

# **A HOLISTIC SOCIOECOLOGICAL SYSTEMS APPROACH AT THE REGIONAL LEVEL – THE EMPI (EMMI).**

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## **ABSTRACT**

In this paper the EMPI [EMMI] approach is described together with its use and intended use in the Mid Sweden region, the counties of Jämtland and Västernorrland. EMPI is an abbreviation of the Swedish words “Energi, Materia, Pengar och Information”, which in English gives EMMI: Energy, Matter, Money, and Information. The EMPI [EMMI] approach has to some extent so far been used in a project assessing the ecosystem services in the five northern counties of Sweden, “Norrland”, and later in a strategic document regarding energy and climate on the county level. The emergy methodology (by H.T. Odum) has been the inspiration for the EMPI [EMMI] approach. But since the emergy concept is not yet fully accepted by the scientific community, the EMPI [EMMI] approach does not use the controversial parts of the emergy approach, but rather has the aim to work as a general background material for any regional analysis, may it be emergy, ecological footprint, material flow or substance flow assessments, regional monetary accountings or other types. Finally future plans for the EMPI [EMMI] approach is presented, as application on the watershed level connected to the EU Water Framework Directive, and further development of the ecosystem services concept. Maybe most interesting is that the work with the EMPI [EMMI] and emergy approaches have revealed a lack of measure for quality aspects of information. The scientific community seem today only use the quantitative measure of information, the bit, while the general public definition of information includes a large qualitative aspect.

Keywords: emergy, socioecological, regional

## **INTRODUCTION**

The first EMPI [EMMI]<sup>1</sup> document was saved early one morning at October 13, 2007. Under the heading “Flows and stocks of energy, mass, money and information in Jämtland county 2007 - a systems analysis prestudy”, it contained the following (Grönlund, manuscript 2007):

In theory, there is no more comprehensive decision support for a county other than a survey of the flows and storage of Joule, Kilograms, Crowns [the Swedish monetary unit], and Bits. Science simply does not know any other types of flows. In practice it is very difficult to carry out this survey, and the decision data we use in the county are all sub analyzes, each with its boundaries. In practice, the sub analyzes are also often held apart: money for themselves, and energy and mass on its own. Information studies are as yet very rare, except in the case of computing power.

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<sup>1</sup> EMPI is an abbreviation of the Swedish words “Energi, Materia, Pengar och Information”, which in English gives EMMI: Energy, Matter, Money, and Information.

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It is questionable whether it is time-efficient to try to determine all flows and stocks in the county. The sun deliver 1300 W/m<sup>2</sup>, whatever we do, ... A holistic analysis can make us more clearly see the opportunities and constraints for development in the county.

And as the objective:

In this study, we try to identify the flows of energy, mass, money and information contained in Jämtland County. We do not, however, take the analysis further in this document, for example, make exergy accounts based on energy flows, or emergy accounting from all types of flows, nor make any scenario analysis. Such analysis may be done in their own documents. This compilation is rather a basic document for any type of detailed analysis than you intend to do.

### **OBJECTIVE**

In this PAPER the EMPI [EMMI] approach is described together with its use and intended use in the Mid Sweden region, the counties of Jämtland and Västernorrland.

### **HISTORY**

In 1997 the Division of Ecotechnology (or Ecotechnics, which was the English word used at that time, Thofelt 1995), was searching for an available scientific theory as a base for its very practical interdisciplinary environmental focus. This since the rather small regional university was applying for full university status (which later success as Mid Sweden University). The slogan for the Division of Ecotechnology was (and to some extent is): “Ecology, Economy, and Technology together for a Sustainable Development”. Everyone who has touched these questions know that there is a huge theoretical gap between ecology and economy, as is also the case between natural and social science, sometimes called the C.P. Snow gap (Snow, 1955, Grönlund et al, 2009). One of the methods found, however, bridged over this gap: the emergy concept by H.T. Odum (1983, 1994, 1996, 2007). Since the emergy methodology could handle energy, matter, and money within the same theoretical framework it fitted well to the slogan. It is from the use of this method the following decade that the EMPI [EMMI] approach has been developed.

Expressions in the emergy literature as: “waste energy is not a relevant concept when you go to the next higher hierarchical level, it is already in good use in biosphere”, was the inspiration for putting the regional energy plan in context of the larger scale, as described below in the EnKlim project.

However, the emergy concept is not so easy to grasp, probably because it included the quality aspects of energy and therefore divert to some extent from the traditional scientific use of the energy concept, se figure 1. The emergy concept is not yet fully accepted by the scientific community, probably for this reason. The energy hierarchy concept, which provides the basic definition of the emergy concept is probably non-controversial in the scientific community. However, it is often shaded by the maximum empower concept developed before and in parallel with the emergy concept, and is highly controversial among scientists.

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Measures used in the scientific community		Perception of the scientific community		Perception of the general public	
Quantitative	Qualitative and quantitative	Quantitative	Qualitative and quantitative	Quantitative	Qualitative and quantitative
Energy, J	Exergy, J Emergy, seJ	Energy, J		Exergy, J Emergy, seJ	
Mass, kg	Type of atom- & molecule, kg Material, kg		Type of atom- & molecule, kg Material, kg	Type of atom- & molecule, kg Material, kg	
Money, numbers	Money, € \$		Money, € \$	Money, € \$	
Information, bit	- (missing)	Information, bit		- (missing)	

**Figure 1. Flows in the universe known to the scientific community and the major perception of the by the scientific community and the general public (Adapted from Grönlund, 2009).**

### Ecosystem services in Northern Sweden 2007

The EMPI [EMMI] project started in autumn 2007 as a subproject to a rough assessment of the Ecosystem services in the Northern counties of Sweden. Every year the five counties of Northern Sweden – constituting the region “Norrlund” – have a conference, and 2007 one of the conference themes was Ecosystem services. To this conference a small project was started with the objective of giving a rough approximation of the size of the ecosystem services in the Northern counties. The emergy approach was chosen, since it produces a value of annual renewable inputs to the systems investigated. The results are presented in Grönlund (2008). Some aspects of the project relevant for this paper are presented below.

#### *Holistic systems diagrams*

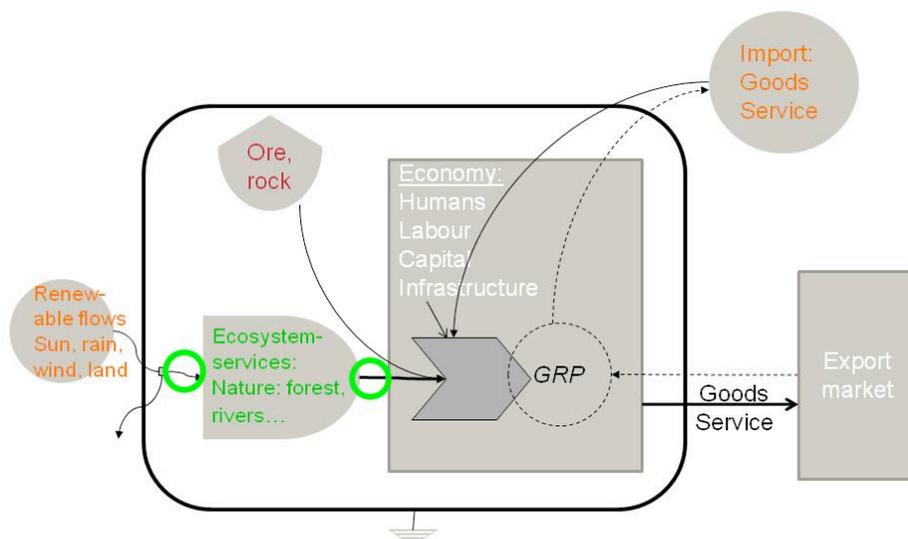
The emergy methodology is holistic in the sense that it takes its starting point from what is driving the total biosphere a chosen year, the so called baseline (Odum 1996, Odum et al. 2000). From the baseline is then allocated the appropriate part to the investigated regional or local analysis. The systems border is of great importance in the emergy methodology. In figure 2, with high degree of aggregation, is shown:

1. Renewable driving forces flowing across the systems border of the county as sun radiation, rain, wind, and land cycle changes (orange text to the left),
2. Storage within the county of renewable character as forests, lakes, rivers, agriculture land, wetlands, and other natural systems (green text),
3. Storage of non-renewable character as ores and rocks released during the year 2002 (red text),

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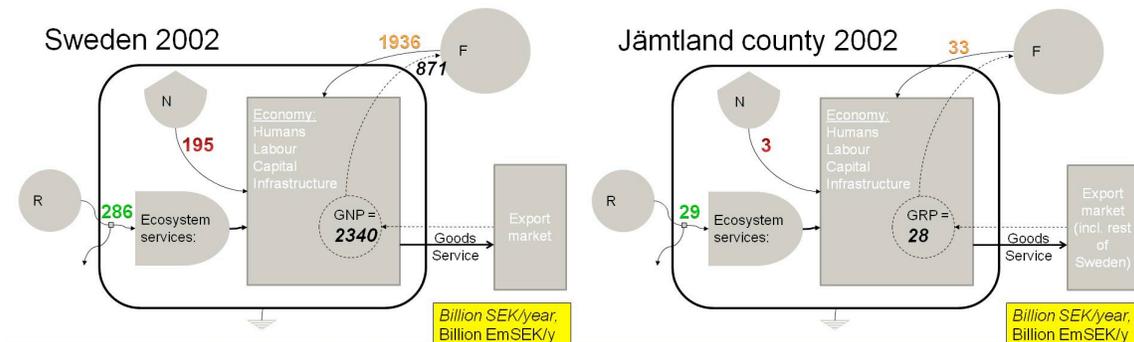
4. The “items” or “storage” in the economy: humans, humans in their special aspect as labour, capital and infrastructure (white text),
5. The imported goods and services as driving forces crossing the systems border from other counties and countries.
6. The imported goods and services (orange text to right),
7. The goods and services exported from the county to other counties and countries, labeled “export market” (white text to the right),
8. The gross regional product (GRP), the flow of money that circulates within the county (dotted circle) as an effect of the interaction between the renewable and non-renewable resources, the economy, and the imported goods and services. Part of the GRP is used to pay for the imported goods and service to the county, and part of it is payment for the exported goods and service (dotted flows).
9. The ecosystem services are represented as the flow marked by the right green circle. This was not possible to assess within the timeframe of the project. Instead the left green circle was assessed, which was done within a couple of days work.

In figure 3 the assessed values are given for Sweden and for Jämtland County for the year 2002 in SEK, the Swedish currency, and EmSEK, the emergy flows expressed in a unit with parallel scale to the ordinary monetary scale and therefore comparable. In the picture the GNP (2340 billion SEK) and GRP (28 billion SEK) values as well as the payment for the imported goods and services (871 billion SEK) are ordinary, “normal” money. The other figures are EmMoney, in EmSEK. In the left figure the difference between the values 1936 and 871 is the ecosystem services imported from other countries. These ecosystem services can be either historical (e.g. the ecosystem work behind oil) or from other parts of the biosphere 2002 (e.g. the ecosystem services behind forest or agriculture growth). Unfortunately this figure was not available in the regional investigation.



**Figure 2. Generic emergy diagram for a county. GRP is the Gross Regional Product. Adapted from Grönlund (2008).**

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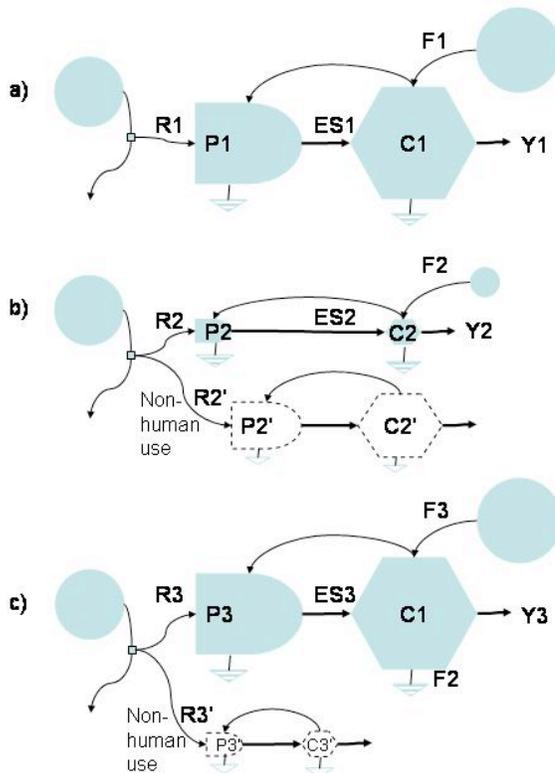


**Figure 3. The estimated flows of energy, material, money and information in Sweden 2002 and in Jämtland county 2002. Both figures adapted from Grönlund (2008), data in left figure from Hagström and Nilsson (2005), data in right figure from Grönlund (2008).**

### *Systems borders, anthropocentrism, and ecocentrism*

After the assessment of the ecosystem services in the northern counties described above a methodological discussion was initiated and presented at an emergy methodology conference in 2008 (Grönlund and Salomonsson 2009). The conclusion was that according to the emergy accounting rules (Odum 1996) the ecosystem services value must always be larger than the R value (renewable) in opposite to the conclusions in Grönlund (2008), see figure 4.

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**Figure 4. Adapted from Grönlund and Salomonsson (2009). According to the energy algebra (Odum 1996) the ecosystem services, ES, must always be larger than R when an independent source F is available.**

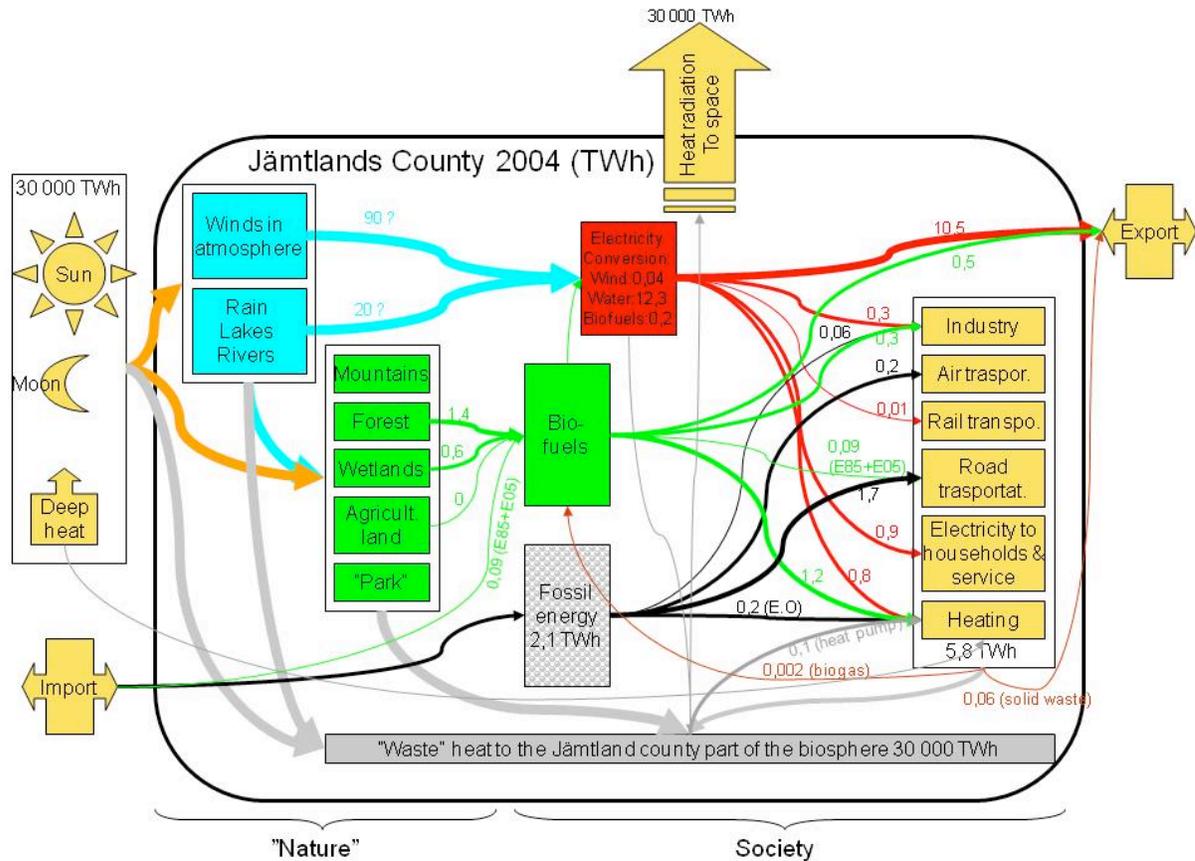
A possible explanation of the different outcomes may be the view of anthropocentric and ecocentric perspectives. The systems window used in figure 2 can be interpreted as using an ecocentric perspective since the system is in focus, which includes both the society (economy is here used in its broader sense, not just where money is flowing) and the natural systems. The term ecosystem service has been defined from an anthropocentric perspective to give value to the services natural systems provide to humans without receiving any payment. A true anthropocentric system in energy methodology have to have its systems border around one human if hard core neoclassic economic theory is used, or a group of people – family, city, county population, country populations – if not so hard core neoclassicist or belonging to another (minor) economy paradigm (the economy paradigm question is further discussed in (Grönlund et al. 2009).

### EnKlim 2009

The EMPI [EMMI] approach was touched again in 2009 when all county administrations in Sweden were supposed to make a strategy document regarding energy and climate (County Administrative Board of Jämtland, 2009). As a small part of this work an attempt was made to put the energy question in a larger scale context using the EMPI [EMMI] approach. This resulted in a text regarding energy and energy quality, and a systems

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diagram, see figure 4. In this approach available data, mainly from the energy sector were put into the context of a larger scale. In this larger context it became evident what was energy sources and energy carriers, a division that is not always very clear in energy policy discussions. The position of heat pump energy is also put in its right context. But most striking is the large amount of energy that is flowing through the natural systems compared to the human systems. In spite of this the small human use often has a large impact on the much larger flows coming through “nature”. The expression “feedback flows as control flows” really comes alive in these type of diagram (even though the feedback flows are not represented in figure 5, since they are carrying so small amounts of energy along with the high qualitative information flows).



**Figure 5. Energy flows in Jämtland County 2004, as presented in the EnKlim project. Adapted from the EnKlim report (County Administrative Board 2009).**

### Experiences from the EMPI work so far EXPERIENCES FROM THE EMPI [EMMI] SO FAR

The EMPI [EMMI] work is not done easily, but is a time consuming activity. Some conclusions that can be drawn so far from the work in Jämtland county are:

- Many energy numbers available. The energy sector has made many estimations on available kWh of bioenergy, hydropower, wind energy, heat pump energy, and so on.

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Estimations is also often easily available through meteorological data on sun radiation, rainfall, and wind.

- Fewer material number available. The material “metabolism” of the society is often not recorded. This was also the conclusion of the large investigation in five industrial countries made by Matthews et al (2000).
- Many money numbers available. Monetary costs are often estimated in planning documents, and also in regional statistics to measure the economic activity in different sectors.
- Very few information numbers available. Information is very rarely measured or estimated. A growing field is of course the IT sector where connections are measured in bits per second and similar units. But in social science information measures seem to be rare, and in everyday practice in society it is never used outside the IT sector.

Regarding information many information numbers are probably not available to quantify at all as is discussed in the context of hard and soft thinking. However, it is interesting that a quality measure of information seem to be lacking, see figure 1. And that the general public’s perception of information is in quality terms rather than in only quantitative terms of bits, as used by the scientific community.

### **FUTURE EMPI [EMMI] WORK IN WATERSHEDS**

The last decade the European Union Water Framework Directive<sup>2</sup> (WFD) has been implemented in the EU countries. It has an approach in the holistic direction, since it use the water shed or the water basin as a main unit. All the land area of Europe is therefore covered to some extent. The WFD has been described as a meeting point of ecology and economy. There are substantial descriptions of ecological measures that need to be assessed in appendices to the WFD. Regarding the economic assessment the WFD Article 9 about “Recovery of costs for water services“ says:

“1. Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs...”.

To some extent environmental economics or ecological economics is going to be used in the WFD. Hopefully this means that numbers will be produced with relevance to ecosystem services.

The WFD is not similar to an EMPI [EMMI], but heading in that direction. A work has been initiated to apply the EMPI [EMMI] approach to two major watersheds in mid Sweden: River Ljungan, and River Indalsälven.

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<sup>2</sup> **Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.** *Official Journal L 327 , 22/12/2000 P. 0001 – 0073. Available 2011-05-14, <http://eur-lex.europa.eu>*

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### **OTHER FUTURE RESEATCH QUESTIONS**

The EMPI[EMMI] approach opens up the following lines of thinking (among other) to the author of this paper:

- Lack of an information quality measure. Is there really no qualitative measure of information quality? This is a fundamental question to science, and further search probably reveal that there are at least attempts for this somewhere in the scientific literature.
- Being strict with systems border, both in space and time. Starting working with system diagrams reveals that in everyday thinking it is common for the human mind to jump frequently between system windows in space in time. We, seem to have a scenario “machine” built in to our brains. However, representing these fast jumps graphically is really challenging. And jumping fast between different scales of systems border without being fully aware of it seem to be misleading the logic thinking in some cases. So, investigating the line of being more careful in relation to the system borders seems interesting and maybe fruitful.
- Ecosystem services – it is an interesting confusion that the emergy methodology seems not to be fully compatible with the current definition of ecosystem services. Two tracks may solve this confusion:
  - Systems border view, as described above
  - Active/passive. Ecosystem services seem currently to be defined in very passive term, what the ecosystem gives to humanity without being payed. One of the basic concepts in emergy thinking is the autocatalytic process, where a small control flow feeds back to amplify a larger flow to deliver more. Regarding several ecosystem services this picture fits better with reality. For example in forestry the society invest resources in cultivation of the forests to harness the large flows of energy that work as the driving force for forest growth. This pattern is even more clear in agriculture.
- Comparison of environmental assessment tools (ESA). ESA used on the regional level all use EMPI [EMMI] data, but in with small differences in treatment and interpretation. This goes for the emergy assessment mentioned above, ecological footprint and other footprint approaches, MFA (material flow assesement), SFA (substance flow assessment), and more. The data gathered in the EMPI [EMMI] process can be used to compare and evaluate these tools.

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