DRAFT – WORK PROGRAM

Recommendation from IEA HIA Task 16, subtask B[1]

IEA
Hydrogen Implementing Agreement (HIA)
Proposal for a new Task:

Near-market routes to hydrogen using biomass as a renewable energy source

[1] Task 16 – subtask B – Biomass to hydrogen

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Introduction

Hydrogen can be produced from a large number of energy sources, with different conversion technologies. It is generally expected that hydrogen production in the near and medium term will be based mainly on carbon containing materials. However, for introducing large scale hydrogen on the energy market it must be obtained from sources and by processes that are more sustainable than current energy carriers in terms of lower greenhouse gases and reduced fossil dependence. To achieve this, carbon-lean, and ideally carbon-free, pathways must be favoured for hydrogen production.

In 2002 the HIA started up Task 16 on *Hydrogen from carbon containing materials - By advanced thermal processes designed for minimal CO_2 emissions*. Task 16 comprised three subtasks ranging from large-scale hydrogen production with CO_2 –handling, hydrogen from biomass, and small-scale stationary reformers for on-site hydrogen production.

Subtask B on hydrogen from biomass started up in May 2002. The objective in Subtask B was to stimulate and accelerate research and development of hydrogen from biomass. The issue of hydrogen from biomass was a new activity within HIA and the emphasis has been on preparing assessment of state of the art, evaluating the technical and economic potential of different applications and analysing gaps and needs.

The approach has been market based, with the aim to identify most feasible routes for commercialisation and priorities of research and development needs along these routes.

Some of the highlights from the final report in Subtask B are:

1. Biomass represents a main pathway from renewable energy sources (RES) to hydrogen that can be implemented on a large scale without a need for R&D breakthroughs, albeit with continued and sustained demo efforts and without use of electricity already generated from RES.

2. Thermochemical routes for biomass gasification and processing the resulting synthesis gas to H_2, are clear candidates for commercialisation within a 10 year perspective. By continuing to adapt technologies of gasification commercialised for coal, the remaining work appears to be manageable, given a concerted industrial development effort. The current strong interest for Fischer-Tropsch fuels may constitute an important driving force for biomass gasification technologies and demonstrations.

3. In order to achieve economies of scale, large plants are needed; processing a minimum of 0.5 to 0.75 million dry tons of biomass per year. This requires either locating biomass-to-hydrogen plants in areas with *e.g.* large plantations, which could severely limit the number of plants worldwide, or transporting the biomass over long distances, which is both costly and energy-intensive. The transport requirement would in most cases require a location next to port to secure competitive supplies, and for the production output, pipeline infrastructure and/or nearby captive end-users are required.

4. Co-gasification of biomass with fossil fuels such as coal would extend drastically the scale of biomass processing – allowing improved economies of scale, reduce the need for transport of biomass to dedicated plants, and allow important application synergies.

5. An attractive path to market penetration appears to exist via the pre-processing of biomass resources by flash pyrolysis, a process that is competitive on a modest scale: 20,000 – 200,000 t/a. Plants in the lower range are already commercial, several processes exist. Such relatively simple plant may be located in areas with available biomass resources and the pyrolysis oil transported, like a normal liquid, to larger gasification plants where it can be processed to hydrogen.

6. There are important synergies with other uses for biomass-derived synthesis gas such as second-generation liquid biofuels, which could accelerate developments and reduce market introduction risk. Synergies could take the form of processing H_2-rich streams primarily to liquids – fuels or chemicals – or introducing biomass-derived hydrogen into existing non-energy markets. The majority of technical and operational hurdles of biomass processing, gasification and product optimisation would be shared between these applications. Possibly, plants may be designed for output flexibility without compromising efficiency.

The Subtask B members recommend a continuation of IEA – HIA work in a new IEA-HIA Task, based on the findings from the subtask B group on biomass pathways.

In the following we present a draft work-program for a proposed task on ***Near market routes to hydrogen using biomass as a renewable energy source.*** *(working title!)*

Proposed New Task:

Near-market routes to hydrogen using biomass as a renewable energy source: Integrated technology and policy development tools

Objective

The overall objective of the new Task is to advance the development of hydrogen production based on renewable sources in the market place, focusing on biomass and on opportunities of interest for industrial application.

The specific objectives are to

- Identify and evaluate feasible processes for co-gasification of biomass together with fossil fuels, e.g. coal;
- Quantify the potential for hydrogen supply and market building in a "combined/split" scenario of pre-processing the biomass resource by distributed pyrolysis, and using the resultant tradable intermediates as fuel in centralised (co-) gasification plants;
- Develop and verify a Roadmap for the market introduction of biomass-based routes to hydrogen.

These objectives form the basis for three Subtasks of the proposed new IEA-HIA Annex.

Approach

The work will be carried out in cooperation with the IEA Bioenergy Programme, related to their specific work on the technologies of biomass gasification and on pyrolysis; and with the IEA Greenouse Gas R&D Programme, specifically on their new proposed work on co-production of hydrogen and electricity. Coordination and information exchange with other relevant IEA Programmes will be sought when appropriate.

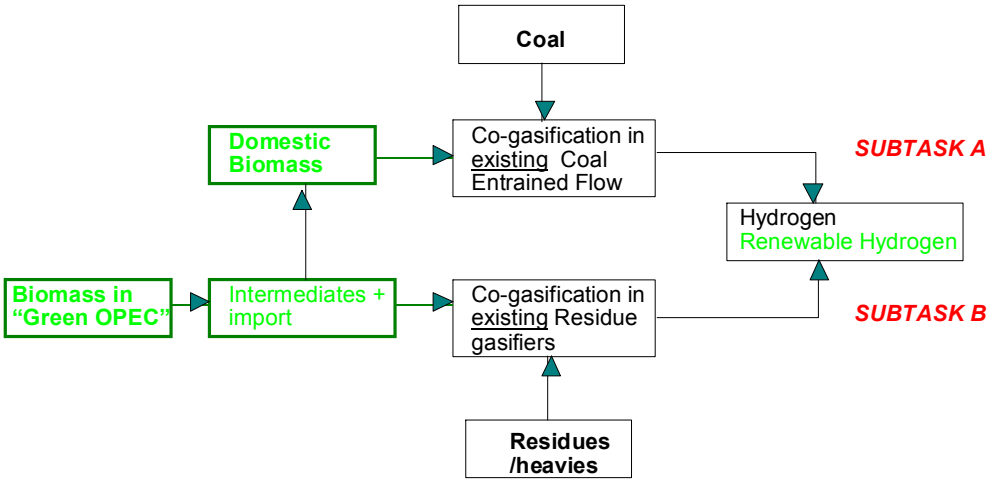
The participants will come from industries, research institutions and independent experts.

The Task will be mainly based on task sharing, but may include cost sharing for specific analyses.

Subtasks and activities

The structure of the proposed work is shown by the figure below. In a near term perspective, biomass resources both available locally and traded (as liquid intermediates) can be used in combination with fossil sources – primarily coal, but also crude oil residues – in order to achieve both a high ultimate volume – *i.e.* a potentially huge new outlet for biomass – and potential for an early market penetration – *i.e.* with potential for contributing to, and even leading, the transition to a continent wide hydrogen economy.

"Near term hydrogen from biomass"



The two mostly technological (market driven) Subtasks feed into a Subtask C concerned with the roadmap and policy framework development.

Subtask A: Co-gasification of biomass with fossil fuels

The objective is to identify and evaluate the most attractive and realistic process pathways towards a large-scale demonstration of biomass co-gasification with fossil fuels, paving the way for future commercial application of co-gasification as a competitive process to produce hydrogen, electricity and other products.

The activities will include:

- RESOURCES: Analyse and classify resources (types of biomass, coal, others*..), assessing their compatibility with co-gasification; location(s) and related logistics]

- TECHNO-ECONOMIC EVALUATION
    - identify critical issues: ash management, gasifier operation on variable fuel (optimised slagging performance, temperature, variability compensation…)
    - scale of production: Simultaneous front-end and back-end compatibility
    - operational flexibility; reducing sensitivity to seasonal variation
    - cost: investment, operation; risk…

- STEPS for moving towards demonstration plants / markets
    - feasibility study involving selected technologies and suppliers
        - Shell/Texaco/other EF gasifiers, possibly BG/Lurgi (Sasol) fixed bed… (dictates where biomass ends up, in gas or in the aromatics?)
    - Non-technical barriers; financing models/partnerships, public acceptance…
    - Identification of the optimal demonstration approach; select for retrofitting, or incorporate in new plants: Dependent upon available partners and plants

  *) oil refinery residue, petcoke; lignite, peat?

Subtask membership: should include members also from outside W. Europe;

Subtask A has an **interface** to the IEA Clean Coal Centre in addition to the IEA Greenhouse Gas and IEA Bioenergy programmes (which are interfaced at Task level). Collaboration will be implemented in an informal way, by asking to share mutually.

Main deliverable: A feasibility study as basis for proposing a funded (demonstration) project.

Subtask B: Hydrogen market facilitation based on the distributed processing of biomass to tradable liquid intermediates

The objective is to establish the potential for a renewable-based hydrogen supply chain based on the distributed production of pyrolysis oil, its commercial transport, and use in centralised gasification.

The use of a "biomass carrier" is a means of buffering against the seasonability characterising many biomass resources. It is the most direct way to address the contradictory requirements of the local availability of primary biomass resources, with associated logistics challenges, and the need to achieve economies of scale in processing by gasification. The availability of well characterised, standardised biomass intermediates also represents an important opportunity for international trade in biomass that could place this renewable source on a more equal basis in world energy markets comparable to globally traded fossil fuels such as coal, oil or LNG.

The emphasis in this Subtask is on the use (storage and transport) and properties of the liquid, not on the technology details of the pyrolysis process. The scope covers liquid intermediates produced from biomass, both those that are not usable directly as fuels and those that could be feed for other conventional processing. A full range of biomass resources, including forestry as well as agricultural by-products, will be assessed on a global resource availability basis.

Work is linked to that of Subtask A, with cross-participation and practical coordination.

Activities will include:

- AVAILABILITY: Mapping where pyrolysis oil could be obtained from locally available biomass resources, input for standardising the properties of the intermediate product
- TRANSPORT AND LOGISTICS for pyrolysis oil
- MARKETS: The role of resource owners, end users, and other stakeholders
- SCALING: Choice of technologies; siting and processing optimisation

Main deliverable: A detailed quantified scenario for use of pyrolysis oil as a traded energy commodity ("biomass carrier")

Subtask C: Roadmap – development and verification

The objective is to develop a business-oriented roadmap specifying the barriers to penetration, into the various market segments, of hydrogen produced using biomass as a renewable source. This will be achieved by integrating the findings of Subtasks A and B, in a near term context. The results will be used to produce a set of decision criteria that can be used in the planning of demonstration activities, and as a basis for defining a set of effective policy framework conditions, incentives, and regulations.

Activities will include:

BUSINESS MODELS for stimulating the penetration of renewables using hydrogen
- The need for new business models
- Identification and roles of stakeholders
- Building "green hydrogen" value chains

The need for radically new business models (value chain) will depend on the primary uses and outlets for the hydrogen, at any given stage in market development, so requires an in-depth understanding of the dynamics of existing and anticipated hydrogen markets and a clear appreciation of the technical and logistical challenges of available production routes.

INDUSTRIAL IMPLEMENTATION SCENARIOS
- OFFTAKE: Overview of available *residue* (liquid) and solid fuel gasifiers worldwide; in operation and decided
- SCALING: of the total value chain in the "combined/split" process and with reference to market opportunities such as openings for biomass-derived hydrogen in non-energy market segments as a means of building demand; or alternatively, networks of smaller-scale distributed gasifiers (by less scale-dependent technologies than entrained flow), processing the pyrolysis oil for non-hydrogen energy purposes
- SYNGAS: Synergies with other products (e.g. liquid biofuels); role of intermediates

MAINSTREAMING "Hydrogen from biomass, and Biomass to hydrogen"
- Using the availability of biomass feedstocks to leverage hydrogen
- Using co-gasification with established fossil fuels
- Effects on overall process economics of linking into pre-existing value chains

The work on Subtask C is related to Subtasks A and B but its focus is even more on market introduction opportunities and barriers. The work is dedicated to pushing renewables into the hydrogen production chain; it uses a pragmatic approach emphasising the mainstreaming of both hydrogen and biomass with the existing energy-industry revenue streams.

Main deliverable: Proposed roadmap integrating the findings from the above activities.

Participants

The members from the now completed Annex 16 Subtask B will be invited to participate in a new Task.

The Executive committee members of the HIA will be asked to give their recommendations for invitees. A balanced participation is sought, involving industry, notably energy companies (majors and utilities), stakeholders, and representing a broad range of markets and interests.

Geographically, it is desirable to expand the scope of the activity beyond Europe, including IEA associate and non-member states with an interest in the topic and able to contribute. In particular, countries in regions of the world having a good availability of biomass resources and a stake in the development in the hydrogen economy will be welcomed.

Work Plans

The new Annex members, when selected, will develop detailed work-plans for each subtask.

Level of effort

The estimation on how much each participant / country are expected to contribute in man-months will be done later when the participation is more settled.

Provisional planning is for a three -year work program, with intermediate milestones and a set of defined deliverables adjusted annually if needed.

Information Plan

The work program and the results will be presented in dissemination activities. This is an integrated part in order to develop the technology and the market. Possible information tools can be a public web page and technical brochures. Since industrial participation is anticipated, the handling and protection of proprietary information has to be taken into account. The participants must have an exclusive access to the results and processes developed during the work-program and the dissemination of results has to be done based on consensus.

Activity reports will be provided and presented for the Executive committee of the HIA in IEA on a regular basis.

Time Schedule

The Task is scheduled for a three-year period. The work plan is expected to start in 2006, with a Kick off Meeting in quarter 4. Further details to be provided by the new Task members.

Deliverable list

Only main deliverables as defined above are shown, partial or sub deliverables will be defined as part of the work plan definitions

1. Feasibility study of co-gasification		
2. Scenario for pyrolysis oil as a traded energy commodity		
3. Proposed roadmap		