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Promotion And Assessment Of Early Stage Technologies By The Eminent Initiative Supercritical Water Gasification Technology As An Example

Jan Zeevalkink, Jaap Koppejan, Wilfrid Hesseling,
TNO Science and Industry PO Box 342 7300 AH Apeldoorn Netherlands
Mailto: jan.zeevalkink@tno.nl

The aim of the EMINENT initiative is to identify and accelerate the introduction and implementation of innovative leading edge European energy and environmental technology into the worldwide market place. The EMINENT software tool to be developed is supposed to be capable of identifying and assessing the potential of early stage technologies (ESTs). This paper describes the main activities in the Eminent initiative. Supercritical Water Gasification is described and analyzed as an example of what the web-based Eminent software tool is able to achieve. The Eminent initiative is supported by DG-TREN.

1. The EMINENT initiative

Introduction

The first EMINENT (Early Market Introduction of New ENergy Technologies) project was launched by the EC DG TREN in 2003. This three-year-long project has achieved substantial results in all its key areas. Recently it has been granted for continuation until 2008 (EMINENT II). The main objective of both initiatives is to identify and accelerate introduction and implementation of leading edge European energy and environmental technology into the market place in Europe and worldwide. The EMINENT project is coordinated by TNO and the project consortium consists of:

- SINTEF Energy Research, Norway; University of Manchester UK;
- Instituto Superior Technico, Portugal (IST);
- European Biomass Association (EUBIA);
- European Association for the Promotion of Cogeneration (COGEN Europe);
- Fraunhofer Institue for Systems and Innovation Research (Germay);
- Commissariat a l'Energie Atomique (CEA-LIS, France);
- EC Baltic Renewable Energy centre (EC BREC, Poland);
- University of Veszprem (Hungary);
- ETA Renewable Energies (Italy);
- CEPE Eidgenössische Technische Hochschule Zürich (Switzerland);
- Centre for Research and technology Hellas (Greece);
- Joanneum reseach (Austria);
- Chalmers University of Technology (Sweden).

EMINENT project consists of five the following main activities):

- Networking

- Development of web-based Eminent tool,
- Identification and evaluation for the potential for EST's,
- Dissemination,
- Strategy recommendations.

The EMINENT project contains the background information on the technologies in its database and generates information on the potential market for the technology and the prospective merits in terms of cost savings, CO_2 reduction and reduction of primary fossil fuel consumption by using the developed assessment tool.
This paper presents an overview of the project and the software tool. Also, an example of a novel technology in its early stage of development is considered in this document.

The EMINENT II initiative

The main items of the EMINENT initiative to strengthen the European industry and policy institutions by establishing and operating a network, are described below.

Networking
For industry and other developers of new technology, quite often, the transaction costs of new technologies are rather high and build an obstacle for the fast diffusion. One of the policy instruments to overcome the high transaction costs are local or regional learning networks. In EMINENT two of these kind of stakeholder groups in the form of Energy Tables will be established and the results of these local networks will be evaluated.

Improvement of existing software tool
The existing software tool for evaluation of early stage technologies will be improved to evaluate the performance and potential impact of ESTs under national conditions, in terms of financial, energetic and environmental criteria. The improved tool will be able to analyse what impact the EST can have in a predefined energy supply system

Evaluation of EST's
The evaluation of EST's is schematically presented in Figure 1.Criteria for evaluation of the performance of new energy technologies under national conditions will be applied, which fit closely to the aims of the EU energy policy (efficient supply of energy, implementation of the Kyoto protocol, security of supply).
The analysis tool will be used to identify options for application of EST. Performance data of new ESTs as supplied by R&D organizations and DG-Research through the project partners are continuously added to the energy conversion database and made available through the internet.
The energy system evaluation software tool will be used to analyze the potential socio-economic and environmental impact of early stage technologies per country. The tool is capable of evaluating local renewable energy supply chains with regard to efficiency, cost effectiveness and security of energy supply as well as CO_2 mitigation. Results of the evaluation are fed back to the thematic networks as well as to the respective R&D organizations that supply data on the new EST.

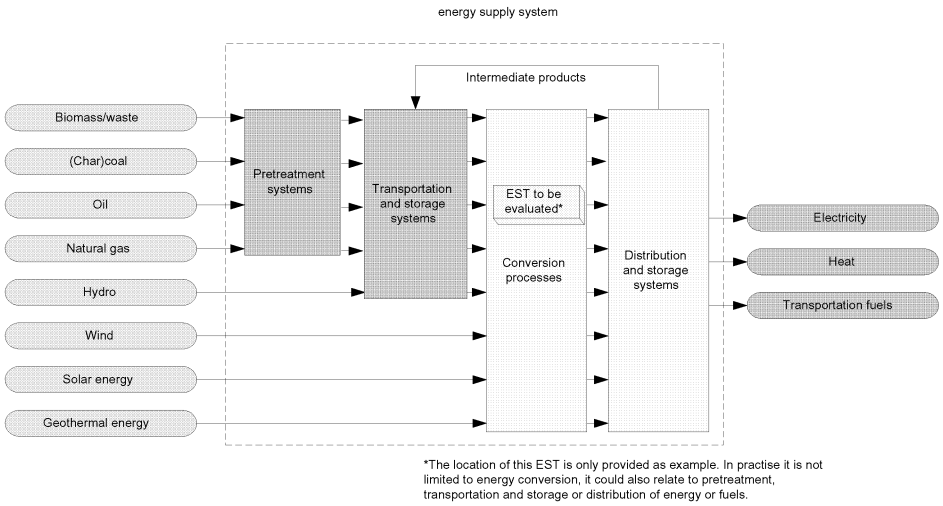

Figure 1 Evaluation of ESTs in the energy supply chain

Dissemination program

The above motioned activities will be accompanied by a dissemination program. This concerns the results through the existing thematic energy networks in the EU. The outcome of the analyses of EST will be used to advise thematic networks on the merits of application of the EST in a certain renewable energy supply chain.

Specific activities of EMINENT, offered to the thematic networks are:

- Preparation of 10 EST assessment reports, which illustrate the EST evaluation process by means of case studies per country or region
- Preparation of 2 thematic workshops on EST assessment;
- Preparation and continuously updating a website with technical performance data of individual technologies
- Preparation of a CD-ROM containing technical information and a version of the analysis tool

Conceptual approach for lead market identification

The conceptual background of the identification of suitable target groups for the dissemination activities is the lead market concept and the economics of technology diffusion. These are regional/national markets that first adopt an innovative solution and that have specific characteristics (Lead Market Factors).. The concept to be applied distinguishes three categories of factors influencing the probability of a country to become a lead market:

1. specific market factors (e.g. demand conditions, price conditions, market growth potential or the competitive situation).
2. firm specific factors (e.g. technological performance of the firms, their strategic positioning such as export orientation).
3. politics and regulation topics.

Possible indicators for the above mentioned factors are patent shares, number of competitors and their market shares, or government funding on R&D and market introduction.

After the lead markets have been identified and quantified, the information is used to estimate possible cost reduction perspectives by learning and economy of scale effects.

Evaluation and recommendations

The results of EST assessments produced are used to advise the Commission on the potential for application of the EST in different countries, covering technology, knowledge, education, market aspects, economics, incentives and partnership arrangements. The complexity of many energy-and-environmental systems calls for careful considerations – especially because such systems by nature are prone to be associated with inherently split responsibilities. Therefore, it is necessary to elaborate different strategies and recommendations considering the different realities. This analysis will be elaborated to help the adjustment of the software tool and the exploitation of the EMINENT results in the target regions.

Follow-up

EMINENT can be considered as the start of the European Energy Science Community. One of the deliverables is a business plan for follow-up of EMINENT. The business plan shall be completed by the end of year 1 of the project in order to enable a smooth follow-up. Exploitation of EST's through venture capitalists, IPR or patents should be considered in the business plan.

Brief Description of EMINENT Software Tool

The software tool developed within the EMINENT project has the aim to design possible energy supply chains and to evaluate each of them based on weighting factors given by the user. It consists of integrated resource manager, demand manager, EST manager, databases on resources, demand and EST's as well as the analysis tool (Fig 2). The resource manager describes details of resources available in the country, modifies and enters the new data, selects the data for technology assessment. Seven energy resources can be handled by the tool: electricity, fuels, geothermal, hydro energy, ocean tidal energy, wave energy and wind energy.

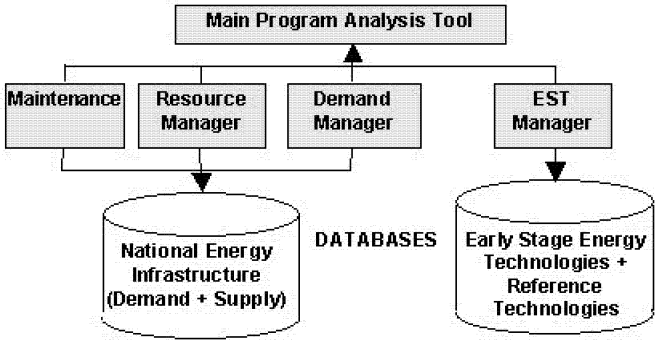

Figure 2 The EMINENT software tool

The demand manager describes details of energy demands per sub sector in a given country, modifies data and enters new data, selects data for technology assessment. The EST manager operates the databases which are an integral part of the tool, contains key data on a number of technologies that are either commercially available or in their early stages of development. The analysis tool is the central part of the software package. It provides the evaluation of the market assessment of full energy chains.

2. Description of Supercritical Water Gasification Technology (SWG)

The SWG technology is entered in the EST database but with additional background information. Suitable organic compounds for this early stage process should preferably meet the following criteria:

- Liquid or soluble in water, or pumpable slurry;
- Organic content more than 5 wt.%
- Low mineral content (Na, K: acceptable; N, S: precipitation risk)
- Low purchase price
- Availability at one location: at least 1 ton organic matter/hour, or more than 5,000 ton organic matter per year.

Organic compounds like ethanol, glycerin (from bio-diesel production) and sugar/starch type of feedstock are suitable materials for the process. This process takes place in a super critical reactor. The reactor operating temperature is typically between 600 and 650 °C and the operating pressure is around 300 bar. Heat exchange between the inlet and outlet streams from the reactor plays an important role to achieve high thermal efficiencies. The two-phase product stream is released from the reactor, and separated in a high-pressure (HP) gas-liquid separator. Due to these conditions, a significant part of the CO2 is dissolved in the water phase. In a low pressure (LP) separator, a second gas stream is produced containing relative large amounts of CO2. Figure 3 presents a schematic overview of the process.

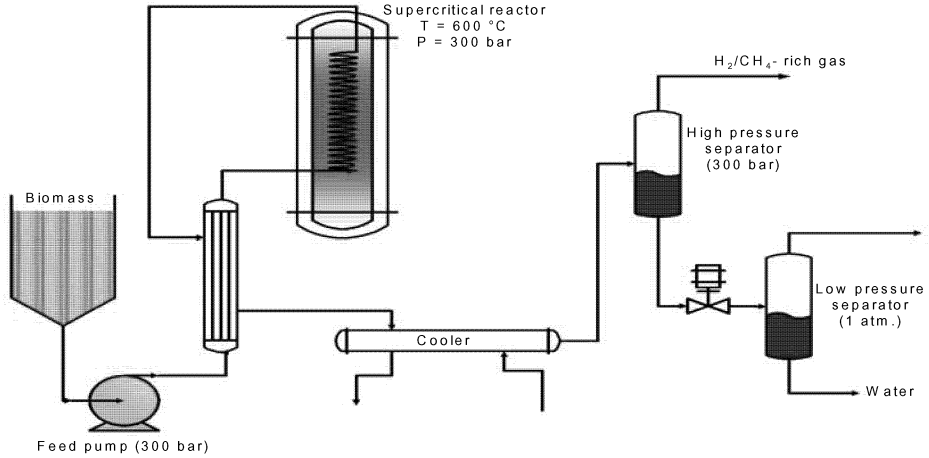

Figure 3 Scheme of Supercritical water gasification process

Experiments were and are carried out in a10 l/hr continuously operating pilot plant at TNO, Apeldoorn with liquid biomass (e.g. ethanol) and fossil fuels (hexane, gasoline, diesel).

3. Potential Impact due to the assessment with the EMINENT tool

For the SWG process the following starting points are selected:

- Input material: “Fuel”; Ethanol with a typical LHV (Lower heating Value) of 26.75 MJ/kg.

- Output material: “Fuel”; Hydrogen with a typical LHV of 120 MJ/kg.

The results are based on the use of ethanol with a fossil origin. Investment costs are based on the use of ethanol. Other biomass input material such as organic residues from households, food industry or greenhouses, roadside grass are cheaper but need pre treatment costs, which are not included. Investment in the total plant: €15,000,000 . This means 1,316 €/kW. O&M costs are estimated on 6% of the investment costs: €900,000 per year.
The SWG process is unique in the sense that it enables conversion of wet biomass into a high quality fuel with a high efficiency. Further, it is expected that it could become economically feasible within a few years.
The EST assessment compares the production cost and energy aspects of SWG with hydrogen production by a more traditional electrolysis route. The hydrogen consumer is a hypothetical Dutch refinery industry. The resulting main figures are:

Performance data for the subsector this chain delivers energy to

	This chain	**Reference chain**	**Savings**
Energy supply costs per unit delivered energy	122 €/MWh	167 €/MWh	45 €/MWh
Chain efficiency	74.6 %	74.4 %	0.3 %
Renewable fuels used	0 %	2.0 %	-2 %
CO2 emission per unit delivered energy	332.48g/kWh	604.94 g/kWh	272.46 g/kWh

The reference chain using electrolysis produces hydrogen at 167 €/MWh, (46 €/GJ) whilst the supercritical route produces hydrogen at 122 €/MWh (34 €/GJ) according to the theoretical financial data in the literature. The total CO2 emission reduction amounts to 272 g/kWh even using fossil ethanol. The reference chain used in this case for providing electricity to the same consumers is by using an electrolysis process, using for power production the Dutch energy mix containing 2 % renewables. Based on the cost figures and the volume of the selected subsector, the EMINENT tool calculates the potential volume of the market for SWG installations, the potential cost savings and CO_2 emission reduction.

Concluding remarks

The EMINENT II project aims at the transformation of the EMINENT tool to a powerful instrument for the evaluation of early stage technologies and the identification of market segments for which the EST can be successful on a short term.
It can contribute to an early insight in favorable market segments and volumes for ESTs and its potential contribution of energy and carbon dioxide savings.

Relevant publications

Sparqle International and others, Final report , 2006, by BTG, TNO,
Superhydrogen: Biomass And Waste Conversion In Supercritical Water For The Production Of Renewable Hydrogen.
J.M.L. Penninger, L. van de Belt and J.A. Zeevalkink, Presentation on the Renewable Hydrogen Economy. Manila, 2004, Supercritical water gasification: Sustainable hydrogen from wet biomass resources.