GBEP Working Group on Capacity Building for Sustainable Bioenergy

ACTIVITY GROUP 2

"Raising awareness and sharing of data and experiences from the implementation of the GBEP indicators"

Template for the Compilation of GBEP Indicators Experiences

OVERVIEW

- Country: Viet Nam
- Scale at which the GBEP indicators were measured: national
- Year(s) during which the GBEP indicators were measured: 2016-2018
- Organization(s) commissioning/overseeing the measurement of the GBEP indicators: FAO/GBEP
- Organization(s) carrying out the measurement of the GBEP indicators: FAO/GBEP in cooperation with the followings Centers of Excellence:
    - The Institute of Agricultural Environment (IAE) and the Centre for Agrarian Systems Research and Development (CASRAD) at VAAS, which took the lead on the environmental indicators and measured part of the economic indicators as well;
    - The Vietnam Japan International Institute for Science of Technology (VJIIST) at the Hanoi University of Science and Technology (HUST), which had the primary responsibility over the economic indicators; and
    - The Asian Institute of Technology Centre in Vietnam (AITCV), which led the measurement of the social indicators.
- Source(s) of funding: the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety of Germany.
- Funding size: USD 500 000 – 1 000 000;
- Existing bioenergy pathways (e.g. feedstocks, processing technologies, fuels and end-uses) in the country:
    - Bagasse and rice-husk for heat and power generation
    - Traditional biomass (e.g. fuelwood, rice straw and rice husk) used for cooking and heating water (34.1 percent of households in Viet Nam)
    - Biogas for lighting and cooking at household and farm scale
    - Biogas for steam and power production at industrial scale
    - Biodiesel from Jatropha (pilot level)
    - Gasification of solid biomass (pilot level)
    - Ethanol from cassava for transport
    - Ethanol from sugarcane for transport
    - Ethanol from maize for transport
- Bioenergy feedstocks assessed through the GBEP indicators:
    - Pig manure for biogas production at household and farm scale
    - Cassava wastewater for biogas production at industrial level
    - Cassava chips for ethanol production

- Liquid, solid and gaseous fuels assessed through the GBEP indicators and respective end-uses (e.g. heating and cooking, power generation and transport) and end-use sectors (e.g. residential, commercial, industry):
  - Gaseous fuel (biogas) for lighting, heating and cooking at residential level
  - Gaseous fuel (biogas) for lighting and heating at farm scale
  - Gaseous fuel (biogas) for steam and power production for own consumption at industrial scale
  - Liquid fuel (ethanol) for transport

- GBEP indicators measured (disaggregated by bioenergy feedstock, fuel, end-use and end-use sector considered, as necessary):
  - Cassava-ethanol fuel for transport. GSI measured: 1-2-3-4-5-6-7-8-9-10-11-12-14-16-17-18-19-20.1-22-23-24;
  - Biogas from pig manure for lighting, cooking and heating water at household scale. GSI measured: 1-3-4-5-6-11-12-13-14-15-17-19-20-21.1-22-24; and
  - Biogas from pig manure for lighting and thermal energy production at farm scale. GSI measured: 1-3-4-5-6-11-17-18-19-20-22-24;
  - Biogas from cassava wastewater for steam and power production at industrial level. GSI measured: 3-5-17-18-19-20-22-24.
- Approach/methodology used for attribution of impacts to bioenergy:

Cassava based ethanol

For the Cassava-based ethanol value chain, two scenarios were analysed under the various sustainability indicators implemented in Viet Nam:

- Domestic ethanol consumption as of 2016 (assumed to be equal to domestic production) vs. a baseline that was set in 2007, i.e. the year of introduction of the first ethanol support policies in the country; and
- Domestic ethanol consumption to meet a hypothetical E5 mandate for RON92 gasoline in 2016 vs. the aforementioned 2007 baseline.

For the feedstock production stage, two different cultivation systems were considered:

- flat land with high input level; and
- sloping land with low input level.

The following criteria were used for the attribution of cassava to bioenergy:

- In the current actual scenario: due to lack of data on actual ethanol production, it was assumed that this was equal to domestic ethanol consumption, e.g. to 29 500 m^3 in 2016 (MOIT, 2017). It was estimated that the production of this amount of ethanol requires 162 840 tonnes fresh cassava (1 litre of ethanol requires 5.52 kg of cassava fresh root). Assuming an average cassava yield of 18.8 tonnes/ha (see indicator 18), 8 662 ha of land under cassava cultivation (i.e. 1.53 percent of the total amount of such land) were used for ethanol feedstock production in 2016.
- In case an E5 mandate had already been in place in 2016: total ethanol consumption in the country would have been 370 million litres (370 000 m^3 - see indicator 24). To meet this ethanol demand, Viet Nam would have needed about 2.04 million tonnes of fresh cassava equivalent, requiring 108.6 thousand hectares (assuming a yield of 18.8 tonnes/ha), or 19.1 percent of the total area under cassava cultivation.

Biogas from pig manure at household and farm scale, and biogas from the wastewater from cassava starch processing at industrial level.

For the assessment of the sustainability of the biogas pathway under the various GBEP indicators, the situation as of 2016 (with biogas) was compared with a scenario without biogas.

In case of biogas produced from pig manure, **GHG emissions from the livestock raising process were entirely attributed to the main products (e.g. meat, milk) and not to manure, which is considered as a residue/waste**. Therefore, the GHG emissions from the livestock activities have not been taken into account in the assessment of the GHG emissions derived from the biogas pathway.

- Year when the next measurement of the GBEP indicators is planned:

tbd

KEY RESULTS

- Overview:

Cassava based bioethanol

As of December 2017, **only two out of five fuel ethanol plants were operational in Viet Nam**. Furthermore, the volume of production of these two plants was only a small fraction of their capacity. At the same time, over the past few years, only minor volumes of ethanol were blended with gasoline in the country, with less than 30 thousand m^3 of domestic ethanol consumption in 2016. These **low levels of ethanol production and consumption recorded in Viet Nam** are due to a number of factors. Even though the first ethanol support policies date back to 2007, a nation-wide E5 blending mandate (for RON92 gasoline) was only introduced in January 2018. This, combined with low gasoline prices between 2014 and 2017 and an inadequate ethanol pricing policy, has led to **very low ethanol blending levels over the past few years**. Furthermore, the **lack of a reliable supply of affordable feedstock**, is a challenge that ethanol plants have been facing at times in Viet Nam and which has contributed to the **volatility of the ethanol market over the past few years**.

The cassava industry in Viet Nam is heavily export-oriented. In particular, during the 2013-2016 period, exports accounted for between 80 and 91 percent of the total cassava demand. During the aforementioned period, the demand for ethanol (for the fuel market) accounted for a minimal share of total cassava demand, between 1.2 and 2.9 percent. During this timeframe, the ethanol demand had a negligible impact on cassava production.

Biogas from pig manure at household scale.

At household level, around **450 000 Anaerobic Digesters (ADs) - 90 percent of which are currently operational - have been installed in Viet Nam**, thanks to the support of the Government and of international and regional entities, such as the Netherlands Development Organization (SNV), the Asian Development Bank and the World Bank. Among the 405 000 households with operational ADs, biogas provides most of the energy for cooking and is used for heating and lighting as well, displacing traditional biomass and fossil fuels, with multiple environmental and socio-economic benefits.

Biogas from pig manure at farm scale.

At farm level, ADs are mainly used as a **waste management strategy, i.e. to reduce odour and emissions from pig manure**. Only a small fraction of the produced biogas is used (for cooking, heating and lighting by the households living on the farm and its surroundings), while most of it is flared or even vented. This leads to significant methane emissions, and is **a missed opportunity in terms of renewable energy generation** (e.g. Ind.s #1, #18, #24). Power generation, including for injection into the grid, from agricultural and livestock residues, should be promoted, as it is already done for landfill biogas. Furthermore, opportunities to further distribute biogas to local communities should be explored.

Biogas at industrial level from the wastewater from cassava starch processing.

Biogas production from the wastewater of cassava processing is successfully applied in Viet Nam and **all starch factories produce biogas that they use as fuel for steam production and for drying starch, but no power is produced**.

- Environmental pillar:

Cassava based ethanol

Ethanol production and use (for transportation) results in total GHG emissions of 57.5–59.2 gCO_2eq/MJ of product, which is a 37-39 percent (depending on where cassava is cultivated) GHG emission savings in comparison to gasoline.

In order to further improve the sustainability of the cassava-based ethanol value chain and achieve higher GHG emission savings (see Ind. #1), **the reliance of ethanol plants on coal for their energy needs should be reduced, in favour of less carbon intensive options** such as biogas or other renewables. Furthermore, the logistics of the supply chain should be improved and the transportation distances of both feedstock and ethanol should be reduced (see Ind. #23), with positive effects in terms of both cost and emission savings.

To date, the demand for cassava-based ethanol does not appear to have put significant pressures on land/land use, biodiversity, land tenure or food security. In case the E5 blending mandate introduced in January 2018 will be met (mainly or exclusively) domestically, leading to a significant and rapid increase in the volume of ethanol produced in the country, the aforementioned pressures might increase and thus should be closely monitored.

Biogas from pig manure at household and at farm scale.

The manure-based biogas pathway has GHG emissions of 9.21 gCO_2eq/MJ of biogas (or 28.78 gCO_2eq/MJ useful heat), which represents a 32-42 percent GHG emission saving in comparison with cooking using commercial cookstoves running on natural gas or LPG. The LCA shows that the emissions of SO_2 from 1 MJ of biogas is much greater than the emissions of SO_2 from 1 MJ of natural gas or LPG. On the contrary, the emissions of NOx, CO and VOC from 1 MJ of biogas are much less than the emissions of the corresponding non-GHG pollutants from both 1 MJ of natural gas and 1 MJ of LPG. The emissions of PM_{10} and NH_3 are negligible in all three cases.

ADs and digestate are often poorly managed, thus giving rise to a number of issues. In particular, oftentimes **too much water is put into the ADs** (see Ind.s #6 and #21), thus **reducing the efficiency of the digestion process** and leading to an **excessively diluted digestate**, that discourages farmers from transporting it to the field and to apply it to the soil. As a consequence, **digestate is generally discharged into the environment** nearby farm houses (e.g. into lakes, canals, rivers, soil), instead of being used as a fertilizer, **thus leading to negative impacts on water and soil quality**, due (among other things) to its high heavy metals content.

Other challenges are the potential biogas leakages due to cracks in the ADs, and the intentional release (or venting) of surplus biogas, which can result in significant emissions of methane (CH_4). These problems are being exacerbated by the growing size and intensification of livestock production units. Increased input into an AD designed for smaller livestock production may increase the risk of leakages. Furthermore, it may lead to a decrease in retention time and in the efficiency of the digestion process. If the increased input of manure leads to a higher biogas output, households are likely to release into the environment the biogas that exceeds their energy needs.

Biogas from cassava wastewater at industrial level.

The results of a survey conducted for the scope of this study indicate that **power is produced only when biogas plants are coupled with ethanol production plants**, even though it was not possible to estimate the amount of power produced by such plants, due to lack of data on the amount of energy consumed in the process. Only part of the biogas produced in industrial cassava starch plants is consumed to meet the plant energy (heat) needs, while the rest of it is flared or vented (e.g. Ind.s #18, #24). Power generation from this surplus biogas should be promoted. This way, the methane emissions associated with biogas flaring and especially venting would be avoided, and renewable energy could be generated, leading to further displacement of fossil fuels and to further GHG emission savings, in addition to various other environmental and socio-economic benefits.

- Social pillar:

Cassava based bioethanol

Under both of the scenarios considered, **the demand for ethanol did not have any negative impacts on food security, neither by significantly increasing cassava (producer) prices, nor by reducing its demand for food** (Ind. #10). This is because there is a large surplus of cassava in Viet Nam, with the vast majority of the domestic production of this crop being exported.

Most of the land used for cassava cultivation is privately owned by households (Ind. #9). In these cassava growing regions, 93.7 percent of the interviewed households have land for cassava cultivation and a further 87.3 percent of households confirmed that they already have the land use right certificates.

Biogas from pig manure at household scale.

Amongst the social benefits, biogas produced at household scale allows for **reduced household energy expenditures on energy** (ind. #11); **increased access to modern energy services** (ind. #14); **reduced time spent collecting fuelwood** (ind. #13); and **reduced exposure to indoor air pollution and to the related health risks** (ind. #15). The positive effects of biogas extend beyond biogas-using households. For instance, despite its relatively low labour requirements, the biogas sector in Viet Nam **has generated demand for a number of skilled jobs linked to the construction and operation of ADs, such as masons and technicians**. These workers were trained in the context of the biogas support projects mentioned above and especially by SNV (ind.s #12 and #21).

- Economic pillar:

Cassava based bioethanol

As of 2016, the total production of dry cassava chips in Viet Nam was about 4 million tonnes. In 2015, in terms of dry cassava chips, imports and exports of cassava and cassava products amounted respectively to 1 million tonnes (from Cambodia) and 3.7 million tonnes. Thus, about 1.3 million tonnes of dry cassava chips were consumed domestically, mainly for processing animal feeds, and **66 376 tonnes were used for ethanol production**. **China remained the main export market in 2016, accounting for an 87 percent market share**.

The competitiveness of the cassava-based ethanol industry is hindered by **low levels of productivity and efficiency along the supply chain and especially in feedstock production**. As described under Ind. #17, with an average yield of 18 tonnes/ha, cassava productivity in Viet Nam is relatively low in comparison to other countries with similar agro-ecological conditions. To improve the efficiency and sustainability of the cassava-based ethanol pathway in Viet Nam, the productivity of cassava should be improved, through the use of improved varieties, advanced cultivation techniques and good agricultural practices. At the same time, in order to increase the overall productivity of the supply chain, ethanol plants should make use of more efficient processing technologies.

Biogas from pig manure at household and at farm scale.

Although only 1.83 percent of Vietnamese households currently use biogas. The potential for further biogas development in Viet Nam is very high if the following factors are taken into consideration. Firstly, **the number of Vietnamese households with pig husbandry is six million**; 81 percent of these households currently without biogas stated that they wanted to build an AD and among those 55 percent would also build an AD without the help of a subsidy (EPRO, 2014). Secondly, apart from household ADs, the country also has **23 000 small pig farms and 1 500 industrial-scale pig farms where a large volume of biogas could be produced** (LCASP, 2017).

Biogas may be an effective option to replace fossil fuels and other less efficient and sustainable biofuels. However, **the cost of building ADs is still high and the payback period is long**. For this reason, the biogas sector still needs policy support in Viet Nam. Promoting power generation from surplus biogas at farm and industrial levels would be key in order to ensure higher returns for investments in ADs. At household level, micro-financing schemes could be established to support the installation of ADs.

Based on the life cycle inventory of the manure-based biogas pathway, it seems that no electricity production from biogas occurs in Viet Nam so far, neither at small nor at medium production scale.

Biogas from the wastewater of cassava starch at industrial level.

Indicator 20.1 shows that biogas produced from cassava starch wastewater can be used to generate steam and heat for drying cassava starch, thus replacing a significant amount of coal and DO oil, with positive environmental and economic impacts.

However, only 58.2 percent of the bioenergy generated from biogas from cassava starch wastewater at industrial level is consumed in-house for the production of steam and heat for drying cassava starch whilst a significant amount of biogas is wasted by biogas flaring and venting. This amount of of surplus biogas should be used for power generation and distributed to communities living close to cassava starch plants.

KEY LESSONS LEARNT AND RECOMMENDATIONS ON THE RELEVANCE, PRACTICALITY AND SCIENTIFIC BASIS OF THE INDICATORS

- <u>Overview / cross-cutting, e.g. stakeholder engagement</u>:

A preliminary detailed description of the bioenergy value chain as it is actually implemented in the specific context is key to highlight the various facets, scales, peculiarities to be considered in the LCA. The Vietnamese implementation of the GSI has highlighted the importance of considering various feedstock for the same type of bioenergy product (e.g. pig manure and wastewater from cassava starch) but also various production scale for the same value chain (e.g. biogas at household; farm and industrial scale). Furthermore, the Vietnamese example has also highlighted the importance of taking into account the actual conditions in which the biomass production occurs in the specific context (e.g. cultivation of cassava in sloping areas with low input level or in flat areas with high input level).

Not all indicators are always relevant for certain pathways or contexts. This was the case for Ind. #16 which was deemed as not relevant in case of the biogas sector and in the case of Ind.s #13 and #15 which were deemed as not relevant in the case of the cassava-based bioethanol value chain.

Ensuring data consistency is key. The same data could be used as input for the calculation of various indicators. Therefore, it is important, at the beginning of the GSI implementation, to agree on the use of the same data sources. This phase is particularly important when the implementation of the GSI is developed by a multidisciplinary team of experts focusing on different indicators. Furthermore, some data could be calculated as an output of one indicator and then used as inputs in one or more other indicators (e.g. results of Ind.s #14, #17, #18 and #24 used as inputs for measuring ind. #20). Also in this case, it is extremely important to ensure the consistency of all the data used and produced in the report.

Access to data owned by the production companies is key as well for a thorough monitoring of the selected bioenergy value chains. Part of the information could be of a commercially sensitive nature (or could be perceived as such by operators) and thus should be treated as confidential. Where necessary, **confidentiality agreements could be signed**.

Concerning primary data, the **size and geographical coverage of the field surveys carried out during the project were rather limited**, due to time and resource constraints. In order to get an accurate picture of the effects of modern bioenergy development in the different regions of Viet Nam, it is recommended to collect additional data. Priority should be given to the **areas that are most relevant in terms of prominence of the various sustainability issues addressed by the GSI**, as well as in terms of volume of production and use of the selected bioenergy pathways.

- Environmental pillar:

Ind. #1 and #4. In the case of biogas, the comparison was made with two other 'modern' fuels that could be used to displace traditional biomass use for cooking, i.e. LPG and natural gas.

Ind. #2. SOC-change databases are not common in many countries and this may require primary data campaigns in order to assess the percentage of land used for bioenergy feedstock production for which soil quality is maintained or improved. These analyses, however, are complex, and time and resource intensive as they involve a large number of samples to be mapped with extreme accuracy over a large surface in order to be representative. Furthermore, due to the fairly rapid and highly variable changes that can occur in topsoil as a result of land use and soil management practices, this indicator depends in principle on site-level measurements associated with individual bioenergy production areas that need to be repeated after at least 5-10 years in the same sampling point and using the same methodology. These requirements limit the practicality of the indicator and its methodology in a context such as Viet Nam.

Ind. #5. In Viet Nam, data on TARWR at the watershed level was not available and the analysis was done on the basis of water requirements per unit of planted surface and consequently inferred at the national level.

- Social pillar:

Ind. #9. With regards to the practicality, attaining the data and information required for the measurement of this indicator was quite challenging, given the sensitive nature of part of such data and information, and the complexity of the issues at stake. Because of this, a quantitative measurement of this indicator following the defined GBEP methodology was not possible.

However, the results of the survey provided an indication of the situation in Phu Tho and Tay Ninh provinces.

Ind. #11. No data could be found or collected for certain stages of the analyzed value chains, including cassava dealers, biogas equipment and appliance suppliers. Regarding the processing stage of the cassava-based ethanol value chain, since no information on wage and income was available for ethanol plants, data were collected from cassava starch plants with the same processing capacity.

Ind. #12. In order to obtain the necessary information currently missing for a thorough assessment of this indicator in the future, and get access to data considered sensitive (as it is often the case when it comes to labour conditions), a close cooperation should be established with relevant government authorities and producers' organizations. In case of data gaps, primary data should then be collected, mainly through surveys.

- <u>Economic pillar</u>:

Ind. #17. Data on ethanol production cost could not be obtained from ethanol plants, due to the commercial sensitivity of this information. Therefore, proxies were used based on data available on the literature.

Ind. #18. Two bioenergy pathways were investigated, i.e cassava-based ethanol and biogas from pig manure at farm level. An attempt was also made to analyze biogas produced from cassava starch wastewater, but the measurement could not be finalized because of lack of data on the amount of power used in the process.

Ind. #19. Biogas pathway. In Viet Nam, biogas and digestate produced at all levels (i.e. household, farm and industrial) are used exclusively for own consumption and not sold to third parties. For this reason, the gross value added for the biogas value chain was measured based on the savings on the cost of fossil fuels and fertilizer made possible by biogas use. Therefore, the gross value added for the biogas value chain was measured by taking into account the cost sustained for producing biogas, as well as the savings derived from replacing the use of fossil fuels or other fuels and from replacing the use of fertilizers (assuming the digestate from biogas production is used instead).

Ind. #19. Cassava based ethanol pathway. Due to lack of data related to the ethanol processing stage, a detailed analysis was conducted for the cassava starch value chain and assumed as a proxy to perform an estimate of the gross value added for cassava-based ethanol.

Ind. #20. Biogas pathway. The formula used for measuring sub-indicator 20.1 was not applicable for measuring the capability of biogas to replace fossil fuel energy in Viet Nam due to lack of data. As a consequence, proxies were adopted, based on secondary and primary data collected for the scope of this study.

Ind. #20. The wording of indicator component 20.1b appears to be tailored mainly to oil-importing countries. In the case of oil-exporting countries (as in the case of Viet Nam), it is more appropriate to assess the increase in exports rather than the import savings associated with the substitution of fossil fuels with biofuels. Therefore, a more neutral wording of indicator component 20.1b would be desirable in order to capture the full spectrum of substitutions and annual savings/revenues due to modern bioenergy trade.