Global Core Set of Forest Indicators supporting the implementation of the 2030 Agenda and the UN Strategic Plan for Forests 2030

Indicator 10: Wood based energy share of total final energy consumption

Background paper

18 December 2019
STATUS OF INDICATOR 10

Indicator 10 is defined as a tier 2 indicator facing two significant challenges:

1. the availability and quality of wood energy data and
2. the need for integration between forestry and energy statistics.

The nature of the indicator requires close collaboration between forest product and energy statistics.

Feedback from the expert workshop and exchange with relevant stakeholders revealed that computation of Indicator 10 is feasible when following methodology of indicator 7.2.1 (SDG 7.2). Data required for computation is available in global energy statistics. However, it’s recommended to conduct an assessment of data quality and coherence prior to production of Indicator 10.

Concrete next steps for the production of Indicator 10 included:

1. Assess and improve the consistency and coherence of data across agencies;
2. Review and evaluate existing models for estimating wood fuel production and consumption where data are missing;
3. Produce a dataset;
4. Improve the quality and availability of pellet data;
5. Conduct pilot analyses for a subset of countries to assess the effectiveness of the proposed calculation methodology;
6. Organize capacity building at country level to increase data availability and quality and;
7. Develop a task force.

A more detailed description of the recommended next steps are provided in the final chapter of this background paper (Way forward/next steps).

SUMMARY

This is a background paper for the Global Core Set (GCS) of forest related Indicator 10: Wood-based energy share in total final energy consumption. The first chapter: background information provides information on the rationale and history of this paper; a summary of present methodology and; data providers, inclusive of country examples with sound data collection methods and an overview on variables used for estimating wood energy consumption. Based on this information the working paper provides recommendations for computing Indicator 10. A chapter: Recommendations for Computing Indicator 10 focuses exclusively on Indicator 10 and provides definitions, methodology, data sources and additional recommendations for computation of the indicator. The chapter: Way forward/Next steps provides guidelines for starting production of Indicator 10.
BACKGROUND INFORMATION

RATIONALE AND BACKGROUND ON THE WORKING GROUP

Rationale

The UN Strategic Plan for Forests (UNSPF) 2017-2030 provides a global framework for actions at all levels to sustainably manage all types of forests and trees outside forests and to halt deforestation and forest degradation. Agreed upon at a special session of the UN Forum on Forests (UNFF) in 2017, the Strategic Plan contains six Global Forest Goals (GFGs) and 26 associated targets to be achieved by 2030, which are voluntary and universal (UN 2017).

These six GFGs support the objectives of the International Arrangement on Forests and aim to contribute to progress on the SDGs, the Aichi Biodiversity Targets, Land Degradation Neutrality, the Paris Agreement adopted under the UN Framework Convention on Climate Change (UNFCCC) and other international forest-related instruments, processes, commitments and goals. To streamline action and reduce the reporting burden on countries, the Collaborative Partnership on Forests (CPF) has developed a Global Core Set (GCS) of 21 forest related Indicators. These indicators address topics identified in high level political commitments on forests and forest related aspects of SDG indicators (FAO 2017a, UN 2017).

Wood energy, as the world’s most important single source of renewable energy, is equally important for SDG 7 “Ensure access to affordable, reliable, sustainable and modern energy for all” and SDG 15.2 “By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally” (UN 2015, Whiteman 2017).

Forests contribute to achieving SDG7 by providing fuel for cooking, heating and industrial needs (including power and heat transformation). In addition, forest services such as protection of watersheds may have positive effects on other renewable energy sources (e.g., hydropower generation). From a global perspective, wood fuel is an affordable, reliable and local energy source, which provides basic energy services to one third of the world’s population and acts as a safety net for basic energy needs. In particular, low-income populations in developing countries and people affected by natural disasters and humanitarian crises rely on wood energy as a simple, inexpensive and principal source of energy (FAO 2018). However, the use of wood for energy generation can also have negative effects on e.g., sustainable forest management or human health when wood is burnt inefficiently. Links between poverty and wood fuel consumption as well as wood fuel use and sustainable forest management require reliable wood energy data in global energy and forest product statistics (Broadhead et al. 2001).

Global wood energy consumption affects SDG15.2 too. Often wood energy removals are not officially registered and reliable data don’t appear in statistics which challenges assessment of sustainable forest management. Thus, wood derived energy production can counteract SDG15.2 targets if too much unregistered wood is removed from forests. However, if applied appropriately, wood energy use can also enhance sustainable forest management. For
instance, forest thinning provides resources for energy conversion and prevents forest degradation (e.g., forest fires, forest pests) as well as increases forest productivity (Broadhead et al. 2001, Asikainen and Aguilar 2018).

**Background on the Working Group:**

An earlier version of this paper has been drafted for and reviewed by participants of the Expert Workshop on Strengthening the Global Core Set of Forest Indicators to support the implementation of the 2030 Agenda and the UN Strategic Plan for Forests 2030. The workshop was held on 22-24 October 2019 at FAO, Rome, Italy. Country representatives provided recommendations for improving methodologies and data availability of Indicator 10. Based on the recommendations received the draft document was revised.

FAO is the custodian agency for SDG15 indicators 15.1.1, 15.2.1 and 15.4.2. In order to improve the complementarity of the work undertaken with SDG7, the working group invited the custodian agencies for SDG7, the International Renewable Energy Agency (IRENA) and the United Nations Statistics Division (UNSD) to provide input to this paper.

**Methodology**

Computation of **Indicator 10: Wood-based energy in total final energy consumption** follows the logic of SDG 7.2, indicator 7.2.1: *Renewable energy share in the total final energy consumption*. Following explanation denotes a summary of metadata sheet for indicator 7.2.1. The complete metadata sheet can be found under UNSTATS (2019).

Indicator 7.2.1 is computed through formula 1,

\[
\text{Indicator 7.2.1} = \frac{REC}{TFEC}. \tag{1}
\]

*Renewable energy consumption* (REC) includes consumption of energy derived from: hydro, solid biofuels, wind, solar, liquid biofuels, biogas, geothermal, marine and waste.

*Total final energy consumption* (TFEC) is calculated from national balances and statistics as total final consumption minus non-energy use.

Information on TFEC and REC is obtained from energy statistics. Energy statistics use energy balances to structure energy flows. Figure 1 shows the methodology used to obtain indicator 7.2.1 from an energy balance.

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Figure 1: Energy balance scheme to compute indicator 7.2.1.

Renewable energy consumption (REC) is derived from final consumption of renewable energy products (incl. of transformation products e.g., wood charcoal and pellets) and consumption of renewable electricity and heat. The allocation of renewable electricity and heat consumption is done according to the shares of renewable electricity and heat production in the total electricity and heat production. Therefore, multiplying respective shares by final energy consumption of electricity and heat respectively provides required information to compute REC. TFEC can directly be taken from an energy balance. The calculation approach to derive shares for renewable electricity and heat consumption denotes a simplification presuming equal distribution losses and trade flows among energy sources which might deviate from the real situation where distribution losses (e.g., local district heating system) and trade flows might vary conditional on energy sources used.

DATA PROVIDERS

By definition, indicator 7.2.1 is strongly related to the methodological approach applied in energy statistics. Thus, when using a similar methodology for computing Indicator 10, data on wood products used for energy conversion and direct consumption, as well as final energy consumption will likely be found in energy statistics. Information on final energy consumption is available on a global level in energy statistics. Information on wood products for energy conversion and direct consumption is weak however (UNSD 2018, Glasenapp and McCusker 2018).

Global data providers

The main international organizations responsible for wood-energy data collection are FAO, UNECE/FAO Forestry and Timber Section, IRENA, UNSD and IEA/Eurostat/UNCE within their respective mandates: UNECE and FAO contribute to global forest product statistics; IRENA, UNSD and IEA/Eurostat/UNCE contribute to energy statistics.

In general, forest products statistics show a high level of disaggregation in forest products, whereas energy statistics distinguish consuming sectors (e.g. industry, agriculture, household) very well. Figure 2 depicts assets of relevant data providers (Glasenapp and McCusker 2018).

![Figure 2: Assets of wood energy reporting schemes in energy statistics (black) and forest product statistics (grey).](image)

Non-OECD countries often cannot provide wood energy data. Thus, global data providers estimate consumption data. For instance, residential wood energy use is often estimated through population. In 2000, FAO changed modelling approach and used population data as well as information on urbanization, income and forest cover to estimate wood energy consumption. Wood energy use in the non-residential sector has received little attention in global energy statistics and might be underreported at present (Whiteman 2017).

**National data providers**

Most countries in the ECE region\(^2\) do have official and non-official wood energy data at country level (Glasenapp and McCusker 2018). National energy balances or commodity balances denote official data sources which can provide required information. National energy balances are usually compiled by the National Statistics Office (NSO) or the Ministry responsible for Energy. However, National Energy Balances might include commercial energy only and neglect other forms of energy (e.g., decentralized energy use and production). In fact, observation of wood energy consumption is often challenged by its decentralized use and that wood energy isn’t a top priority energy

\(^{2}\) ECE region comprises countries of the northern hemisphere.

In addition, collaboration with entities responsible for forest product statistics can significantly improve data quality. Relevant entities may include official (e.g., Ministry of Agriculture, Environmental agency, Forestry administration) and non-official institutions (e.g., academia, private research institutes, industry associations). Information on wood energy use may also be found in reports (e.g., statistical yearbooks, research papers or press releases) and trade statistics (National Customs Office) which can be used to improve National Energy Balances (Whiteman 2017, Glasenapp and McCusker 2018).

Germany, is a good example for an effective collaboration between entities from energy and forest product statistics. The German Ministry of Economic Affairs and Energy (BMWi) is responsible for the production of official energy balances. BMWi mandated the working group on energy balances to produce national energy balances for the entire energy sector. To trace progress towards a more renewable energy sector, BMWi also mandated the working group on renewable energy statistics (AGEE-Stat) to gather more detailed information on the development of renewable energies. AGEE-Stat reaches out to Thuenen Institute (TI) to complement its wood energy data for national energy statistics. The TI is a federal research institute which participates in international forest product reporting on behalf of the Ministry of Food and Agriculture (BMEL).

In Germany final wood energy consumption in businesses of at least 20 employees is collected through official annual surveys. In addition, energy plants for heat and/or electricity production are enquired to provide individual wood energy consumption data in a separate official survey. Due to sample restrictions, this survey collects data for plants of at least 1 MW only. Wood energy demand in plants of up to 1 MW is estimated through wood derived electricity injected into the national power grid (Glasenapp and Weimar 2019).

The fraction of wood energy that is not covered in official statistics due to sample limitations is obtained from national forest products statistics. Forest products statistics use empirical survey data to estimate total wood energy use in energy plants of up to 1 MW and of at least 1 MW. Empirical data is available for selected years only and wood energy use in years without empirical data has to be interpolated. A model for plants below 1 MW uses heater inventory data and heating degree days to predict wood energy consumption. Longitudinal data for wood energy use in energy plants of at least 1 MW is estimated through indexed consumption data from plants covered in official surveys. The difference of official wood energy consumption and total wood energy consumption from forest products statistics denotes wood energy use in other final energy consumption (e.g., commercial and public services, agriculture) which is not covered in official statistics due to limitation of official sample data (Glasenapp and Weimar 2019).

Residential wood energy consumption is collected through household surveys for selected years in Germany. Household samples comprise ca. 10,000 households each. Information on wood energy use is extrapolated using census data. For years without empirical data, wood energy consumption is modelled through a regression model accounting for changes in heating degree days as well as prices for alternative energies (Jochem et al. 2015, Mantau 2019).
Austrian wood energy data derives from empirical data too. Four separate surveys (small and medium businesses; large businesses; private and public services and; households) are conducted to cover all sectors using wood for energy conversion. Small and medium businesses report individual wood energy consumption data voluntarily every two years. Data points for years without empirical information are estimated through regional production data of respective businesses. Large businesses are obliged to report wood energy use in annual surveys (Mertens et al. 2013).

Private and public services are enquired to report wood energy consumption data every two years on a voluntary basis. Consumption data is extrapolated for the entire Austrian nation through number of employees. If empirical data is missing, wood energy use is interpolated through heating degree days weighted by regional distribution of the population. Residential wood energy consumption is monitored through biannual and voluntary surveys. Annual wood energy consumption for years without empirical data is interpolated through heating degree days (Mertens et al. 2013).

In Serbia annual wood energy consumption data is collected through empirical surveys for households, commercial facilities, public facilities and industry sector for selected years. If empirical data is missing for a year, wood energy consumption is estimated through statistical models. For instance, residential wood energy consumption data is modeled through information on heated area, thermal insulation of walls and roof, timing of firewood procurement and age of installed appliances. Other sectors use additional information on production, export and import to specify estimation models. Although good quality data is available for Serbia, lack of collaboration at national level hampers consistent use of this data as official data in national statistics (Glavonijc 2019).

The energy department of the National Statistical Office in Ukraine collects wood energy data through household surveys and surveys for energy plants, including heating plants (e.g., for district heating) as well as small boilers (e.g., in villages). To derive residential wood energy consumption data for the entire nation, sample data is extrapolated based on distribution of the population and consumption patterns. In addition to survey data, information on wood waste is provided separately by the agricultural department of the National Statistical Office in Ukraine. Collaboration between relevant institutions is weak at national level and a significant amount of wood for energy conversion is presumably not covered in official statistics.

**Estimated data**

Best estimates can be generated if some information is available e.g. in energy balances. For instance, if information on transformation input of wood-based energy products is available in the energy balance, heat and electricity output can be estimated using best estimates for the efficiency in respective transformation processes. In addition, an assumption that solid biofuels consists of wood energy might serve as a best estimate for some regions too.

If neither source provides wood energy data, relevant information can be predicted through models (Mertens et al. 2013, Whiteman 2017). The transformation sector, industry sector, residential sector and other final consumer show different use patterns and deserve separate model estimations.
Transformation sector uses wood for conversion into electricity and heat as well as energy products (e.g., wood pellets, briquettes and charcoal). Information on installed capacity can be a useful starting point to determine the wood used for electricity and/or heat production. IRENA (2018) provides such information for installed electrical capacity. In addition, variation in wood energy consumption might be associated with e.g., prices for wood resources, prices for competing fuels or stock prices for electricity. In addition, feed-in tariffs and other public policies were reported to influence wood energy use in the transformation sector of the United States and Germany (Aguilar et al. 2011, Scheftelowitz and Thrän 2016). The production of energy products, which also denotes a transformation process, is covered by the demand of final consumers.

In the UNECE/FAO JWEE, industry sector refers to wood processing industry which uses wood residues and other by-products for energy generation. Production data (e.g., sawnwood, wood panel, pulp) denote potential variables explaining variation in annual wood energy use. Austria for example interpolates wood energy use in small and medium businesses by regional production data. In addition, Aguilar et al. (2011) noted that wood energy consumption in the United States’ industry sector has mainly been linked to paper production. In fact, black liquor denotes a by-product of chemical wood pulp production which is used for on-site combustion in pulp and paper mills. Information on the production of chemical wood pulp, which is comprised in global forest product statistics (FAOSTAT 2019), can be used as an explanatory variable for estimating black liquor production (Glasenapp and McCusker 2018).

Other final consumers comprise public and private services (e.g., bakeries, restaurants, public building, agriculture) that may consume some amount of wood energy. Country examples have shown that variation in wood energy consumption are modeled by heating degree days or production data. However, diversity of this sector makes it very difficult to produce good quality estimates which explains that wood energy consumption data in non-residential sector is likely underestimated for this sector at present (Whiteman 2017).

The residential sector demands wood energy for heating and cooking. Wood energy used for heating is correlated with several explanatory variables like heating technology, heating degree days, apartment area and prices for alternative energies. In addition, sociodemographic information (e.g., household income, number of dwellers) as well as availability of wood resources (e.g., forest area per land area, rural population or forest owners) were associated with residential wood energy consumption (Vaage 2000, Arabatzis and Malesios 2011, Couture et al. 2012, Song et al. 2012, Glasenapp et al. 2019). Other than heating, wood energy used for cooking might show less variation given that preparation of food is a daily routine. Variation between countries might be explained by share of rural population, income levels (i.e. GDP per capita), prices for alternative cooking fuels and availability of forest resources (Leach 1992, Heltberg 2004, Kowsari and Zerriffi 2011).
CONCLUSION

Development of Indicator 10 is part of a process towards a more sustainable future and includes stakeholder from different fields of expertise. The nature of the indicator requires close collaboration between forest product and energy statistics in particular.

The methodology of Indicator 10 should be based on the methodological approach of the indicator 7.2.1 which monitors the share of renewable energy in the total final energy consumption. Information required calculating Indicator 10 can be found in energy statistics at the national and international level.

The two biggest challenges associated with calculation of Indicator 10 are:

1. Availability and quality of wood energy data: Wood fuel data are unsystematically collected, very often haphazardly estimated and ignored by the international energy organizations.
2. Required data structure: Forestry statistics does not have global by sector information required to calculate the indicator and thus have to reach out to energy statisticians to obtain necessary information.
3. Indication issue: Due to the lack of detailed information on the sources of wood, the indicator won’t be able to identify whether wood energy contributes to sustainable or unsustainable forest management. Harmonization of forest products and energy statistics might provide required information in the future.

IRENA, UNSD and IEA/Eurostat/UNCE provide energy statistics at a global level. However, for some countries, wood energy data is not available. If data is missing, information might be available at national level, in national energy balances or commodity balances. If data is not available at national level, data has to be estimated and/or predicted through statistical models.
RECOMMENDATIONS FOR COMPUTING INDICATOR 10

DEFINITION

Indicator 10: Wood-based energy in total final energy consumption is a ratio of final consumption of energy derived from wood by total final energy consumption inclusive of energy from renewable (e.g., wood fuel) and non-renewable (e.g., fossil fuels) sources. The indicator is measured in percentage.

Renewable energy is defined as energy from natural sources that are replenished at a faster rate than they are consumed, including hydro, bioenergy, geothermal, aerothermal, solar, wind, and ocean (World Bank 2013).

Total final energy consumption is the total energy consumed by end users, such as households, industry and agriculture. Final consumption covers final energy consumption, as well as non-energy use of energy products (OECD and IEA 2004, UNSD 2018).

Bioenergy is defined as energy generated from the combustion of solid, liquid and gaseous products derived from biomass. Biomass includes but is not limited to wood energy (IEA 2019a).

Wood energy is the energy generated from wood or wood-derived products – usually through combustion processes – and used for e.g., cooking, heating or electricity generation. It includes wood sourced from forests, non-forest land, by-products from wood processing industries and post-consumer recovered wood (FAO 2019). It can also include coconut trees, bamboo and palms.

METHODOLOGY

It is proposed computing GCS Indicator 10 through formula 2, following a methodology already applied to compute indicator 7.2.1 (formula 1).

\[ \text{Indicator 10} = \frac{FWC + WEC + WHC}{TFEC} \]  \hspace{1cm} (2)

Wood energy products include wood from primary, secondary and tertiary sources. Wood from primary sources comprises any woody biomass directly sourced from forests and non-forestlands (e.g. wood fuel). Secondary sources include unprocessed co-products from forest-based industries (e.g., chips and particles, wood residues and black liquor) as well as processed wood-based fuels (e.g., wood pellets, wood charcoal). Tertiary sources comprise wood originally used for material purposes, which has reached its designated period of use and entered waste streams (Glasenapp and McCusker 2018).

Final wood energy consumption (FWC) denotes direct consumption of wood products by final consumers, inclusive of industry, transport, commercial and service, residential and other sector. It excludes non-energy use.
**Wood derived electricity consumption (WEC)** is final consumption of electricity that derives from transformation of wood products.

**Wood derived heat consumption (WHC)** is final consumption of heat that derives from transformation of wood products.

**Total final energy consumption (TFEC)** is calculated from national balances and statistics as total final consumption minus non-energy use.

It has to be noted however, that WEC and WHC are theoretical measures. In fact, it is not possible to discern energy products used for heat or electricity conversion after they were injected into an energy grid or heat distribution network. Thus, it is recommended using information on production of wood derived electricity (WEP) and heat (WHP) to compute their relative contribution (shares) to total electricity production (TEP) and heat production (THP) respectively. To obtain WEC and WHC, these shares will be multiplied by total final electricity consumption (TFELC) and total final heat consumption (TFHC) respectively.

Formula 3 shows an example of computation for WEC and WHC

\[
WEC = \frac{WEP}{TEP} \cdot TFELC
\]

\[
WHC = \frac{WHP}{THP} \cdot TFHC
\]

(3)

The recommended method implicitly assumes that wood-based electricity and heat are subject to the same distribution losses and international trade flows as all other heat and electricity.

**DATA SOURCES**

Table 1 provides an overview on required data related to GCS Indicator 10. In general, energy balances can provide information on transformation output and final energy consumption. However, information on wood derived electricity and heat output as well as final wood energy consumption might not be available in sufficient level. Often wood energy is considered as an aggregate, inclusive of non-woody solid biomass.

<table>
<thead>
<tr>
<th>Transformation output</th>
<th>Final energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood derived electricity production (WEP)</td>
<td>Total final electricity consumption (TFELC)</td>
</tr>
<tr>
<td>Wood derived heat production (WHP)</td>
<td>Total final heat consumption (TFHC)</td>
</tr>
<tr>
<td>Total electricity production (TEP)</td>
<td>Final wood energy consumption (FWC)</td>
</tr>
<tr>
<td>Total heat production (THP)</td>
<td>Total final energy consumption (TFEC)</td>
</tr>
</tbody>
</table>
Table 2 shows recommendations for the identification of data providers that provide required data elements to compute **Indicator 10**. In general, it is suggested using IRENA for most of data elements and UNSD for TFEC. However, if IEA data is published significantly earlier than UNSD data, it’s recommended using IEA data.

**Table 2: Data references for computation of Indicator 10.**

<table>
<thead>
<tr>
<th>Data element</th>
<th>Primary reference/secondary preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood derived electricity production (WEP)</td>
<td>IRENA</td>
</tr>
<tr>
<td>Wood derived heat production (WHP)</td>
<td>IRENA</td>
</tr>
<tr>
<td>Total electricity production (TEP)</td>
<td>IRENA/UNSD/IEA</td>
</tr>
<tr>
<td>Total heat production (THP)</td>
<td>IRENA/UNSD/IEA</td>
</tr>
<tr>
<td>Total final electricity consumption (TFELC)</td>
<td>IRENA/UNSD/IEA</td>
</tr>
<tr>
<td>Total final heat consumption (TFHC)</td>
<td>IRENA/UNSD/IEA</td>
</tr>
<tr>
<td>Final wood energy consumption (FWC)</td>
<td>IRENA</td>
</tr>
<tr>
<td>Total final energy consumption (TFEC)</td>
<td>UNSD/IEA</td>
</tr>
</tbody>
</table>

Recommendations follow the logic of data availability. However, some data providers don’t provide data for all countries in the world. To fill data gaps following priority list is recommended:

1. Use best estimates from forest products statistics to fill gaps, e.g. FAO supply data on wood fuel and wood charcoal can be used to estimate wood energy use in residential sector.
2. Use best estimates from trade statistics to fill gaps. Relevant products denote coniferous wood fuel (HS 440111), non-coniferous wood fuel (HS 440112), wood pellets (HS 440131) and wood charcoal (HS 440290).
3. Use best estimates from energy statistics to fill gaps, e.g. solid biofuel figures will be used if no detailed wood energy data is available. Information about chemical wood-pulp production from FAOSTAT (2019) can be used to estimate black liquor, which is a byproduct of chemical wood-pulp production.
4. Use prediction models if no data is available.

**ADDITIONAL RECOMMENDATIONS**

**Within countries, increase the availability of data and of disaggregated data on wood energy.**

While renewable energy statistics are improving in most countries, there are still many problems with the collection and reporting of bioenergy data, especially in non-OECD countries. These countries account for a major share of bioenergy consumption, so uncertainties about their use of bioenergy has an impact on renewable energy statistics at the global level. Experience from UNECE has shown that it is key to bring together experts on forest products, forest resources and energy statistics at the national level. Information on wood volumes used for energy is often available but, in many cases, is scattered among various stakeholders. Improving communication and cooperation between all actors involved at the national level is a key step in providing policy makers with realistic and relevant information. Developing a harmonized overview of the sources and users of wood energy, as well as the volumes and energy used, will enable decision makers and policy makers to make sustainable, fact-based national decisions and policies.
Closer collaboration across agencies within countries.
Wood energy data is relevant to forest product and energy statistics. Data is collected by several stakeholders (e.g., forestry, energy and statistical offices as well as ministries, industry associations and academia) for both forest products and energy sectors. However, collaboration between stakeholders at national level can be weak. Member states with a lack of internal collaboration should be identified, and support should be provided to improve collaboration between relevant stakeholders. One reason for a lack of collaboration may be due to weak information on conversion factors at national level which should be addressed when harmonizing forest products and energy statistics. Collaboration at the national level will not only improve national statistics, but international databases will also benefit.

Evaluate and improve the global availability of data on efficiency and sustainability of wood fuel data.
Wood energy can be a very clean fuel if it is used properly. However, in most parts of the world today, wood energy is still polluting. Pollution arises from inefficient storage and fuel combustion. Information about the efficiency of using wood for energy by the final user (e.g. cooking appliances) or the transformation sector (e.g. charcoal making, electricity production) will allow policy makers and decision makers to make wood energy more efficient, cleaner and sustainable in the future. It is recommended that national information be gathered on factors which allow assessment of heater efficiency (i.e., heater’s age, fuel types, average wood energy consumption) of final consumers. In the transformation sector, additional information on conversion technology (i.e., filters, co-firing, heat and/or electricity production) is required to evaluate efficiency. In addition, it’s recommended to collect global data on all types of forest products used for energy conversion. Such information is required to evaluate sustainability of wood energy use.
WAY FORWARD/NEXT STEPS

Assess and improve the consistency and coherence of data across agencies
A desk study to assess the consistency and coherence of databases is recommended. Inconsistencies and lack of coherence might occur due to differences in regional coverage, collection methods or data processing. Comparing datasets would identify the energy agencies, which have the most appropriate data related to GCS **Indicator 10**. In addition, data comparison allows individual country data to be evaluated. Data inconsistencies might arise from differences in agencies’ data processing (e.g., application of different conversion factors) as well as different data sources (e.g., national correspondents, estimated data etc.). Assessments can be made as to why and how information may differ from one agency to another as well as about which countries may benefit most from capacity building and additional training. By encouraging the sharing of information reliability of data can also be improved.

Review and evaluation of existing models for estimating wood fuel production and consumption where data are missing
Many discrepancies between data across agencies result from the application of different models to estimate data where they are missing. The most recent well-used model is the one used by FAO and applied since 2000. New data and methodological approaches could be applied to update this model. It’s recommended to review existing models for estimating wood fuel production and consumption where data are missing and provide an assessment of available methods.

Production of a dataset
Gather data elements required to compute **Indicator 10** as proposed in the Recommendations. The final dataset should comprise data from IRENA and UNSD or IEA as primary data providers. In addition, estimated data can be used to fill gaps where country data is missing.

Improve the quality and availability of pellet data
Improving the quality and availability of pellet data has a high benefit-cost ratio. The energy statistics for quite a few countries report no bioenergy trade or trade flows that do not match their international trade statistics (e.g. for wood pellets). In addition, it’s difficult to identify the purpose of use e.g., energy and non-energy use of these products. However, there is a large amount of existing pellet data, making the cost of monitoring low. Such an effort would focus primarily on developed countries and should therefore be balanced with efforts at capacity building in countries with no or little available wood fuel data.

Conduct pilot analyses for a subset of countries to assess the effectiveness of the proposed calculation methodology
Before recommending a global calculation methodology, the approach should be tested on a subset of countries with both high and medium-level data access and which cover multiple regions. Trends in the pilot indicator can then be compared with other relevant indicators, with data that provides context for the results (e.g. human population density), and across similar countries to build confidence and understanding of the methods and to ensure that the range of country-specific issues is identified and that any errors or necessary adjustments are understood.
Capacity building at country level to increase data availability and quality
At the country level, capacity building can improve the quantity, accuracy, precision and reliability of available information. It can empower agencies to make inferences from the available data, quantify what is known and what is left to measure, and improve local ability to analyze existing data and apply it in a policy-making context. Increased capacity at the country level will improve the reliability and spatial coverage of information available in international databases. The most initial benefit would come from a set of targeted capacity-building workshops for countries where estimated use of wood energy is high but for which data availability and accuracy are low. Capacity building workshops should include participation from forestry and energy departments as well as national statistical offices and non-governmental centers of excellence. In addition, it’s recommended to conduct capacity-building for i) enumerators to apply existing guidelines and ii) trainers to sustain the knowledge base at country level.

Development of a task force.
Recognizing the weakness of wood energy statistics at the global level, the next step could be establishing a Global Wood Energy Data Task Force. The task force would provide a forum for a working group on wood energy data, comprised of representatives from the FAO, UNECE/FAO Forestry and Timber section, International Energy Organizations, relevant biomass industry associations (e.g. World Bioenergy Association) and other international organizations (e.g. WHO). The main objectives of the Working group could include the following: (1) improve the availability and quality of wood energy data; (2) harmonize definitions, conversion factors and methodologies of data collection and processing; (3) build a better understanding of the importance of wood energy statistics for policy-making on a country level and from both the energy and forestry perspectives; and (4) improve the understanding of the contribution of wood energy statistics to the achievement of SDG 7 and to the monitoring of SDG 15.
ANNEX: DATA SOURCES

FAO, UNECE/FAO Forestry and Timber Section, IRENA, UNSD and IEA/Eurostat/UNECE provide relevant data for construction of **Indicator 10**. The following section provides details on the data availability, format, and limitations. A summary is provided in Table 3. Note that wording of definitions in Table 3 has been modified to save space. For precise wording, refer to original sources. In addition, International Recommendations for Energy Statistics are relevant for data provided by IRENA, UNSD, and IEA and thus have been displayed under one single column.

**FAO and the Joint Forest Sector Questionnaire (JFSQ)**

FAO has been collecting and disseminating statistics on forest product production and trade since 1948. Since 1999, information about wood fuel and wood charcoal has been collected, using JFSQ – a joint data collection initiative of partner agencies: FAO, International Tropical Timber Organization (ITTO), the Statistical Office of the European Union (Eurostat) and the UN Economic Commission for Europe (UNECE). In 2012 wood pellet production and trade data were introduced into forest product statistics. In addition to wood energy products, FAO collects information on products such as wood residues, wood chips and particles, sawnwood, wood-based panels, pulp and paper. Some of these products are also used for energy purposes. Based on the information provided by FAOSTAT, it is not possible to accurately discern the purpose of product use. The situation is similarly complicated for wood charcoal and wood pellets which can be used for non-energy purposes in addition to their more common use for energy generation.

In cases where countries have not provided information through the questionnaire, FAO estimates annual production and trade based on trade journal reports, statistical yearbooks or other sources. Where data are unavailable, FAO repeats historical figures until new information is found. FAO estimates also might come from an econometric model (Whiteman et al. 2002). At the end of each year, final statistics are released for the previous year.

Potential reasons for the lack of national data in many countries and strategies to improve quality are widely discussed. For example, decentralized consumption patterns, inconsistencies in conversion factors, incompleteness of considered forest products and missing data points create challenges when working with wood energy data. Overcoming data issues is a global challenge. Distinguishing wood uses (e.g., heating and cooking) as well as refining and harmonizing definitions and classifications should receive particular attention (World Bank 2013).

For ECE countries, UNECE has avoided estimating wood fuel numbers in the JFSQ, generally repeating data from previous years when they are not supplied by the country. No adjustment has been made for population or other changes. All collected data are passed on to FAO and used in FAOSTAT (FAOSTAT 2019).

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1 Legacy of FAO’s work in 2012 HS revision
Table 3: Differences in definitions, units, and data availability by data provider.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Fuelwood or Firewood / Fuelwood</td>
<td>Fuelwood or firewood (in log, brushwood, pellet or chip form) obtained from natural or managed forests or isolated trees. Includes wood residues used as fuel and in which the original composition of wood is retained (charcoal and black liquor are excluded).</td>
<td>Roundwood (m³ solid volume underbark) used as fuel for purposes such as cooking, heating or power production. Includes main stems, branches and other parts of trees (where harvested for fuel) and wood used for charcoal production. Includes wood chips for fuel made in forest from roundwood. Excludes wood charcoal. Includes wood fibres from above- and below-ground woody biomass (excluding bark). Volume of roundwood (m³) used in charcoal production estimated by as 6.0 times weight (t) of charcoal produced.</td>
<td>Roundwood (m³ solid volume underbark) that used as fuel for purposes such as cooking, heating or power production. It includes main stems, branches and other parts of trees (where harvested for fuel) and wood used for production of charcoal, wood pellets and other agglomerates. Includes wood chips used for fuel made in forest from roundwood.</td>
</tr>
<tr>
<td>Wood Charcoal / Charcoal⁴</td>
<td>Solid residue from carbonization of wood or other vegetal matter through slow pyrolysis.</td>
<td>Wood carbonized by partial combustion or the application of heat from external sources.</td>
<td>Wood carbonized by partial combustion or application of heat from external sources (t).</td>
</tr>
<tr>
<td>Wood Pellets⁸</td>
<td>Wood pellets are a cylindrical product that has been agglomerated from wood residues by compression w/ or w/out addition of binder. Diameter ≤ 25 mm; length ≤ 45 mm.</td>
<td>Cylindrical fuel product compressed from milled wood. Raw materials are cutter shavings and sawdust, which are by-products of mechanical wood processing. Agglomerated by compression or binder. Diameter ≤ 25 mm; length ≤ 45 mm.</td>
<td>Agglomerates (t) produced either directly by compression or by addition of binder in a proportion not exceeding 3% by weight. Pellets are cylindrical. Diameter ≤ 25 mm; length ≤ 100 mm.</td>
</tr>
<tr>
<td>Chips and Particles</td>
<td></td>
<td>Wood (m³ solid volume underbark) reduced to pieces for pulping, particle board, fibreboard, fuel, or other. Excludes wood chips made in forest from roundwood.</td>
<td></td>
</tr>
<tr>
<td>Wood residues</td>
<td>Residual roundwood (m³ solid volume underbark) from production of forest products not reduced to chips or particles. Includes sawmill and veneer rejects, slabs, edgings, trimmings, veneer log cores, sawdust, residues etc. Excludes wood chips counted in other categories.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Liquor</td>
<td>Alkaline-spent liquor from digesters during production of sulphate or soda pulp required for paper manufacture.</td>
<td>Alkaline spent liquor from digesters during production of sulphate or soda pulp during paper production. Energy content originates in lignin removed during pulping.</td>
<td></td>
</tr>
<tr>
<td>Post-consumer recovered wood</td>
<td></td>
<td>Wood used for material purposes, which has reached its designated period of use and entered waste streams.</td>
<td></td>
</tr>
</tbody>
</table>

⁴ In JWEE, wood from primary sources includes industrial roundwood and fuelwood from forests and trees outside of forests

⁵ For UNECE and FAOSTAT definitions in this table, consumption of wood charcoal or charcoal and wood pellets can be for energy and non-energy purposes. When FAOSTAT data is used in wood-energy indicator computation, non-energy use should be excluded.
UNECE/FAO Forestry and Timber Section

UNECE/FAO Forestry and Timber Section collects detailed wood energy data through the Joint Wood Energy Enquiry (JWEE). JWEE was developed to obtain information on forest products used for energy conversion. Wood quantities are measured in volume (m³ swe) and mass (tonnes dry matter) (Glasenapp and McCusker 2018).

JWEE distinguishes wood energy use by forest products and consuming sectors as defined in the International Standard Industrial Classification (ISIC). Forest products generally match those of the JFSQ with the distinction that roundwood is reported by source (i.e., from forest and outside forest). In addition, forest products not covered in forest product statistics (e.g., liquid processed wood-based biofuels) are included in JWEE reporting. Consuming sectors distinguish between transformation sectors, industry sectors and other final consumption sectors inclusive of subsectors (e.g., residential sector) (JWEE 2015, Glasenapp and McCusker 2018).

The JWEE database comprises data for 2005, 2007, 2009, 2011, 2013, 2015 and 2017. Due to voluntary reporting, number of submissions varies by year. Figure 3 presents member states’ participation in JWEE reporting. Member states of central and northern Europe participated regularly in JWEE reporting. Information on southern EU member states seems to be weak. In general, JWEE data is published two years after a reference year (Glasenapp and McCusker 2018, JWEE 2019, Steierer, Glasenapp 2019).

Source: Steierer, Glasenapp 2019

Figure 3: Regional coverage of the JWEE in 2005-2017 period.
IRENA
IRENA collects and disseminates detailed renewable energy statistics. The database contains statistics for more than 230 countries and energy balance data for 120 countries. The main source of information for the database is the IRENA Annual Renewable Energy Questionnaire. The IRENA database contains commodity and energy balances from 2012 onward, and electricity and heat production from 2000 onward (Glasenapp and McCusker 2018, IRENA 2018).

National figures for wood energy consumption reported to IRENA often lack specific information on forest products (wood, waste and pellets). In addition, production is often reported instead of the entire energy flow, including transformation and final consumption. To solve these data issues, IRENA uses COMTRADE data and survey results from the European Pellet Council to derive estimates for biomass pellets. If COMTRADE shows large flows in bioenergy trade, correspondents are encouraged to consider revising their national estimates. Validating wood waste data is more challenging due to limited information. However, wood derived electricity production data may provide some information for validating wood waste figures.

Unlike IEA, IRENA recognizes transformation of biomass pellets and briquettes. However, only a few countries can report this information and often use erroneous flows for reporting (e.g. reporting pellet production under primary production instead of transformation activity). If IRENA identifies misspecification of energy flows, flows are corrected manually. Solving erroneous pellet reporting denotes a top priority to IRENA.

Table 4: Data availability through IRENA.

<table>
<thead>
<tr>
<th>IRENA</th>
<th>Commodity</th>
<th>Units</th>
<th>Publicly available (production)</th>
<th>Default NCV (MJ/MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-based energy products in the questionnaire</td>
<td>Wood fuel</td>
<td>tonnes</td>
<td>No</td>
<td>15,120</td>
</tr>
<tr>
<td></td>
<td>Wood waste</td>
<td>tonnes</td>
<td>No</td>
<td>15,120</td>
</tr>
<tr>
<td></td>
<td>Black liquor</td>
<td>tonnes</td>
<td>No</td>
<td>12,240</td>
</tr>
<tr>
<td></td>
<td>Biomass pellets and briquettes⁶</td>
<td>tonnes</td>
<td>Yes, in TJ</td>
<td>16,920</td>
</tr>
<tr>
<td></td>
<td>Wood charcoal</td>
<td>tonnes</td>
<td>Yes, in TJ</td>
<td>30,800</td>
</tr>
<tr>
<td>Data necessary to calculate wood-based energy consumption</td>
<td>Commodity balance, Electricity output, Heat output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final wood-based energy consumption</td>
<td>Can be calculated based on data from the questionnaire = wood-based energy products consumption + wood derived electricity + wood derived heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final energy consumption</td>
<td>Missing non-renewable energy products. Cannot be calculated.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid biofuels, as published</td>
<td>Wood fuel + energy crops + wood waste + black liquor + straw + bagasse + rice husks + Other vegetal and agricultural waste + animal waste + Other primary solid biofuels n.e.s.</td>
<td>Yes, in TJ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⁶ Mostly wood, but it may also include some amounts of non-woody biomass.
Global Core Set of Forest Indicators supporting the implementation of the 2030 Agenda and the UN Strategic Plan for Forests 2030, Indicator 10: "Wood based energy share of total final energy consumption"

UNSD
UNSD collects and disseminates detailed energy statistics for all major energy commodities. The main source of information for the Energy Statistics Database is the UNSD Annual Questionnaire on Energy Statistics. The database contains basic statistics for more than 230 countries and territories from 1950 onwards and is annually updated (UNSD 2019a). The UN energy balances are made available towards the end of a calendar year (publishing information for two calendar years prior). UNSD follows the International Recommendations for Energy Statistics (IRES) which does not recognize the transformation of biomass into pellets or briquettes.

Table 5: Data availability through UNSD.

<table>
<thead>
<tr>
<th>UNSD</th>
<th>Commodity</th>
<th>Units</th>
<th>Publicly available (production)</th>
<th>Default NCV7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-based energy products in the questionnaire</td>
<td>Fuelwood</td>
<td>m3</td>
<td>Yes, in m³ and TJ8</td>
<td>12.6 GJ/t</td>
</tr>
<tr>
<td></td>
<td>Black liquor</td>
<td>TJ</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Wood charcoal</td>
<td>tonnes</td>
<td>Yes, in TJ</td>
<td>29.5 GJ/t</td>
</tr>
<tr>
<td>Data necessary to calculate wood-based energy consumption</td>
<td>Cannot be calculated. Consumption of wood fuel, black liquor and wood charcoal appears in commodity balance, but electricity and heat output is only for solid biofuels9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final wood-based energy consumption</td>
<td>Cannot be calculated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final energy consumption</td>
<td>Can be calculated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biofuels and waste, as published</td>
<td>Fuelwood, wood residues and by-products + Bagasse + Animal waste + Black liquor + Other vegetal material and Residues + Charcoal + Biogasoline, Biodiesels + Bio jet Kerosene + Other liquid biofuels + Biogases + Industrial waste + Municipal waste10</td>
<td>Yes, TJ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment: Default NCV derive from IRES and IPCC, which publish identical values (Garg et al. 2006, UNSD 2018).

7 UNSD 2019c.
8 UNSD 2019b
9 Can be calculated if assumptions are made.
10 UNSD does not count industrial waste as renewable. UNSD counts only half of municipal waste as renewable by default unless it is specified.
IEA/Eurostat/UNECE

IEA/Eurostat/UNECE produces energy balances for OECD member states as well as some non-OECD member states. Information on renewable energies is compiled in the annual questionnaire for renewables and waste. Solid biomass production is the only energy flow broken down into sub-products. All other relevant flows aggregate woody and non-woody biomass under one single product (IEA 2019b).

IEA/Eurostat/UNECE Energy Balances are published once a year providing information for the two previous calendar years11. With the exception of European member states, country information is not publicly available. In addition, bioenergy data12 is reported in TJ which denotes a theoretical measure. In general, bioenergy data is collected in physical units and converted into energy units for comparison in energy balances (Whiteman 2017).

Table 6: Data availability through IEA/Eurostat/UNECE.

<table>
<thead>
<tr>
<th>IEA/Eurostat/UNECE</th>
<th>Commodity</th>
<th>Units</th>
<th>Publicly available</th>
<th>Default NCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-based energy products in the questionnaire</td>
<td>Wood fuel, wood residues and by-products</td>
<td>TJ</td>
<td>Yes for EU2813, No for most non EU countries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black liquor</td>
<td>TJ</td>
<td>Yes for EU28, No for most non EU countries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood pellets</td>
<td>TJ</td>
<td>Yes for EU28, No for other countries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood charcoal</td>
<td>tonnes</td>
<td>Yes for EU28, No for most non EU countries</td>
<td></td>
</tr>
<tr>
<td>Data necessary to calculate wood-based energy consumption</td>
<td>Cannot be calculated. Wood consumption is comprised under solid biofuels, excluding charcoal aggregating woody and non-woody biomass. Wood charcoal is presented as a separate product.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final wood-based energy consumption</td>
<td>Cannot be calculated.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final energy consumption</td>
<td>Can be calculated.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment: Note that solid biomass production is the only energy flow broken down into sub-products. All other flows are reported at the aggregated level.

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11 Some preliminary data for OECD countries are available for the previous calendar year.
12 With the exception of charcoal.
13 Eurostat 2019
REFERENCES:


Global Core Set of Forest Indicators supporting the implementation of the 2030 Agenda and the UN Strategic Plan for Forests 2030, Indicator 10: "Wood based energy share of total final energy consumption"


IEA (2019b): Renewable energy questionnaire. Available online at https://iea.blob.core.windows.net/assets/92c8e9d6-b8b1-4ecc-a0da-f3c00f5fd4f2/RenQues.xlsm, checked on 12/4/2019.


