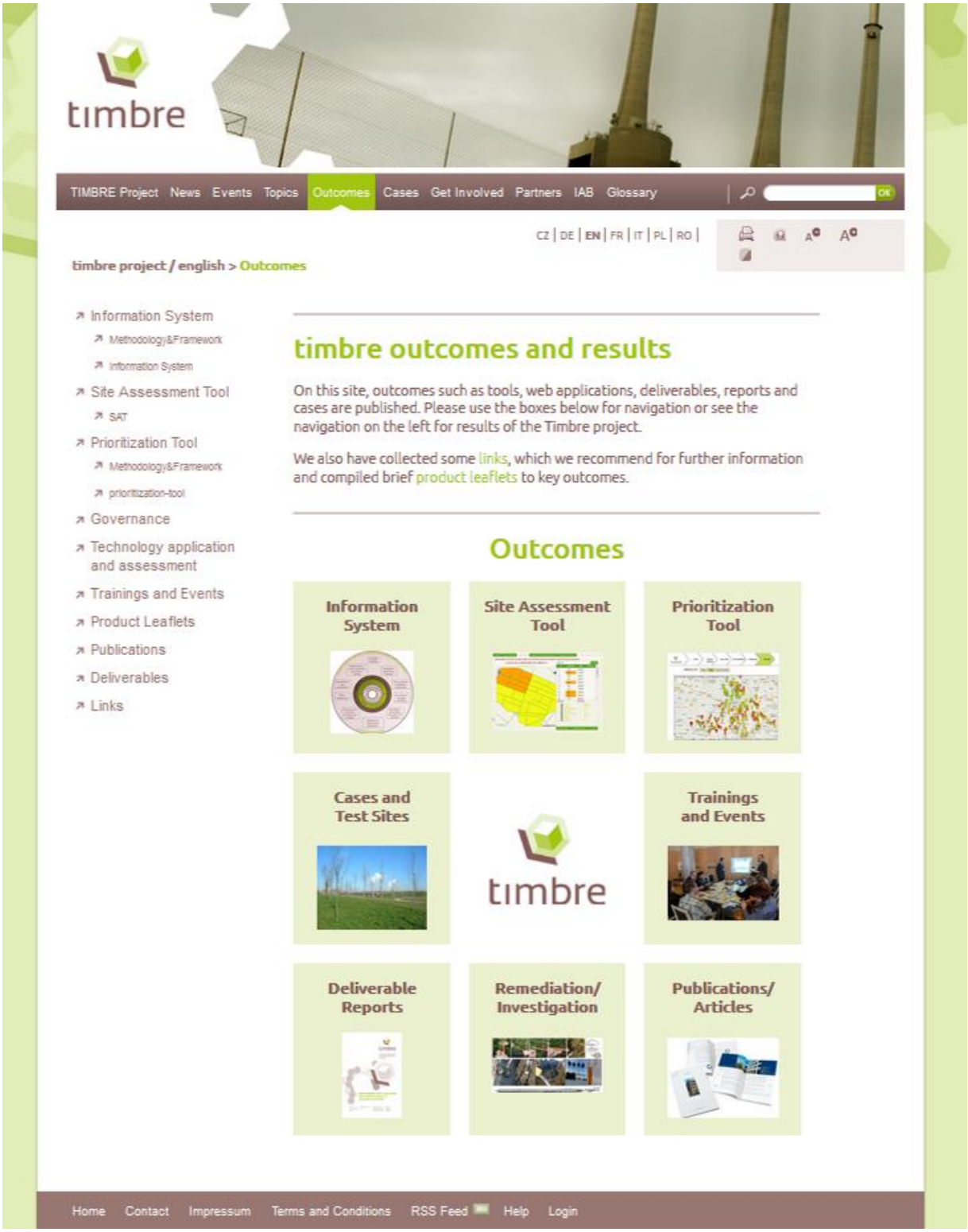
Fig. 20: Connection of Timbre tools with respect to scale and stakeholder participation.



To ease the application for different stakeholders and user groups, a common language was introduced within the Timbre project and summarized in a glossary of terms.

The integration is implemented on the Timbre webpage's outcomes page http://www.timbre-project.eu/outcomes.html, where the specific Timbre tools, deliverables, literature, the glossary and further information are gathered on a common landing page (Figure 21). By clicking on one of the symbols, the user gets a description of the tools and links to further documents.

Fig. 21: Common landing page of Timbre web-based tool suite “outcomes”



4 Description of the potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and the exploitation of results

General potential impact of Timbre

The accomplishments of the Timbre project were to support (i) an enhanced sustainable brownfield regeneration through the development of economically and sociologically sound concepts that enable nurturing the design of tailored approaches, technologies and tools; (ii) a shared strategy for brownfield regeneration in Europe that will lead to accelerated and eased policies for large-scale projects in regions with an urgent need for ecological and economic development; (iii) integrating and fine-tuning already existing technologies in order to deliver solutions being accepted and applied by end-users; and (iv) improving the accessibility of existing state-of-the-art knowledge via a web based platform in order to harmonise European brownfield regeneration processes.

The philosophy of the Timbre project concept has been the interplay between existing European research activities or initiatives and the Timbre project. Timbre presents the consequent continuation of already successful efforts in the area of brownfield regeneration. It developed tools to support the integration of already produced knowledge and know-how with newly developed expertise.

Timbre led to an improved efficiency of existing technologies, methods and tools through their integrated and mutually complementary development in the context of real world cases. Timbre carved out in a "thicker" and more site specific way the driving forces for brownfield regeneration, local cultural and administrative specificities that significantly influence the overall processes of regeneration beginning from initial steps and planning to the re-use of materials and the realisation as well as further impacts on local community. Timbre has not produced yet another normative statement of how public participation can be improved – rather the projects results open the door to new insights for understanding brownfield development and regeneration.

Timbre's activities, based on an assessment of stakeholders' and site owners' needs, along with the development of well-orchestrated problem- and target-oriented packages and the provision of information on the state-of-the-art knowledge can be an important means to stimulate economic recovery and to help paving the way to increase competitiveness of regions impacted by degraded brownfields and megasites.

Timbre's project results support achieving the objectives of several European directive applying to brownfield regeneration, in particular to the Soil Thematic Strategy, the 6th and 7th EAP and the Water and Groundwater Directive. Given that Timbre test sites are located in urban and semi urban settings, Timbre also supports the EU's Thematic Strategy on the Urban Environment by setting out cooperative

activities with local problem owners and authorities in order to enable them to improve urban environmental management. Moreover, Timbre's development and testing of site specific tools is an important addition also for future waste handling and disposal. In line with the EU's Landfill Directive, Timbre helped to reduce negative effects of pollution of ground- and surface water and especially soil.

The project results and outputs strongly emphasize the need for good quality and relevant data. The extent to which the developed tools will be applied will vary according the brownfield maturity of the respective countries. The project appears to have had a significant impact as both observers and influencers of brownfield remediation projects and this could replicate elsewhere. The tools were successful in encouraging stakeholders to work collaboratively. The project has demonstrated the need for a multidisciplinary approach including the social sciences.

Timbre enhanced soil protection awareness and knowledge based on an explicit outreach and dissemination strategy for brownfield regeneration technologies and governance strategies. Divers stakeholder groups were reached via a large number of events and via an easy to access and easy to use web-based platform open to all, who wish to participate and want to constructively add to the knowledge base for brownfield regeneration in Europe.

Information System for Brownfield Regeneration

The developed Information System (IS) is a web-based open centre which allows an easy access to a wide set of information, tools and methods (and related documentation) available in literature or developed within the Timbre project. The IS is expected to become an effective web-platform to share and exchange available information between scientists, stakeholders and especially between different authorities' levels (i.e. national, regional, local). The Information System is not only a static database which provides free and easy access to a wide set of information for different countries and contexts, but it has the ability to deliver tailored results according to stakeholders characteristics and information needs. Moreover, it is expected to become a "living system" which relies on direct end-users' inputs, evaluations and updates. Therefore, it implements an Artificial Neural Network methodology which allows the system to develop continuously and to adapt the provided results, day by day, through the integration of users' inputs (cf. Pizzol et al. 2014).

In order to guaranty that the scientific process for the development of the Information System is producing useful and shared results, Timbre project partners and stakeholders from the project's case studies have been involved in the different stages of its development (cf. Rizzo et al. in preparation). A special focus was placed on the phases concerning i) the development of the framework the collection of information on brownfield regeneration, ii) the evaluation of the available information collected in the IS and iii) the evaluation and testing of the IS functionalities.

Specifically, stakeholders have been asked to evaluate the framework for the collection of information on brownfield regeneration during ad-hoc sessions of stakeholders and experts workshops organized by the Timbre project in Romania, Poland and the Czech Republic. According to the suggestions gained from Timbre partners and the project's International Advisory Board, the tool functionalities have been improved. The revised version of the Information System has been presented to external stakeholders in a more refined version. Stakeholders' suggestions and recommendations have been collected in order to better tailor the tool according to their requirements and needs. Four Timbre workshops, one in Germany (Berlin, 27th November 2013), one in the Czech Republic (Brno, 29th November 2013), one in Romania (Bucharest, 11th March 2014) and one in Poland (Katowice, 28th May 2014) have been organised in order to involve local stakeholders in the evaluation of the tool and to support its dissemination. Moreover, the tool has been presented in scientific conferences (EUROSOIL 2012, AquaConsoil 2013, SURF Italy Day (within REMTECH-2013 conference), CABERNET 2012, SARCLE 2013, CleanUp 2013, US-German Bilateral Working Group 2014, Timbre Final Conference Bucharest 2014, etc.) as well as in the summer school "Building interdisciplinary tools for long-term contaminated site management" hosted by the Helmholtz Centre for Environmental Research - UFZ, in specific training sessions organised within the FP7 Marie Curie IRSES project "GLOCOM – Global Partners in Contaminated Land Management" (contract n. 269233) coordinated by Ca' Foscari University Venice - UNIVE and involving two Chinese research institutes (Chinese Academy of Environmental Sciences and Beijing Normal University) besides one EU partner (Umea University, Sweden).

On those occasions, the Information System was presented and, whenever possible, participants were invited to use it. The four Timbre workshops involved many categories of stakeholders such as site owners, site neighbours, local authorities (town or city), region and sub-regional governments, regional and national regulators, local community groups (neighbourhood, districts), public interest groups, developer/investors, technology providers, consultants, contractors, end-users and researchers. Thanks to participants' inputs, the Information System "knowledge base" increased and useful information about the need for further improvements concerning the tool functionalities has been collected.

The involvement of the Timbre partners and the stakeholders through the Information System testing activities has been of crucial importance both for scientist and stakeholders. In fact, the organisation of the WP1 events was beneficial for researchers who collected useful information necessary for the main aim of the study, including information concerning stakeholders' perceptions, concerns, attitudes and information needs when dealing with brownfields; all this useful for the development of more tailored methodologies, approaches, tools and strategies in the field of brownfield regeneration. Furthermore, these events were an efficient platform to support stakeholders in finding suitable information for their specific problems, since

they created suitable conditions for stakeholders i) to talk with scientists working on the specific topic of brownfield regeneration, ii) to talk to each other and to engage with one another, iii) to build up networks, iv) to identify common problems and visions, v) to exchange information between different authorities levels (i.e. national, regional, local), vi) to identify possible information/solutions/measures suggested by the involved scientist, and vii) to learn about information and decision support tools. Additionally, the use of the Information System and the analysis of the experience with local stakeholders supported the scientific community by i) proposing a systematic stakeholder involvement procedure, ii) identifying a list of stakeholder categories which play a relevant role in the rehabilitation of brownfields, iii) identifying and evaluating stakeholders' perceptions, concerns, attitudes and information needs when dealing with brownfields on the basis of the collection and analysis of empirical data, iv) developing the ranking methodology aimed at providing each end-user with the most suitable instruments, approaches and information for each of the main phases of the brownfield regeneration process, according to his/her specific characteristics, requirements and needs, and v) by providing the web-based Information System which represents an innovative tool for increasing and improving the access to available information on brownfield redevelopment.

All these efforts have contributed to the overarching Timbre objective of supporting the harmonisation of procedures, guidelines, regulations, approaches, tools on brownfields regeneration in Europe and proved – according to engaged stakeholders – to have been particularly beneficial for countries like Poland and Rumania where the knowledge and consequently regulations, guidelines and tools to support the regeneration of brownfields sites are still in a developing phase.

Prioritization Tool

The Timbre web-based Prioritization Tool, which is available for end-users via the Timbre web tool suite www.timbre-project.eu, can create significant socio-economic impact, because this tool, which is based on multi-criteria decision analysis methods, helps stakeholders who are responsible for wider territories (regions, districts, cities) or clusters of brownfields (portfolios) to distribute available resources to those brownfield sites that were assessed to be most critical, urgent or profitable to regenerate. The tool provides a step-by step assessment of the classification of sites from the perspectives of three pre-set dimensions: (i) local redevelopment potential, (ii) site attractiveness and marketability, and (iii) environmental risks, which can be simply modified according the needs specified by end-users. Prioritization results are available in form of both user-friendly Google Maps® and tables which can be downloaded in the format of MS Excel® files – thereby the use of these widely used software products is to facilitate a wide potential applicability of the tool.

The Prioritization Tool is very unique to the degree that it was created, developed, modified and finalised according to feedbacks from stakeholders in all periods of its development (preparation period, period of pilot version and finalisation of prioritisation model) (cf. Klusáček, 2013a/ in preparation). In the first phase of the tailoring process, a preliminary explorative research using qualitative methods (questionnaires with open questions, semi-structured interviews and focus groups) was conducted during several workshops with stakeholders organized in the Timbre studied countries (Czech Republic, Germany, Poland and Romania). Respondents were asked to answer open questions dealing with factors and barriers of the brownfield regeneration process and also to assess positive impacts of brownfield regeneration. The aim was to obtain a detailed and comprehensive set of factors and indicators related to the processes and results of successful brownfield regeneration as possible. As the output of preliminary research a questionnaire form with closed questions and standardized classification scales for the assessment of was created.

In the second phase of the tailoring process, the questionnaire survey, was conducted in four studied countries (the Czech Republic, Germany, Poland and Romania). The distribution of questionnaires among stakeholders was conducted via electronic mail (the research team collected email addresses of potential respondents in studied countries) or as a printed version during sessions of several workshops and seminars organized in four of the Timbre studied countries in Central and Eastern Europe and focused on brownfield regeneration. The sampling of respondents was made with respect to gain a balanced structure of the sample according to various groups of stakeholders and countries in the interest of Timbre activities.

In the third phase of the tailoring process, the stakeholders' feedbacks (criticism and proposals for improvements) to the pilot version of the web-based prioritization tool were collected by means of the following methods: (i) Organizing of four special tailoring workshops with stakeholders in the studied countries (these workshops were held in Ostrava in the Czech Republic on 10th October 2013, in Berlin in Germany on 27th November 2013, in Bucharest in Romania on 11th March 2014 and in Katowice in Poland on 28th May 2014), where all kinds of stakeholders involved in brownfield regeneration (e.g., planners, database owners, academics, etc.) were invited. During these workshops all participants had the opportunity to test the on-line version of the Prioritization Tool on computers using both the model databases for the South Moravian region or a database for the Silesian Voivodship from Poland (the tool was previous tested in the design phase with two databases from Romania and Germany, but these databases cannot be used for demonstrations for workshop participants, because their data are under data protection); (ii) Expert discussions and consulting with individuals in charge of six tested brownfield databases (South Moravian Region database 2013, Tereny poprzemysłowe i zdegradowane 2013; Brno brownfields database 2013, Romanian Ministry of Waters and Environment brownfields database 2013, Saxony brownfield database owned by GESA, Thuringian brownfield database

owned by LEG Thüringen), which were used for testing the pilot version of the prioritization tool; and (iii) Distribution of the dissemination materials (preliminary versions of tool manual, presentations and a brochure, usually distributed by means of electronic communication) took place among the stakeholders invited to participate in the tailoring process. In the Czech Republic, the distribution was facilitated through the collaboration with the Partnership for Czech Brownfields and by means of other contacts, which were available to the IOG team. In the other Timbre research countries (Germany, Poland and Romania), distribution was conducted by related contacts provided by the projects partners.

The feedback by stakeholders collected during the intensive tailoring and dissemination process (cf. Klusáček et al. in preparation, Bartke et al. 2014b) and the reactions of the International Advisory Board allow the prediction that the web-based Prioritization Tool has the potential to be taken up as a useful instrument for end-users not only in the studied countries (Czech Republic, Germany, Poland and Romania) and regions but also in other EU member states and regions, which are dealing with the occurrence of brownfield sites and where the instruments supporting the ranking and prioritisation of sites in decision-making were improvable.

Site assessment and re-use planning tool (SAT)

The web based site assessment and re-use planning tool (SAT) is an online tool that provides several modules for the management of spatial data and information, the planning of brownfield re-use options, and for the integrated of these options. With its capabilities the SAT shall improve the process of revitalising brownfields in Europe.

The tool is intended to be tailorable (i) in terms of the modules implemented and used for the integrated assessment and (ii) with respect to the type and extent of information that will be made visible/accessible for a particular site. This way it aims to establish a high degree of practicability and applicability.

Inherent to the goal of and 'tailorability' is 'user specificness'. That is, individual information and tools may have specific and different target users. Hence there is not a single group of intended users for the web platform but different type of users that will use and benefit from selected information and tools.

Targeted users, their intended way of using SAT, and potential impacts are: (i) Scientists/engineers in e.g. consultant companies may act as tool developers following a well-defined adaption procedure (how-to) on the implementation of additional modules, which is described in Deliverable 6.2. (Finkel et al. 2013) - *Potential impact: Available assessment tools will be compiled and coherently merged into one decision support system.* (ii) Planners and consultants (as expert users of the tool) will use the tool for individual brownfield development projects and will feed the tool with site data, thus preparing the tool for use by non-experts such as municipalities, site developers or investors. - *Potential impact: Facilitation of the communication among stakeholders.* (iii) Planners, site developers, municipalities, and further interested stakeholders (as non-expert users) can use the tool to develop and assess their own idea of future site use by help of a user friendly graphical user interface (GUI) for the creation of land use maps and automated integrated assessment (cf. Morio et al. 2014/2013b, Schädler et al. 2011/2012/2013a/b). - *Potential impact: Active participation of stakeholders.* (iv) Site owners, site developers, investors, and municipalities are beneficiaries of the results of the tool's application, namely with respect to the identification of a brownfield's developmental potential and an optimal utilisation of the available planning scope (ibid). - *Potential impact: Better i.e. more sustainable and specifically optimized re-use of brownfields.* (v) Environmental authorities may benefit from the tool's risk module for the identification and estimation of risks associated to particular agricultural land uses. *Potential impact: Risk-based decisions on future land-use.*

The work on the case studies at the Timbre model sites resulted in a variety of data, maps, reports, and recommendations that are very useful to involved site owners, site developers, investors, and municipalities. Many relevant data and information are collected, pre-processed and provided online in an easy-to-use way. Results give suggestions of economically attractive, sustainable ways in which the particular sites may be redeveloped in accordance with existing guidelines and regulations.

The case studies play an important role as show cases in promoting the tool in order to achieve a widespread dissemination and utilisation within the 'Brownfields community'.

Timbre project partners and relevant stakeholders were directly involved in the work on the case studies. This involvement has been of crucial importance and included discussions and feedback in different stages of the tool's development.

The envisioned web-based SAT as well as the underlying concepts and method, in particular the Megasite Management Toolsuite, were presented several times in Romania, Poland and Germany. Feedback and suggestions were taken into consideration in further development work (e.g. with respect to handling and functionalities) to come up with a tool that meets the end users' requirements and needs. To inform and involve relevant stakeholder groups a variety of events were organized and visited: workshops with hands-on training, local stakeholder meetings, expert panel meetings, seminars, schools, international conferences (e.g. EUROSOIL 2012, Sustainable Remediation 2012, AquaConsoil 2013, Groundwater Quality 2013, CleanUp 2013). The talk "Targeted Design of Sustainable Brownfield Redevelopment" given by Sebastian Schädler received the award for "Most Inspiring Concept" at the 2nd International Conference for Sustainable Remediation, Vienna, Austria. Moreover, a guideline for Megasite regeneration (UFZ and Timbre, 2013a/b) was elaborated along with further manuals and hand-book material to facilitate the uptake of the planning and assessment tools.

There is certainly some potential for commercial exploitation of the web based site assessment and planning tool (SAT). TUB intends - with a spin-off company - to propose a feasibility study within the Horizon 2020 work programme (part 7: Innovation in small and medium-sized enterprises) in order to verify the technological /practical as well as economic viability of the tool and its underlying concept.

Research on governance and cultural elements

All social science research has impacts when the research is carried out. Especially focus group discussions with stakeholders and experts bring to light not only their views on the situation but also help problematize the situation itself. This leads to exchanges between actors over this situation, which can make them aware of similar points of view that they might share. This might stimulate further thinking that leads to action and establishment of new networks of actors. Knowledge on decision structures and socio-cultural factors provide orientation for international but also national actors (e.g. engineering companies and investors) who want to engage in brownfield revitalization.

For the countries of the projects case study sites, the legal structures, major institutions and key actors are described in the two deliverables of work package 2 (Alexandrescu et al. 2012/2013) which are both available on the Timbre website.

The impact on the national and local level – The analyses done in WP 2 provide knowledge useful for decision makers at regional and national levels who want to improve the legal framework and decision making in brownfield regeneration. If the results of the analysis, especially if the knowledge gained on driving factors and barriers are taken seriously, brownfield governance (for example legal frameworks and regulation) can be improved and the application of tools and methods can be more effective.

The knowledge provided on local decision making processes and the role of actors (primary and secondary actors, and veto players) may facilitate the revitalization of single sites and the application of tools and technologies on those sites. The findings concerning the regional and national drivers and barriers could also make decision-makers aware of the critical points on which they need to focus in order to bring brownfield regeneration forward. Two of these points of attention for national decision-makers are the coherence and stability of the institutional context and accumulation of knowledge, in the form of brownfield databases and best practices. For local actors, the important lessons are the acquisition of abilities to organize project networks and the development of swift trust among actors.

Take up of results in scientific community – The findings of WP 2 can stimulate social science research on contamination and revitalization and environmental policy. The framework of project ecologies – borrowed from economic geography – can be seen as an important contribution to the study of how and why actors get organized when carrying out regeneration projects. This approach will be pursued in one or two future publications by WP 2 social science researchers.

Taking up the results on national and regional specifics in future tool development may help to tailor tools for user groups in the three case study countries. This will require taking into account the specific political and policy situation in each country, as well as the relationships between decision-makers the national and local level.

Dissemination activities – The main dissemination activities took place during the Timbre project's running time. A major dissemination channel has been the project website: www.timbre-project.eu. Further activities were (i) Presentation of the results at scientific conferences (June 2011 Brno & Ostrava - Czech Republic, July 2012 EUROSOIL; April 2013 AquaConsoil, May 2013 Democratization through Social Activism, August 2013 ESA), (ii) Presentation of the results for policy makers and practitioners (October 2011 presentation in Romanian at the workshop: "Revitalising the site of the former Siderurgica steel plant". Introduction to site stakeholders, discussion of interests and objectives; March 2012, presentation at expert workshop in Poland; September 2013 presentation in Romanian at the workshop at test site in Hunedoara on "ECOSID – Contamination level, socio-economic framework, remediation pilot tests"; March 2014 presentation at the Timbre conference in Bucharest); (iii) Support with stakeholder engagement in collaboration with other WPs supporting the tailoring of Timbre instruments and dissemination actions (Active engagement with practitioners by facilitating the interaction of other work packages (WP1, WP3, and WP6) with stakeholders in the Czech Republic, Germany, Poland and Romania, in particular for the Information System support for development, pre-testing and application of questionnaires, for the Prioritization Tool support for development and application of questionnaire in Germany and Romania and for the Site Assessment Tool support in assessing the perceptions of stakeholders of with regard to the Megasite Management Toolsuite (MMT) in Poland); (iv) Education (January 2012 – "The use of tools and integrated regeneration of brownfields" session at the LIAISE winter school, Leipzig; June 2014 – "Project Ecologies in Brownfield Regeneration: An heuristic Introduction" lecture at the ADVOCATE LIAISE TIMBRE Summer School "Building Interdisciplinary Tools for Long-term Contaminated Site Management" in Leipzig, January-June 2014 several lectures and seminars at the University of Jena, Germany); and (v) a number of scientific publications (Alexandrescu & Bleicher submitted, Alexandrescu et al. 2014a/b/in preparation.

Strategies and technologies for integrated site characterisation and remediation

Emergent approaches and technologies for effective site characterisation and remediation were adapted, further developed and tested in Timbre, addressing (i) the feasibility of phytoremediation and specific soil washing with recycled solutions (SSWRS), (ii) the effective site characterisation and monitoring of subsurface contamination and remediation, and (iii) the evaluation of remedial options using site models, based on adaptive site characterisation.

Results of the research have been published or are currently prepared for publication to ensure a wide uptake and impact. For example, Kalisz et al. (in preparation) address effective and reliable site characterization at megasites by the use of pre-screening methods. This paper illustrates the usefulness of pre-screening methods for effective site characterization at polluted sites. Results can be basis for conceptual models used for placement of more costly and quantitative methods. The scope is reducing the uncertainties and costs of establishing deserved site knowledge to site evaluation. The methods considered include tree core sampling and direct-push based methods such as soil gas measurements and the high-resolution techniques (MIP and LIF). They were applied together with traditionally chemical analysis of groundwater and soil samples for confirmation at a Timbre test site polluted with fuel compounds. The results are a comparison of methods by a rank-correlation showing that significant correlation between results was sometimes the case. Results demonstrated feasibility of the different pre-screening methods; all methods allow identification of contamination. A combination of methods showed that the risk of missing out contaminated areas was minimized due to a denser sampling grid. The authors conclude that the application of multiple pre-screening methods makes site characterization more efficient. All pre-screening methods are profitable both individually and as supplemental to each other. Overall, the applications of several pre-screening methods will minimize the uncertainty and the use of different methods produces various data useful for later remediation design.

Algreen and Trapp (2014) give a guideline for application of tree coring as an initial screening tool for typical pollutants in the subsurface. Previous guidelines of tree coring as bio-indicators for subsurface pollution are available (Holm et al. 2011a/b, Trapp et al. 2012, Vroblesky 2008), however, these guidelines report that tree coring is more or less useful for a variety of volatile organic compounds (VOC) such as BTEX (benzene, toluene, ethylbenzene, xylenes), methyl tert-butyl ether (MTBE), trimethylbenzene and chlorinated solvents (PCE, TCE, DCE, VC).This new guideline goes beyond the previous guidelines, and the main novelty is that it also includes the application for screening of heavy metals, plus some new examples for BTEX. It is based on field applications at sites polluted with BTEX, chlorinated solvents and/or heavy metals. The guideline describes the method and the application of it including sampling, chemical analysis and data treatment. Finally a short overview of current literature obtained within the Timbre project and by others is given.

Mohamed et al. (2013, in preparation) published a series of articles on soil washing. Washing is among the few alternatives to remove contaminants from soils, especially in case of metals, which are not degradable and have mostly high vaporisation temperatures.

Local and regional impacts. The site investigation and the assessment of remediation options found grateful interest at the local authorities. In combination with the Timbre re-use planning tools (Morio et al. 2013a, 2014), development plans were established that can be implemented by these authorities. The stakeholder contact hat significant influence on the day-to-day work in the respective regions since relevant stakeholder groups were involved in the case studies in order to consider specific requirements and demands, and to get broad acceptance for innovative solutions from the decision makers.

Dissemination events: in Poland through workshops and seminars: (i) Workshop "Przekształcanie terenów zdegradowanych w Europie narzędzia zarządzania" in Katowice on the 28th May 2014; (ii) Workshop in Szprotawa "High Resolution Site Characterisation" on the 18th September 2013 with presentation and demonstration of site characterisation tools and remedial techniques suitable for Szprotawa site; (iii) IETU seminar: Zintegrowane zarządzanie przekształcaniem zdegradowanych megaobektów na przykładzie terenu powojskowego – projekt Timbre (Integrated management of mega-sites redevelopment based on post military site – timbre project), Katowice, 24th January 2013; IETU-seminar: Integrated site characterisation – timbre project, Katowice, 17th May 2014; (iv) results of site characterization and remediation activities were disseminated during the Regional Conference in Szprotawa "Zagospodarowanie dawnej bazy powojskowej szansą rozwoju Szprotawy" ("Challenges and solutions for the redevelopment of the former airbase in Szprotawa") on 12th June 2014 with presentation of the site characterisation results and remediation options for Szprotawa site. Also in Romania a series of events and workshops were organised, e.g. in October 2011 in Hunedoara – a kick-off event which found a significant echo in local and regional media, and a second workshop in 2013 on "ECOSID – Contamination level, socio-economic framework, remediation pilot tests", which was devoted to an expert discussion of the results of the investigations carried out in Hunedoara.

Education: (i) Education of future environmental engineers, teaching at DTU: The Timbre PhD summer school held in 2013 will be continued as regular MSc/PhD course of DTU (course Nr 12906 Modeling of Plant Uptake, PhD summer school, 5 ECTS). In 2013, 14 senior scientists and 18 PhD students participated. (ii) E-Learning - The Timbre PhD summer course at DTU has a website with lectures, models, exercises and movies http://homepage.env.dtu.dk/stt/PhD%20course%202013website/index.htm.

TV: The phytoscreening activities (Mette Algreen, DTU) were part of a TV report (TV 2 Øst, Denmark) already in 2011. The title of this contribution was “Trees find polluted groundwater” (original in Danish, Træer afslører forurenet grundvand). The movie can be seen at at http://www.tv2east.dk/artikler/traeer-fortaeller-om-forurenet-grundvand - We expect that this dissemination reached a very large audience (potentially > 1 Mio people). Later on, this contribution was reevaluated humoristically in a very popular TV show (TV, Sputnik Sputnik late night show, from 3:35 minutes). Regional television broadcasters disseminated the activities and events at the Romanian and Polish Timbre sites (Bartke 2013b, Bartke et al. 2012b). We expect that these disseminations reached regional audiences (potentially > 0.2 mln people in the Lubuskie and Western Romanian regions respectively).

Collateral impact: Urban gardening and the risks from polluted soils (WP 4 and 6, DTU). The handling of polluted soils is an urgent topic in the European Union. In princple, all former industrial and urban areas can be considered as contaminated, and heavy metals are among the most wide-spread contaminants. Moreover, clean, healthy food is a major focus of the European population. Urban gardening is hype, and it is thus no surprise that our studies have found interest in a broad audience, the general public and the urban gardeners.

There are real concerns about risks from vegetables and fruits grown on polluted soils. The outcome of our studies shows that the health risks by contamination of food grown in the City of Copenhagen are small. We could identify major risks (direct soil contact), and counter-measures (wash hands, exchange or cover polluted soil, peel root vegetables). With these little precautionaries, urban gardening can be a pleasant recreational and social activity that contributes to the supply of our populations with fresh, healthy and organic vegetables and fruits. This news was spread at public events in Danish, e.g. the meetings of the gardeners (“kolonihaveforeningsmøde”), and via several interviews with journalists. The message appeared in the top newspapers of Denmark, namely Politiken and Jyllands Posten, and in garden journals (Bolius).

Deconstruction and re-use of structures and materials

Timbre improved the basis for adequate decisions of investors and site owners concerning the destruction and re-use of existing buildings and structures on brownfields. The reports by Hagemann et al. (2012/2013a/b) and by Hesse et al. (2014) support decision makers in developing environmentally friendly and economic strategies under respect of the existing different national laws. The practitioners-led and -focused analyses created reports and technical guidelines that improve deconstruction and re-use of structures and materials at brownfields. Timbre supports the assessment of re-use options of buildings vs new developments as well as the elaboration of strategies to recycle building rubble on-site in order to avoid unnecessary dumping of materials and raw material use for more environmentally friendly site preparations. The results (i) give insights on recent projects and practice in the EU on regulations regarding decontamination measures, working safety, re-use and or disposal (Hagemann et al. 2012); (ii) present approaches to cost- and environmentally friendly strategies to recycle building rubble, to avoid and minimize dump materials, including the estimation of socio-economic impact of possible re-use or deconstruction of buildings on brownfields (Hagemann et al. 2013a); (iii) guide the prediction of emissions during deconstruction measures; and (iv) guide the working safety during the deconstruction of buildings and structures. The results can have a high uptake by practitioners in particular in the developing Eastern European regions with less experience and established regulations on the deconstruction and potential re-use of materials and structure on-site.

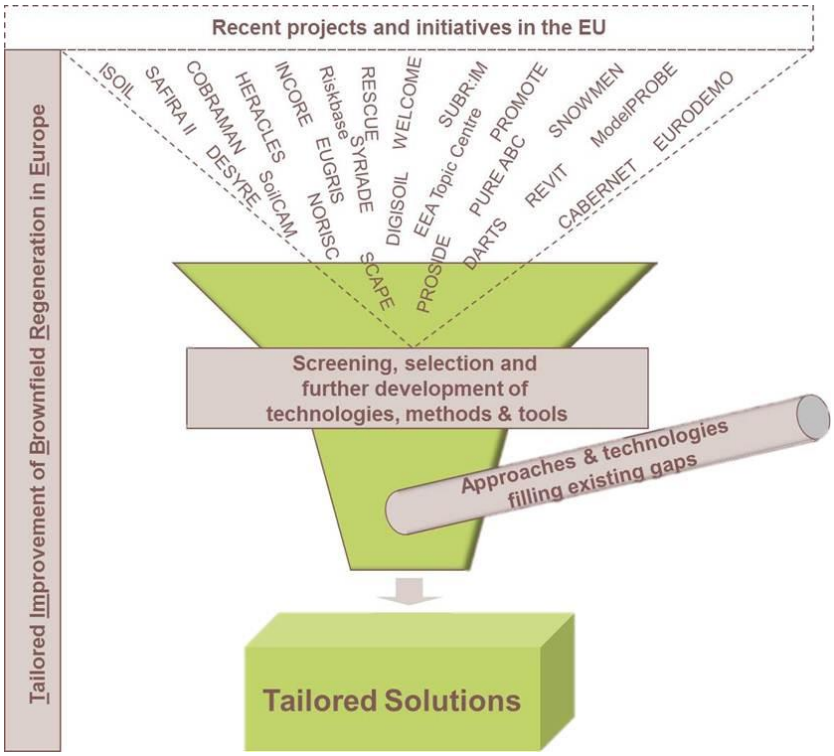
The reports and guidelines elaborated on improving the deconstruction and re-use of building rubble have been disseminated within several Timbre workshops at Timbre test sites in Poland and Romania and at international conferences, e.g. at EUROSOIL 2012, AquaConSoil 2013 and Timbre Final Conference in Bucharest 2014 to accelerate the impact of the research into practical application.

Dissemination

In order to achieve a widespread acceptance and utilisation of the results (products) that Timbre has been emerging, a series of tailored supporting measures for specific end-users was developed. For each result adequate packages have been designed according to the requirements of different target groups. Appropriate approaches were needed that increase the visibility and hence the application of Timbre products throughout Europe and beyond.

The Timbre dissemination actions were to support the project's overall objective to overcome existing barriers to brownfield regeneration by developing and providing customised problem- and target-oriented packages of approaches, technologies and tools, i.e. as illustrated in Figure 22, to filter out from the diversity and abundance of available instruments developed in recent programmes and projects those having the capacity to support the satisfaction of user-needs' requirements through a customisable toolbox specifically addressing the diverse processes that have to be dealt with during the course of a regeneration project. To this end, the Timbre web-based tool suite was developed to link the Timbre results and to enable end-users to find best information, technologies and practice based solutions. To facilitate these purposes, Timbre developed a tailored dissemination programme to transfer existing and emerging knowledge to its target groups, especially to the scientific community and end-users. The dissemination strategy built up on the identification of relevant actors/ networks for dissemination measures, interaction and networking.

Fig. 22: Timbre concept illustration.



In the duration of the project, activities for potential end-users were planned to include them actively into the development and final design of the Timbre outcomes. Therefore, a number of end-user specific events was organised that supported (i) fitting Timbre products to user needs and (ii) accelerate the implementation of products on the markets. It was scheduled that at least three events were to be performed each year of the project – in the end, more than 20 key Timbre events were (co-)organised partly with collaboration partners. For each of the events, such as technology workshops, technology application on demonstration sites, training courses, expert panels and scientific symposia, appropriate formats were developed that met the specific requirements of the corresponding product and its potential end-user group (e.g. site owners, developers, regulators). Next to the key-events a number of further disseminations activities have been prepared and documented such as presentations and posters at conferences and public workshops or technical meetings as well as different lectures. More than 150 dissemination activities have been initiated, including also social media usage of twitter® and linkedin® groups. Still, the main dissemination tool of the Timbre consortium has been its website: www.timbre-project.eu – which therefore shall remain online available for at least five years after termination of the project.

All Timbre events and products are documented by specific publications for the identified target groups. All documents are available for free and downloadable on the Timbre website as long as in line with copyrights and licencing restrictions (of e.g. academic journals). The publications address the practicability and windows of application for real cases of the Timbre tools and technologies. They include the description of approaches, methods, and technologies developed in Timbre for end-users. The publications clearly address their practicability and windows of application for real cases. In the reporting period, Timbre publications encompassed (i) Timbre event documentations, including workshop synthesis; (ii) Timbre tools documentations, manuals, applications and demonstrations; (iii) Scientific publications to disseminate distinctive scientific results generated within the consortium – in the reporting period, a considerable number of articles for publication in peer-reviewed and preferably in ISI-indexed scientific journals have been prepared. All partners in the consortium have been asked to negotiate and retain the copyrights for these activities. In total, by date of this report, 10 ISI-indexed articles have been published (or are in press) and further 14 are currently in preparation; (iv) Webinars as informative PowerPoint presentations and additionally including illustrative examples or exercises (such as calculation exercises) shall be provided on the project website; (v) Documentation of the demonstration of successful technology application and (vi) Standard operation procedures for proposed approaches and technologies.

5 Public website address, as well as relevant contact details

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Annex II: Figures as referred to in the Timbre Final Report

For the online submission of this report, all Figures are included in a separate file as Annex II.

Annex III: Contributors to the report and Disclaimer

Contributors

This report is the result of discussions between all partners of the Timbre consortium. It has been edited by Stephan Bartke (UFZ).

Disclaimer

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