**Meeting Notes:**

**Houston Meeting of PGC D4, “Life Cycle Assessment (LCA) of LNG**

**J. W. Marriott, Houston, Texas**

**15-16 April 2013**

**Participants**

Steven Von Eije

Jukka Kaijainsinkko

Anastasia Markova (15 April)

Jupiter Ramirez

Phil Redding (15 April)

Olga Senina

Ted Williams

**Notes**

The following meeting notes are organized around action items identified at the meeting and other information:

**ACTION ITEM (Study Group)**: The Study Group in Houston resolved to revise the approach of the project toward development of LNG chain "modules" that would for users of the LCA to configure LCAs based on different combinations of chain elements. This approach is intended to meet the broader needs of users of LCA approaches by allowing individual users to construct LNG chains that are specifically relevant to their needs. This approach also addresses uncertainties over how to select a limited number of LNG chains as the most relevant chains. Furthermore, the change in approach may allow for more complete coverage of LNG chains generally without the need to analyze all chains simultaneously.

Modules would be developed for generic segments of LNG chains including the following:

* Upstream (gas supply)
* Gas transport to liquefaction
* Liquefaction
* LNG Transport
* Regasification
* End use.

As *an example of one combination of modules,* the following combination of modules is illustrative:

* Upstream: Coal seam methane
* Gas Transport to Liquefaction: Onshore pipeline
* Liquefaction:: APCI (“large scale”)
* LNG Transport:: 170,000m3 DFDE drive carrier,
* Regas: Submerged combustion
* End Use: Combined cycle gas turbine power generation).

The following modules were proposed for development of LCA data. Final definitions of modules will be developed by task groups (discussed later) and Study Group review. Modules are intended to be differentiated by obvious differences in LNG industry technology and according to categories that may have important differences with respect to LCA footprint:

* Upstream
  + Conventional gas – onshore
  + Conventional gas – offshore
  + Unconventional gas – coal seam methane
  + Unconventional gas – shale gas
  + All gas supplies – gas quality with respect to CO2, sulfur, other constituents relating to air emissions streams.
* Transport to liquefaction
  + [Inputs from PGC A3 will be sought for characterization of modules]
* Liquefaction
  + Onshore “Large scale”
    - APCI
    - COP
  + Onshore “Medium/small scale”
    - Bev Prico
    - APCI SMR
    - Linde
  + Offshore
    - Conventional cycles
    - N2 cycles
  + All liquefaction – differentiation according to drives (electric, steam, gas (aero-derivatives, industrial)
  + All liquefaction – possible impacts on location, gas quality (including rich/lean), cooling medium.
* LNG transport
  + Marine carrier
    - Propulsion system – steam, DFDE, fuel type/combinations (including heavy oil and vaporized LNG)
    - Insulation system – Moss sphere, membrane (by type), and boiloff management
    - Size/scale ranges – </=125,000, </=170,000, </=215,000, >215,000 m3.
    - Operational variables – speed, etc.
  + Road carrier
    - Insulation system
    - Pressure and relief design
    - Size/scale ranges.
  + Rail carrier
    - Insulation system
    - Pressure and relief design
    - Size/scale ranges.
* Regas
  + Vaporization
    - Submerged combustion
    - Open rack (water/air)
  + Power sources and requirements
  + All regas – differentiation according to onshore/offshore, climate/water temperature, cold utilization (where applicable).
* End use
  + [Inputs from PGC A3 will be sought for characterization of modules]
  + Augmentation of end uses of regas should consider LNG as a vehicle fuel, bunkering fuel, peak shaving gas source.

Final definition of modules will be undertaken by working groups focusing on specific segments of the LNG chain. Therefore, the modules shown above were proposed at the Houston meeting and, in no way, are final.

**ACTION ITEM (Study Group):** The Study Group resolved to assign members to task groups to carry out LCA data gathering and analysis based on the interests of members attending the meeting and needs to complete task group rosters. The following were assignments made at the Houston meeting:

* Upstream Task Group: Ted, Olga, Anne, Karin, Abdelkarim
* Liquefaction Task Group: Jupiter, Phil, Rob, Vaclav, Max and/or Xavier, Emma, Sandeep
* LNG Transport Task Group: Jukka, Ted, Karin, Emma, Jupiter, Sandeep, Beom Ho Seo (proposed from PGC D general roster)
* Regas Task Group: Phil, Calogero, Andreja, Emma, Izana Mohd (proposed from PGC D general roster)
* End Use Task Group: Olga, Steven, Anastasia, Jukka, Ahmad, Hannu Kauppinen (proposed from PGC D general roster).

Additional expertise in shipping is sought. Task Groups will be responsible for authoring report sections on modules. Additional report sections will be assigned. Note: No task group was defined for Transport to Liquefaction as it is expected that the PGC A3 work will provide the basis for defining appropriate modules.

**ACTION ITEM (Task Groups):** Task Groups should interact independently (via conference cal or other means), select a Task Group Leader, and begin work by refining module definitions with a focus on characterizing air emissions.

**ACTION ITEM (Study Group):** Development of LCA tools for utilizing data developed during the project and performing LCAs should be discussed. The intent is to use such tools (such as for data handling and calculation such as use of standard spreadsheet software) to augment the Study Group report. A specialized task group was defined to coordinate this work:

* LCA Tools Task Group: Jukka (lead), Olga, Sandeep.

**ACTION ITEM (Ted):** Draft preliminary rules for evaluating data quality for LCA usage. Since emissions data will vary widely in terms of direct relevance to specific module definitions, some criteria should be developed for qualifying the data for specific uses and the breadth of use that the data will support. Criteria should consider the following:

* Emissions ranges, covering variation and uncertainty
* Emission rates (such as tonnes per MTPA LNG)
* Confidence limits of data.

Basic air emissions described in the LCA should include the following:

* Species: CH4, CO2, NOx, SOx
* Sources: Points sources (including flaring), fugitive emissions.

**REPORT OUTLINE:** The following Study Group Report outline was proposed at the meeting:

Executive summary

Introduction

* Purpose/scope
* Overview of LNG chain
* Boundaries/assumptions
* Intersection with other groups

Modules

* Upstream
* Transport to Liquefaction
* Liquefaction
* LNG Transport
* Regasification
* End use

[Explain each module, quantify emissions on a unit/energy basis, potential for improvement.]

Example Chains/Case Studies

* How to use the model
* 3-4 case studies

Comparison with Other Studies

* Other LNG studies
* Other fuels

Conclusions

**ACTION ITEM (Study Group):** Identify primary authors for report sections.

**ACTION ITEM (Study Group):** Consider adding a report section on “data gaps/technology roadmap” for addressing emissions uncertainties and emissions reduction opportunities.

**LCA WORKSHOP:** Cancellation of the April LCA workshop in Houston was discussed. A workshop in conjunction with the 6-9 October meetings of PGC D in Barcelona was briefly discussed.