Aggregates Resources Policies in Europe

Development of IT solutions for the Enhancement of Planning & Permitting Procedures

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Abstract-As the aggregates demand steadily increases, comprehensive legal frameworks as well as advanced technologies have to be established in order to provide a sustainable supply of mineral resources in the future. For the most precise determination of key factors within the aggregates supply-chain, a profound IT-based environment is crucial. The authors will discuss the actual state of affairs in Europe within the scope of this paper.

Keywords-aggregates, mining, mineral policy, economics, IT, system dynamics modelling, mineral resources

I. Introduction

In recent years, the need of aggregates – principally crushed stone, sand and gravel – has been increasing particularly in Eastern Europe and Asian economies like China and India. Some 3 billion tonnes of aggregates are needed annually in Europe, mainly used for construction purposes as structural sub-base materials and in concrete and asphalt products. Thus they are the vital building blocks of the domestic, commercial and social infrastructure of the European society. Taking an EU average price of € 7-8/tonne, in 2010 the European aggregates sector represented a turnover of around € 20-25 billion [1]. The lack of adequate and comprehensive aggregates planning policies including waste management has yielded some serious problems, which endanger sufficient aggregates supply: limited access to deposits, growing quantities of construction and demolition waste, lack of appropriate tools to indicate the future need of aggregates. Objective of this paper is to provide an overview of the economic importance of aggregates resources; to point out the requirement of appropriate aggregates resources policies for securing sustainable aggregates supply, based on new approaches and using IT-supported application tools.

II. The Demand for Aggregates and Linkage with Economic Growth

A. General Features of Aggregates

Natural aggregates can be defined as sand, gravel, crushed rock or a mixture of these, extracted from extensive naturally occurring mineral deposits either in the ground or from the sea bed. Manufactured aggregates are by-products of other extractive operations or industrial processes. Recycled aggregates can be sourced from construction and demolition waste, highway maintenance etc. in the meaning of the new European Waste Framework Directive, which was published in 2008 [2].

Naturally occurring aggregates can only be sourced from quarries and pits where geological conditions yielded suitable deposits. Gaining access to these increasingly critical deposits is becoming ever more difficult because of competing land uses (not only) across Europe, particularly in more developed, densely populated regions. Generally, an economical transport distance is limited to 30-50 km, also considering environmental reasons (CO_2): As aggregates are heavy and bulky, it is highly desirable from many perspectives that these be sourced local to the point of use, particularly where transport by rail or ship is not possible, as is usually the case. Therefore access to local aggregate resources is a key, fundamental and critical issue [3].

B. Interrelation between GDP and Resources Consumption

The economic importance of a sector in a country's economy is usually measured by its contribution to the gross domestic product (GDP) as well as by the job-creating effects of the respective industry. Usage of aggregates is a function of the state of a national economy: Together with the growth of the economy, the demand for sand, gravel and crushed stone increases, as they are essential for infrastructural development and commercial and domestic building activities. In highly developed economies, the demand for aggregates stabilizes at a high level (i.e. 10-12 t/c). In this connection, the degree of industrialization or development of an economy is of fundamental importance.

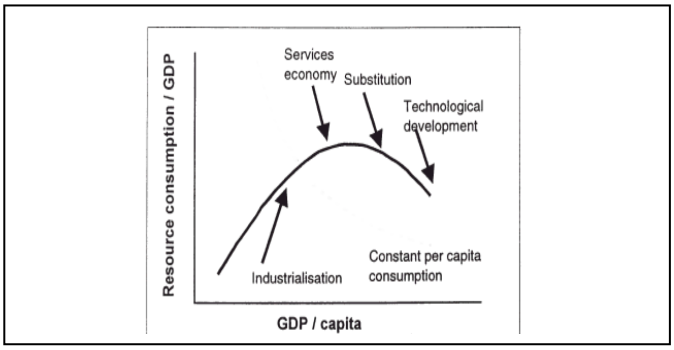

Figure 1. Resource consumption – GDP [4]

Obviously, the structural changes of a nation's economy are reflected in the development of the intensity of material use. It is a fact that in national economies running through the process from primary to secondary sector, the consumption of raw materials *increases* in the same or even a higher degree than the economic performance, industrialization being a material-intensive process. In turn, when the tertiary sector increases, resource consumption decreases, also due to substitution and improved technology (see figure 1).

C. Aggregates Consumption – Global and European View

Aggregates consumption can be defined as production of natural and manufactured/recycled aggregates inside a region (i.e. district, county) + import – export. Figure 2 illustrates the global view in terms of economic growth. In the future, major growth markets will be Eastern Europe, India, China, followed by other Asian economies.

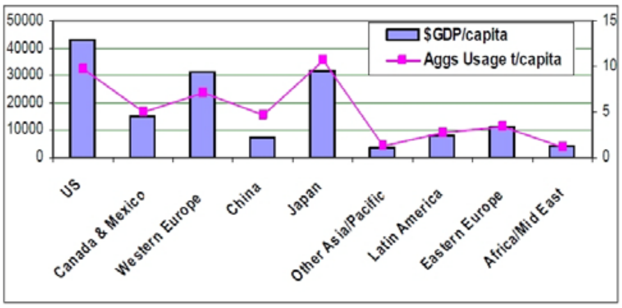

Figure 2. Global aggregates production – tonnes/capita (right vertical scale) & GDP($)/capita and world construction aggregates demand projected 2006-2011, annual growth of rate [5]

At a European level, the linkage between economic development and aggregate consumption differs widely, depending on the various stages of economic development of the different countries. Since the rate of economic development of the new Member States (or Associating countries, particularly those of the south-eastern part of Europe) of the European Union (EU) is considerably higher than that of the old Member States, aggregates consumption will grow substantially in the former in the medium term. Croatia, which will become a EU Member State in 2013, is a good example. All the observed regions in Fig. 3 show a direct linkage between economic growth and aggregate demand [6]. Approx. 60% of the produced aggregates are exported to other counties within Croatia; the region supplies the city of Zagreb (capital of Croatia) with approx. 30% of the aggregates needed for the building sector. Moreover, the revenues from aggregates production in the respective area are about 2% of the total revenues in the counties, but the aggregate production indirectly contributes to the building sector which yields approx. 10% of the revenues in both counties [6].

D. Aggregates Demand Forecasting in Europe

Chapter 2 of the UEPG-report analyses the current and future aggregates demand in Europe [1]. It concludes that, based on extensive data on national and European consumption and economic development profiles, the demand for aggregates in Europe will continue to rise. As economies continue to grow, this could potentially mean aggregate demand to rise from the current 6 tonnes/capita to as much as 9-12 tonnes/capita, indicating steadily growing future demand. Therefore it is reasonable to anticipate that European demand for aggregates will reach 4 billion tonnes in the medium term, driven mainly by economic growth *in Central and South-Eastern Europe*. This growing demand for aggregates highlights the need for a policy to ensure sustainable supply of natural aggregates in Europe into the future, and for economic and environmental reasons, this necessitates access to local raw material resources.

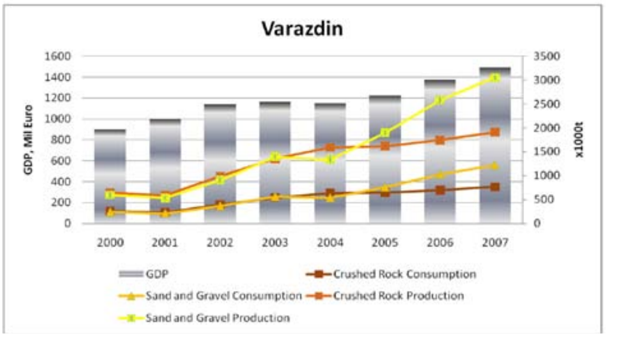

Figure 3. GDP + production + consumption per capita for the Varaždinska and Međimurska counties between 2000 and 2007.

III. KEY ISSUES OF AN AGGREGATES POLICY FRAMEWORK

Only very few Member States of the EU have a well-structured response to the future sustainable supply of aggregates [1]. This may reflect a lack of understanding of the vital role of aggregates in fulfilling society's physical needs. Evidently, in the absence of such policies, aggregate supplies may become critical in several regions, leading to local supply deficiencies with costly consequential inefficiencies in transport, energy usage and CO_2 emissions. Hence the urgent need for establishing aggregates planning policies in all Member States has also been addressed by the new Communication of the European Commission [7]. However, developing of such policies requires new approaches/tools.

Both authors have been involved in projects which are concerned with this issue, particularly the ANTAG project (see section IV) and the SARMa (Sustainable Aggregates Resources Management) project. The SARMa-project started in May 2009 and will finish by the end of 2011. The main objectives of the SARMa-project are to develop a common approach to Sustainable Aggregate Resource Management (SARM) and Sustainable Supply Mix (SSM, i.e. using both natural and manufactured/recycled aggregates) planning, at three scales (local, regional/national and transnational), to ensure efficient and secure supply in South-East Europe [8]. The project includes also the waste issue, i.e. Construction and Demolition Waste (CDW), which has increased considerably in Europe in the last years: For instance, according to the Austrian Federal Waste Management Plan 2006, 22 Mt of waste excavation materials were accumulated in 2004 (2.7 Mt/c), whereof 6 Mt CDW.

An innovative approach of the SARM/SSM projects is, for example, to ensure on one hand the supply with aggregates resources and on the other hand to improve resource efficiency *and* solve the problems of land use. It is recommendable to work on natural and manufactured/recycled raw materials at the same operating establishment. First, (natural) aggregates are exploited; afterwards the resulting hollow spaces can be used as dumping grounds for the communities, e. g. as dump site for construction and demolition waste. Thus a reduction of landfill volume is reached by extraction of recycled aggregates from construction and demolition waste (using the *same processing plant* as for the processing of natural raw materials). In this way, land use is reduced, which is especially important for densely populated countries such as Belgium, Germany, The Netherlands, Switzerland, Austria and Liechtenstein.

Recycling can make an essential contribution. In 2008, recycled aggregates in Europe reached 216 million tonnes, which, although very significant, was only 6.1 % of the total aggregates demand. This shows that there are very high levels of recycling (about 20 %) in some countries, e.g. United Kingdom, Belgium and The Netherlands, corresponding to almost full (90 %) recycling of all demolition materials available [1]. However, most of the other European countries still are at low levels of recycling – this message is clearly indicated through the SARMa-project process. Generally, in sparsely populated countries the economics of recycling are less attractive compared with densely populated regions. In the medium term, the average rate of recycling across Europe is therefore unlikely to exceed 8 –10 %, unless sufficient and appropriate policies will be implemented.

Consequently, it is crucial that national governments should be encouraged to develop appropriate policies based on short, medium and long-term aggregate demand and supply scenarios for the regions at different development stages, taking into account the waste issue, future development plans, and also including natural waterway export routes to adjacent markets which lack aggregate deposits.

IV. IT-SUPPORTED APPLICATIONS

In order to provide such scenarios and to generate a coherent framework for a sustainable aggregates minerals policy, well-founded forecasts considering aggregates application are essential. On the European level, the so-called ANTAG-project was established for certain regions of France and Austria (region Lower Austria and Vienna, capital of Austria) [9]. Jacques Schleifer and his team at the École des Mines de Paris cooperated with the Chair of Mining Engineering and Mineral Economics of the University of Leoben, Austria. The aim of this project was to generate a computerized software toolbox indicating future trends in terms of construction minerals based on System Dynamics Modelling. As a result of the successful project approach, the tool shall be used for supporting the development of the Austrian Mineral Resources Plan. Besides, further developments are in progress.

The software toolbox consists of mathematical sub-models interlinking specific parameters of the aggregates supply chain. Identifying the main parameters and drafting loops is the first step for setting up a new model. The generated sub-models were afterwards arranged by several categories such as “consumption”, “transportation” and “energy”.

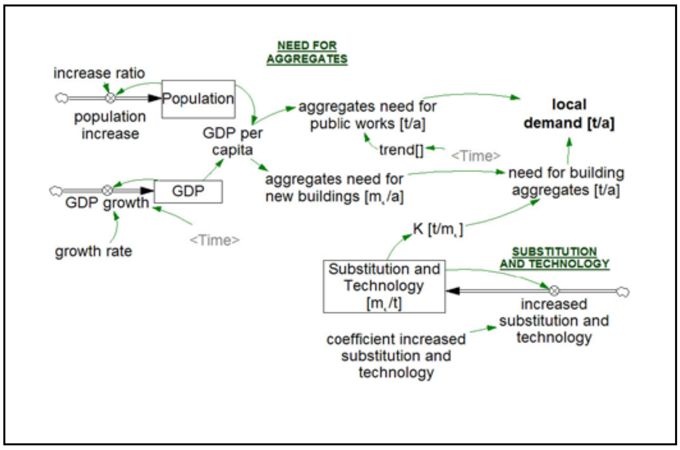

Figure 4. Example for a sub-model (aggregates consumption)

The sub-model consists of various parameters such as different growth rates, GDP and population. Each single parameter has to be individually calibrated with mathematical equations. The fundamental basis for this task is to compile relevant data over a certain time period which is later converted to equations using the Regression Analysis method.

Regression analysis is a widely used method for investigating functional relationships between variables. The relationship is expressed in the form of an equation or a model connecting the response or dependent variable and one or more explanatory or predictor variables.

Fig. 5 confirms the discussion of section II: simultaneously with growing economic performance, the demand for construction materials rises up to a certain saturation level; after reaching this level, the demand for aggregates declines (indicated by the red vertical line). Simplified, this means that the higher the economic performance of a national economy, the higher is generally the demand for mineral raw materials. Accordingly, there is a narrow correlation of the per capita income and the specific aggregates consumption of a country. Fig. 5 shows that the correlation of economic development and consumption in the Lower Austria region and Vienna is positive in a wide range; in other words, the raw materials demand indicates income elasticity. As a consequence of the increasing portion of the service sector it comes to a decoupling of economic growth and raw materials consumption, and material intensity declines (dematerialisation). In the case of the regional development in Lower Austria and Vienna, the decoupling of economic performance and aggregates demand will take place – according to the model – after a bit more than two decades in the simulation period. At this, a maximum aggregates demand of more than 45 billion tonnes would be reached (this is nearly 50% of today's total production in Austria). With regard to the decoupling (raw materials reduction), substitution, increased material efficiency and improved technologies play essential roles.

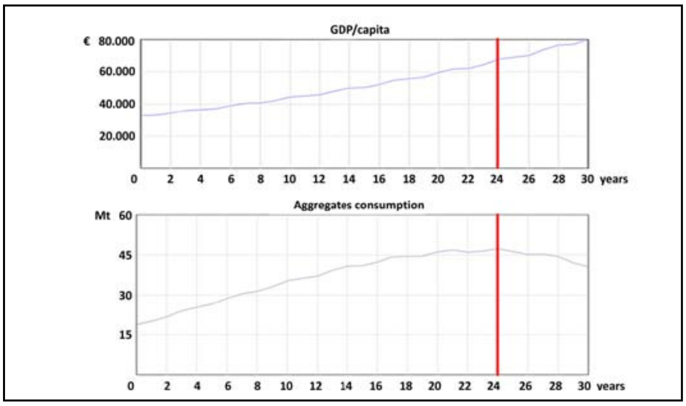

Figure 5. GDP per capita and aggregates consumption of the Lower Austria region and Vienna in the simulation period

a) Construction and demolition waste

Besides the demand and supply issue, another essential point to be considered is the construction and demolition waste (CDW). In the same time (i.e. simulation period of 10 years) the amount of CDW will be strongly increasing. Therefore it is important simultaneously to simulate the CDW development and the need of aggregates. As mentioned, the so called SARM and SSM planning approach account for the importance of the issue. Moreover, considering the high portion of demolition and construction waste on total waste volumes, the European Parliament and the European Council introduced a new Waste Framework Directive (2008/98/EC), defining that 70% of non-hazardous demolition and construction wastes must be recovered or recycled by 2020. Complying with this directive requires appropriate aggregates policies (e.g. aggregates levy taxes), boosting the recycling of CDW, considering market prices (which are presently low). Fig. 6 shows the sub-model "Recycling of CDW". As for Austria, the results of the simulations indicate an increase of CDW from 6.25 Mt (2005) to 7.5 Mt in 2015. Concurrently, the recycled amount of CDW will increase from 4.4 Mt to 5.5 Mt which results in a quite steady recycling quota of approximately 75%.

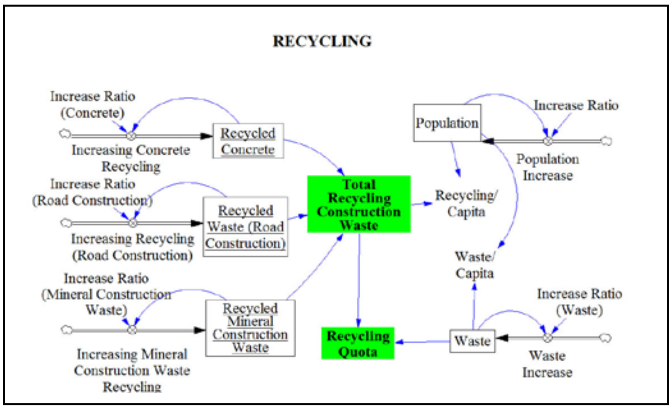

Figure 6. Sub-model recycling

b) Transportation

Transportation is an important part of the ANTAG model, different simulations can be generated. At an average transport distance which remains constant over the time period, CO_2 emissions increase due to the continuously increasing transport volume.

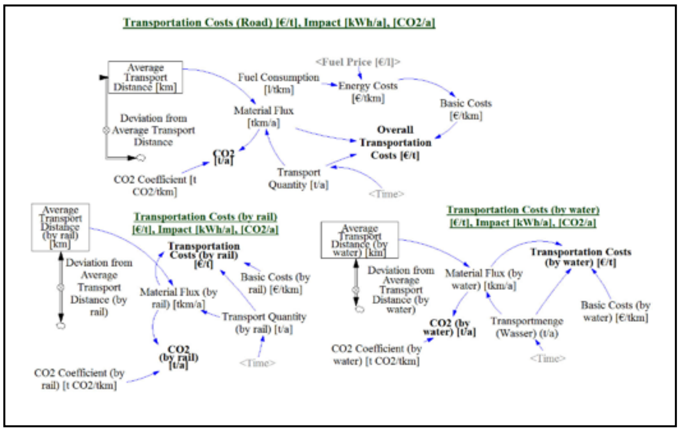

Figure 7. Sub-model transport

V. CONCLUSIONS

With the increasing need of aggregates, also the inherent problems related to aggregates production and consumption are increasing. In all regions of the World, whether they are developing and emerging economies or mature industrial states, appropriate policies are required to enable the balance between demand and supply, production and environmental impact, infrastructural construction activities and climate protection. This global challenge requires new approaches and tools, particularly IT-supported applications to generate realistic models and simulate different scenarios. Such scenarios are needed to provide decision makers with efficient tools to decide about the implementation of adequate policies.

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