IAEA
International Atomic Energy Agency

Renewables and Waste

Workshop on Energy Statistics

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Renewables – Difficult to define

- *Renewable energies are those naturally occuring non-depleting energies that are derived directly and indirectly from the sun, such as biomass, geothermal, hydropower, ocean currents, solar irradiation, tidal wave and wind energy
- **Renewable energy is energy that is derived from natural processes that are replenished constantly
- Alternative approach – provide list of products that are considered renewable

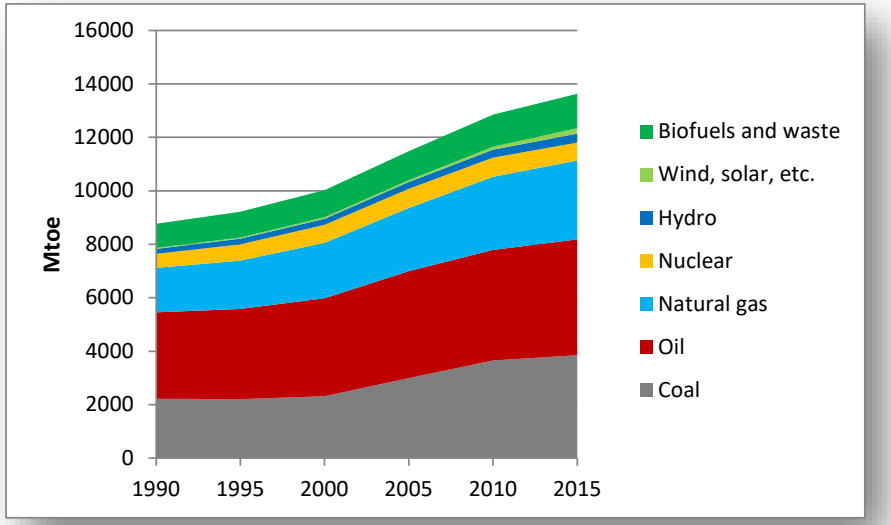


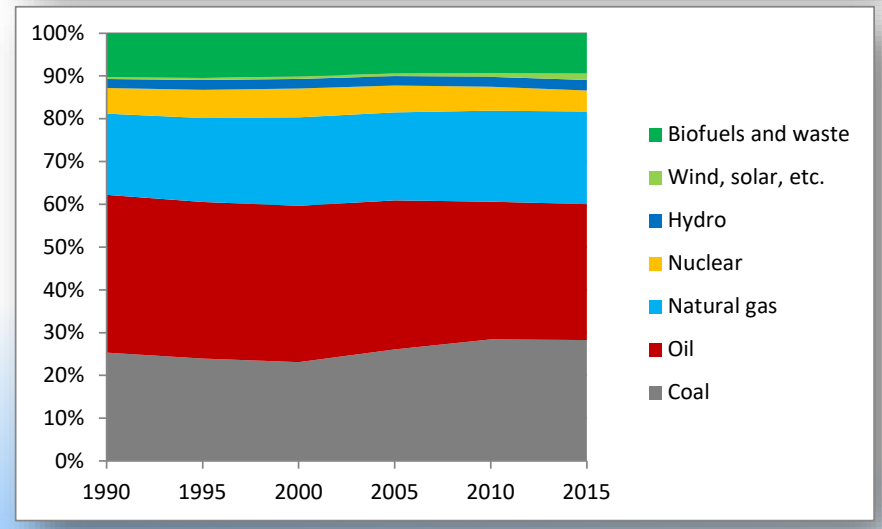

** Encyclopedia of Energy, Elsevier, 2004*
*** Energy Statistics Manual, OECD/IEA, 2004*

Role of Renewables in Energy Supply
Share in TPES

IAEA

World





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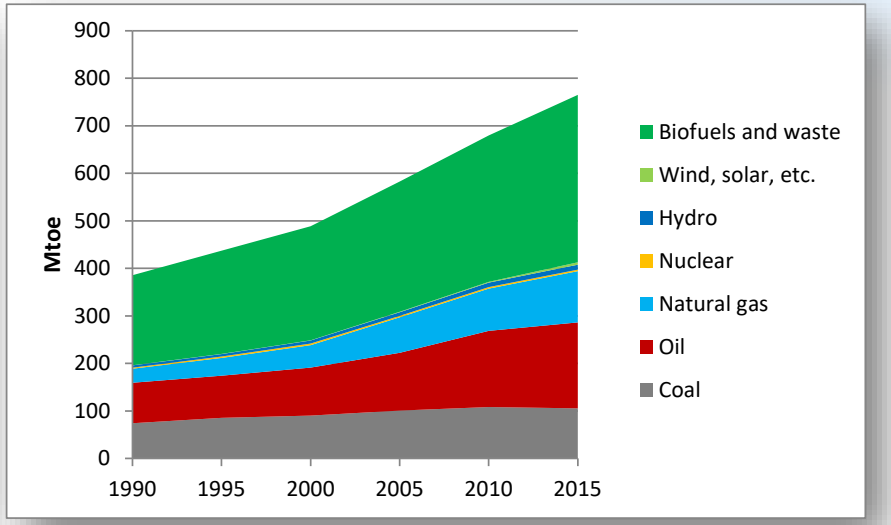
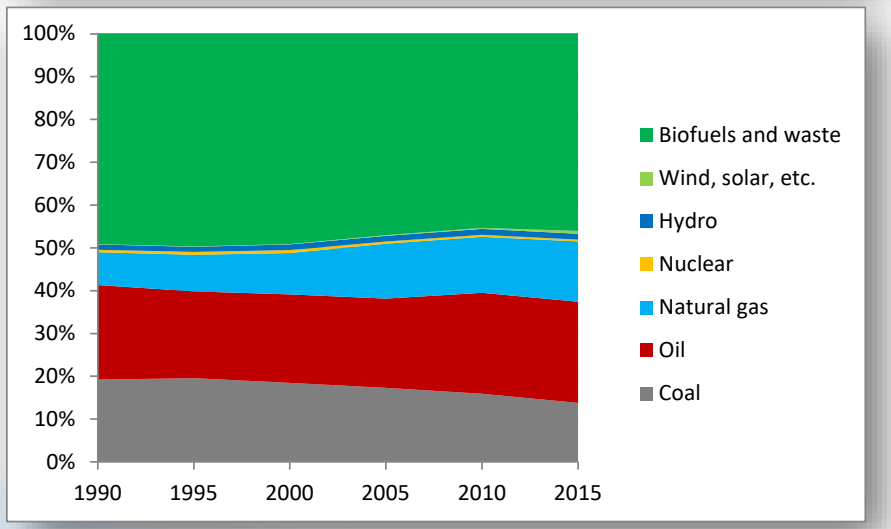
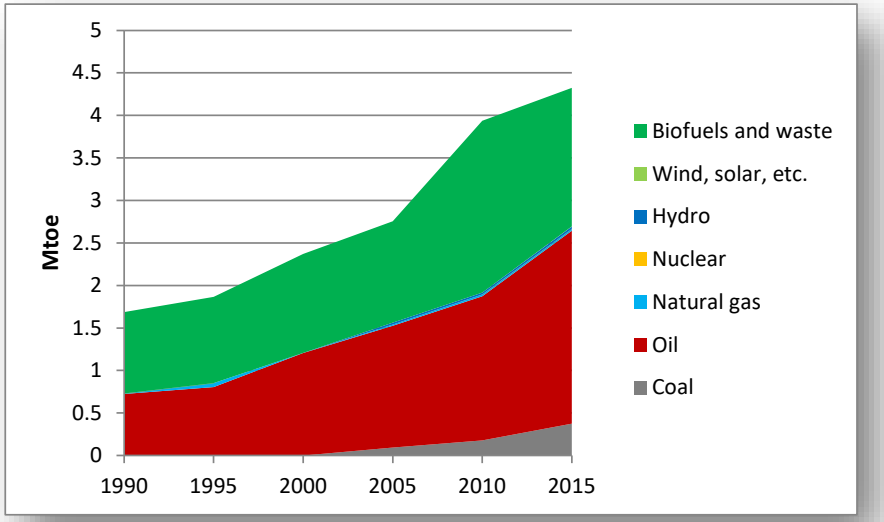


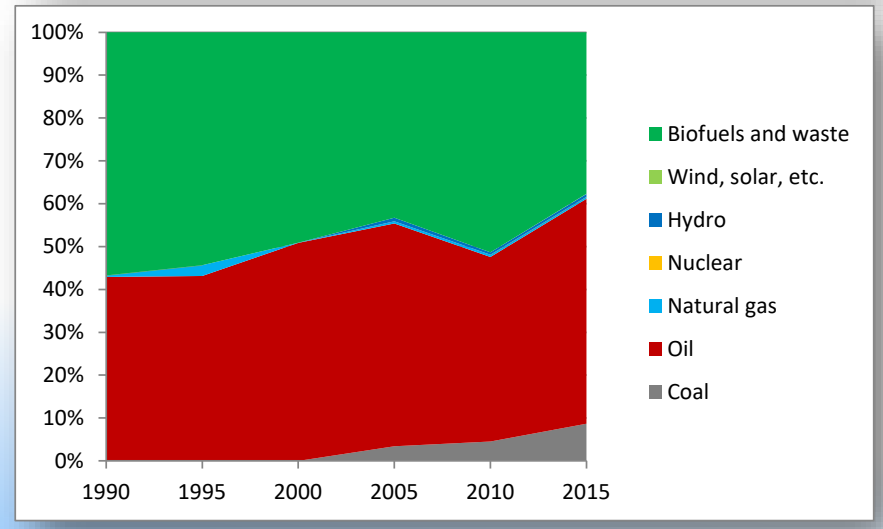


Role of Renewables in Energy Supply

Share in TPES

Senegal





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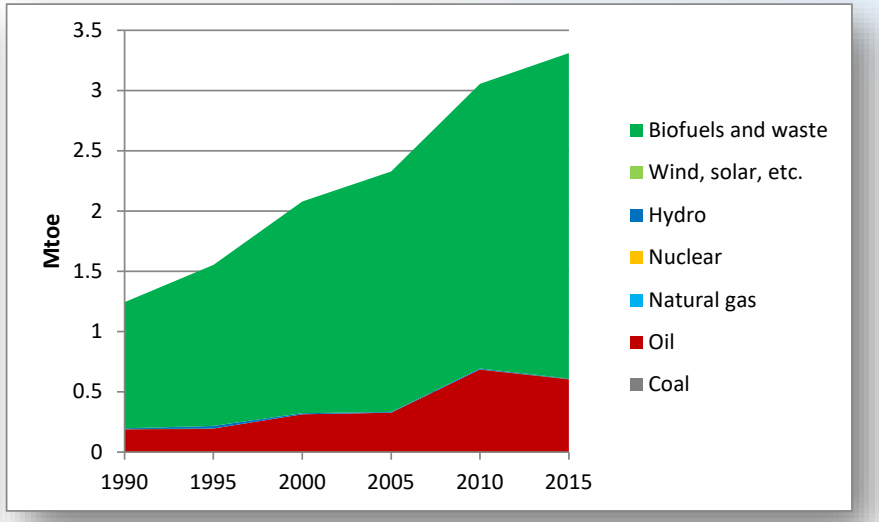
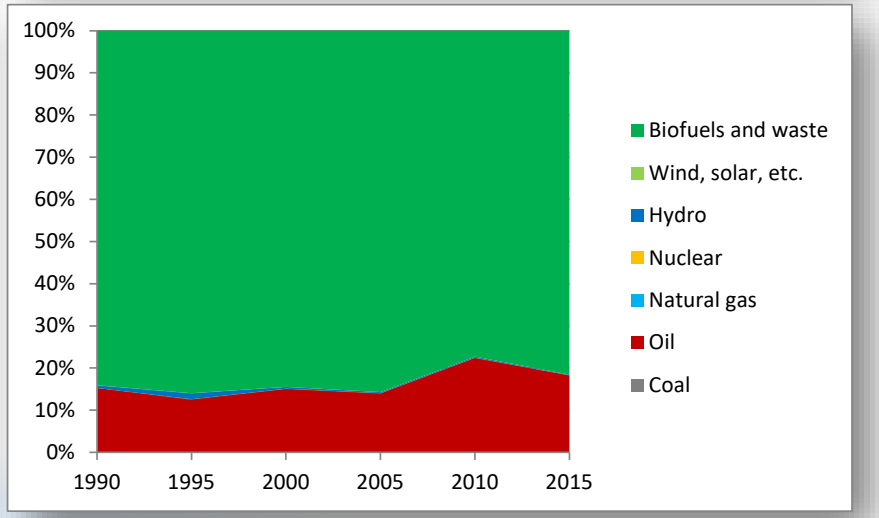
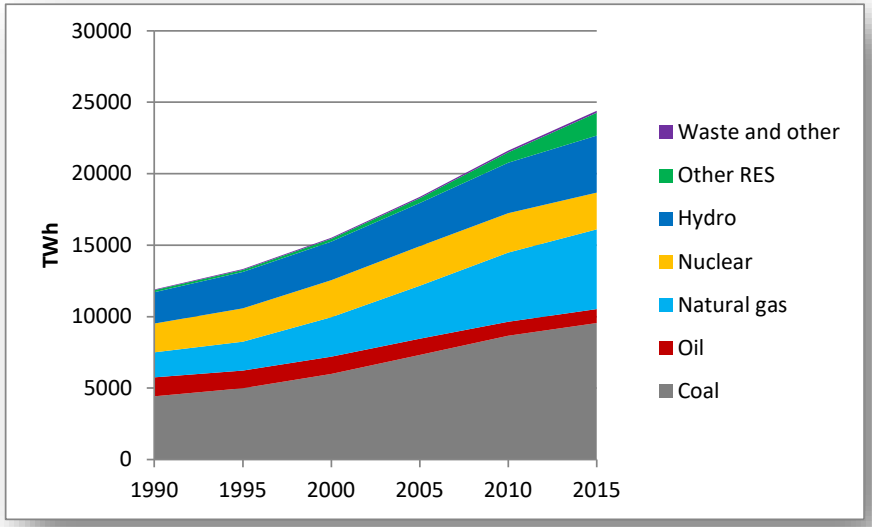
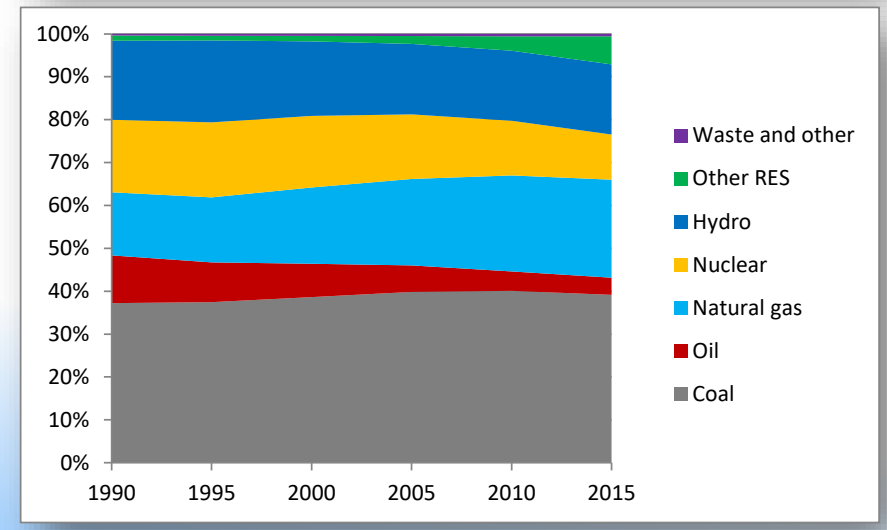




Role of Renewables in Energy Supply
Share in Electricity Generation

World





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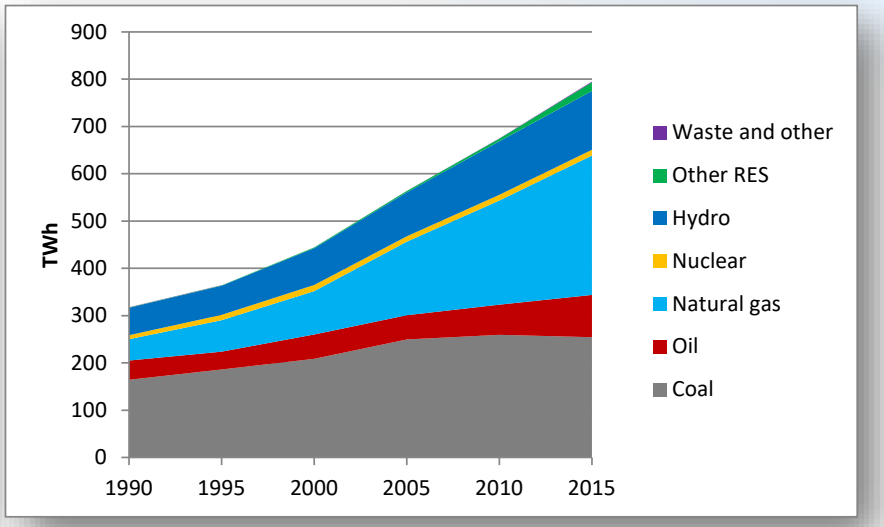
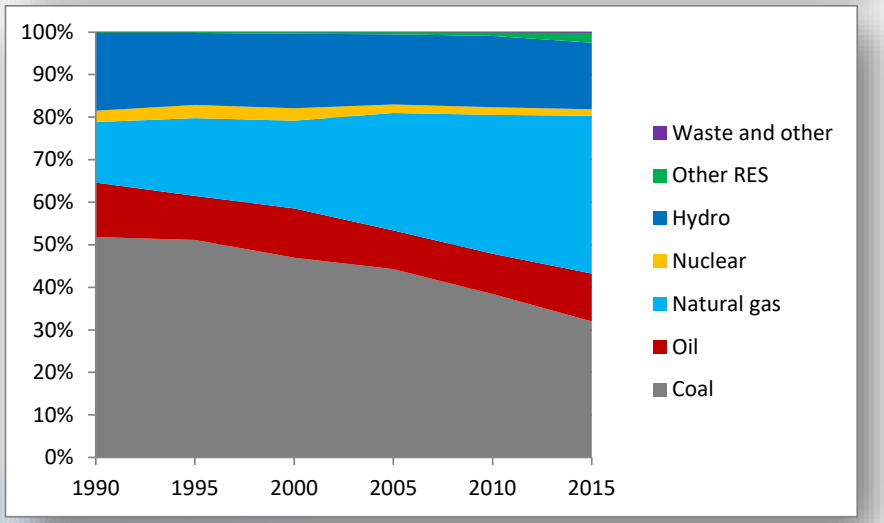
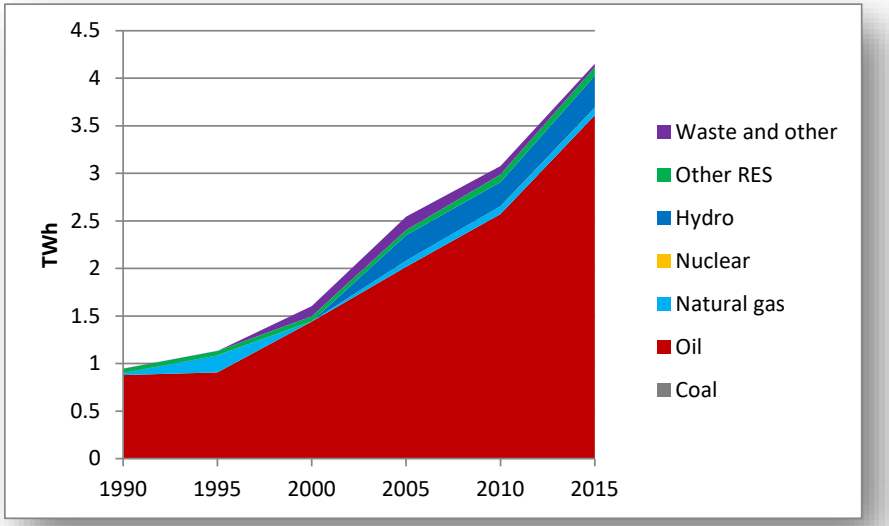
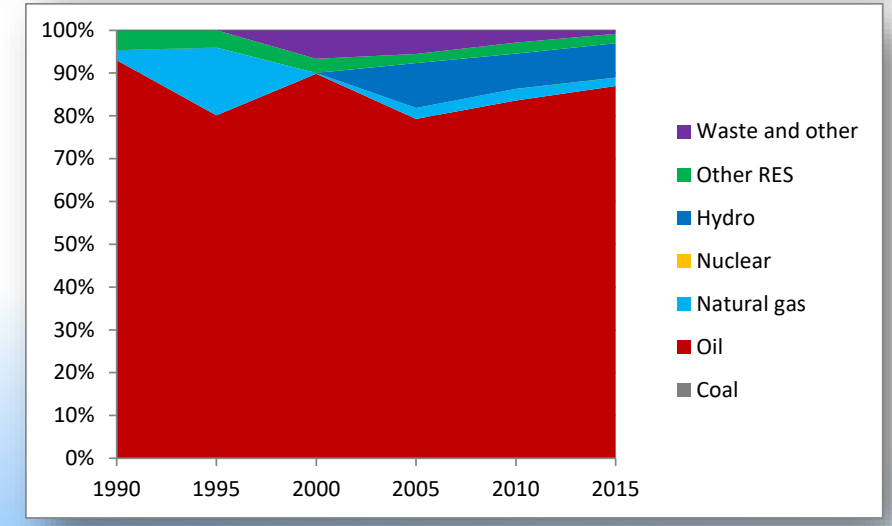




Role of Renewables in Energy Supply
Share in Electricity Generation

Senegal





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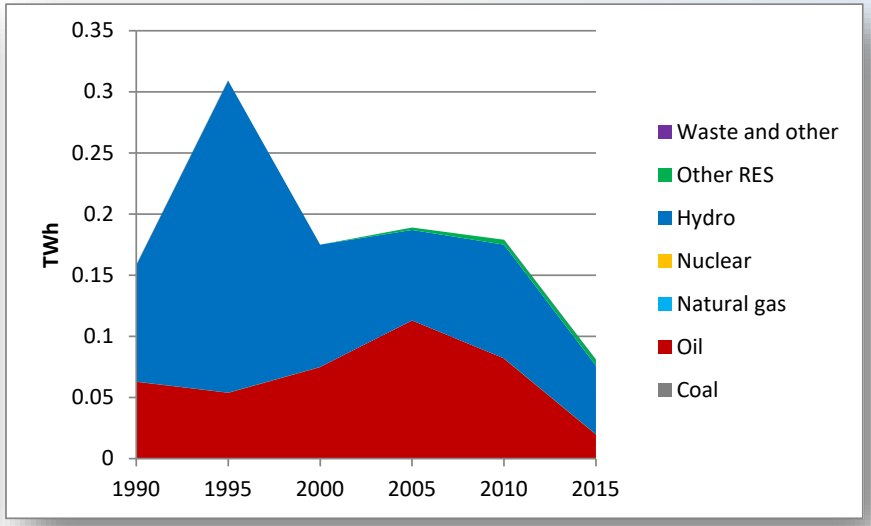
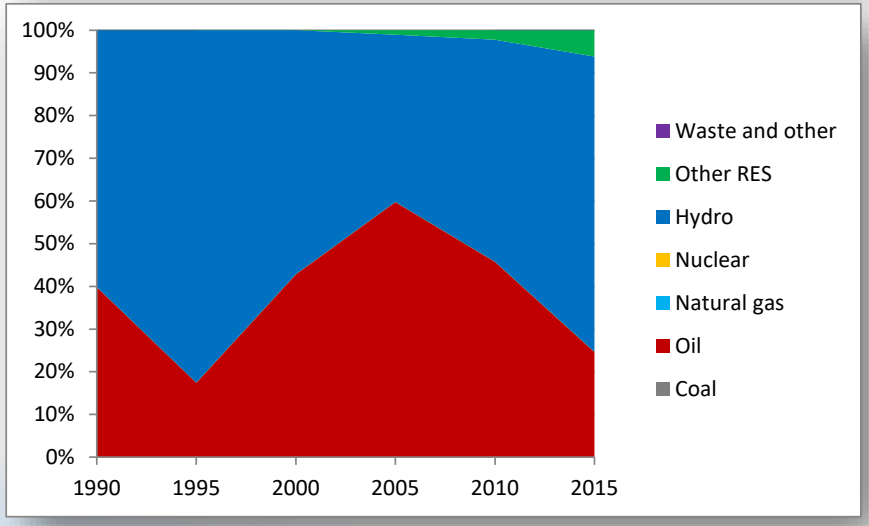
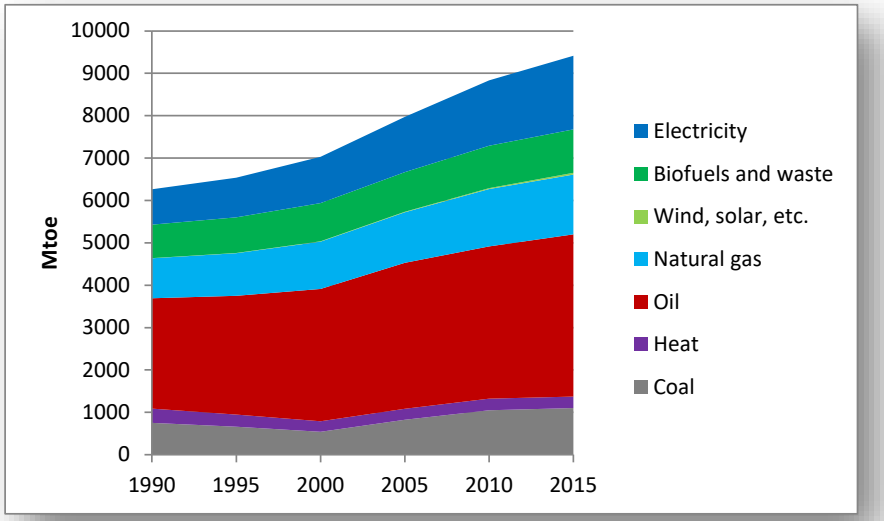


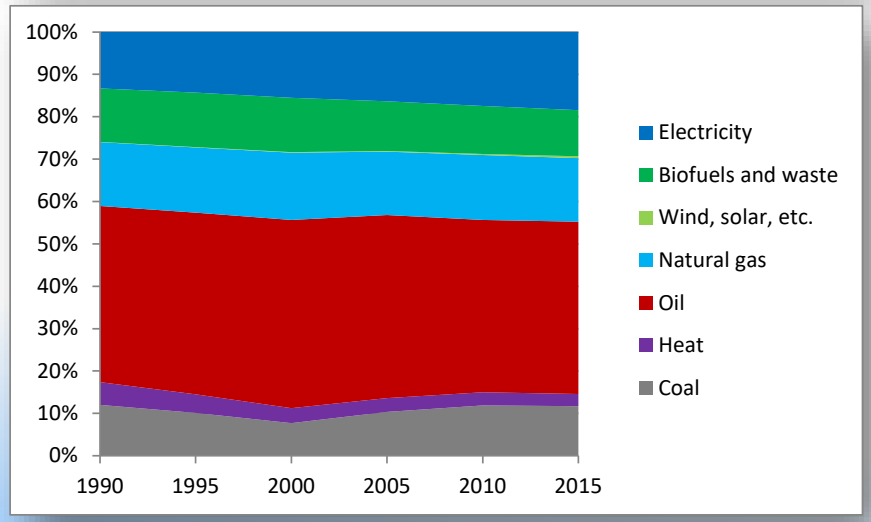


Role of Renewables in Energy Demand

Final Energy Consumption

World





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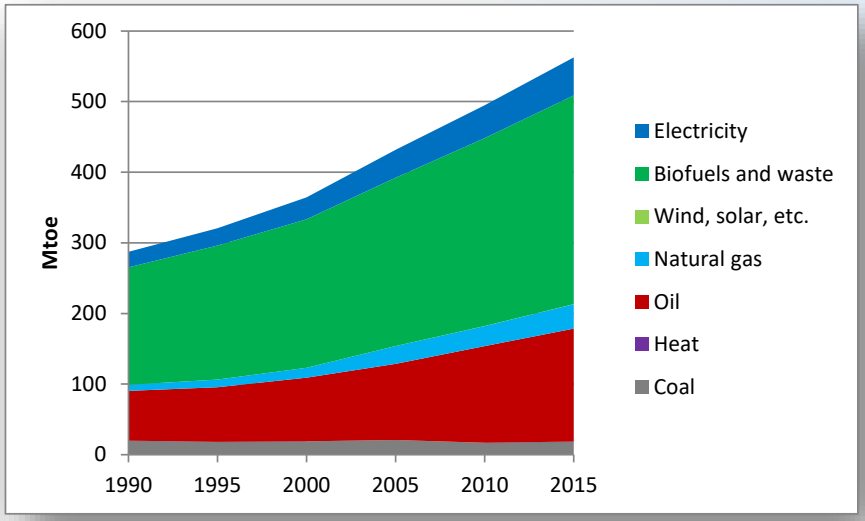

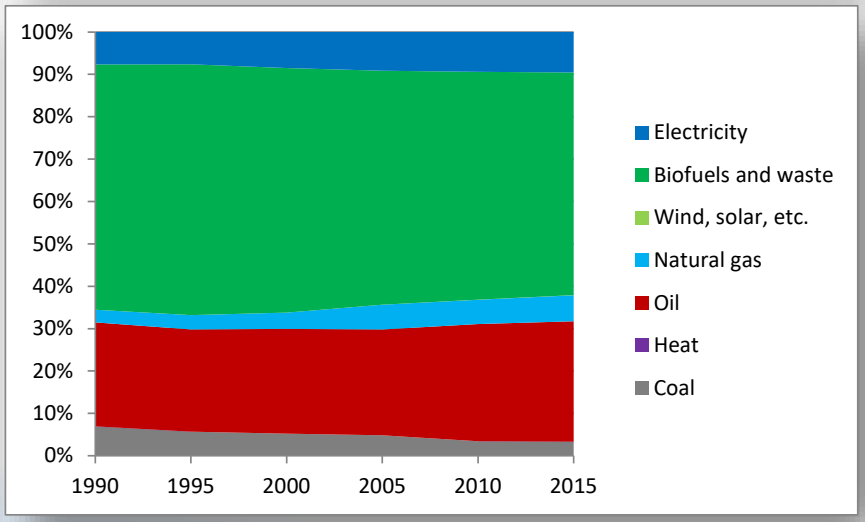

Role of Renewables in Energy Demand

Final Energy Consumption

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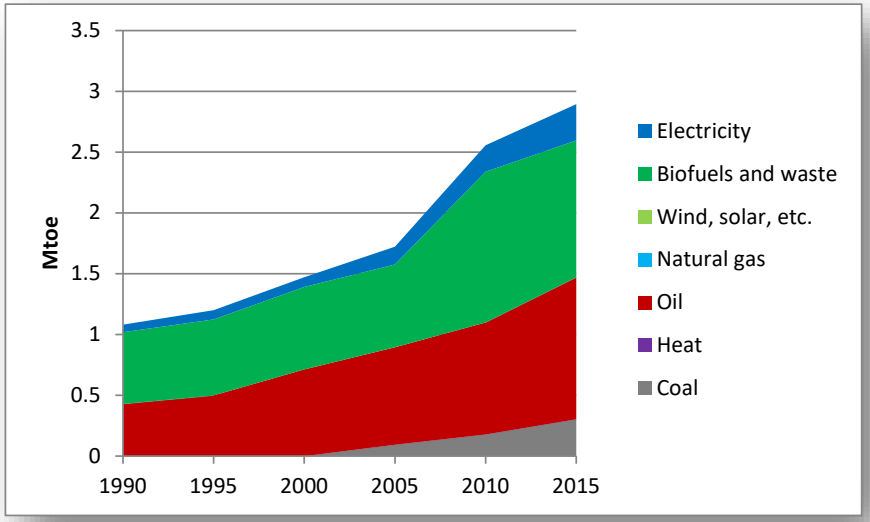

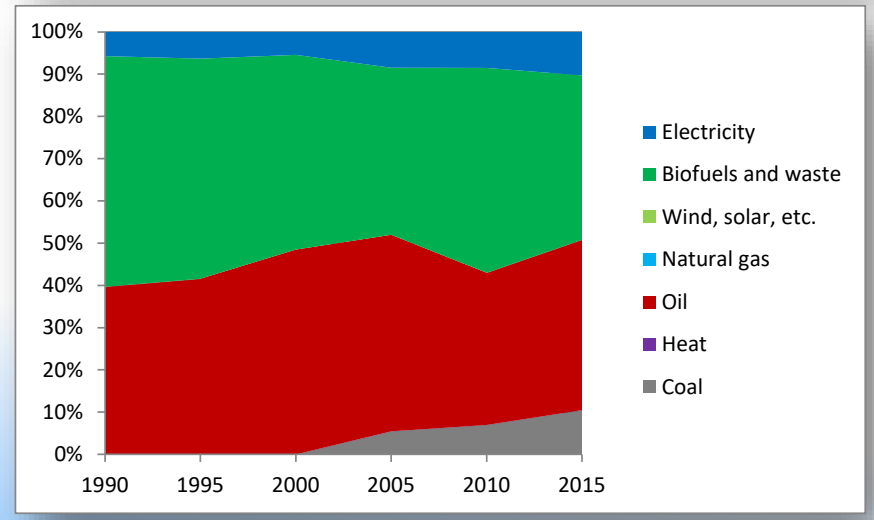

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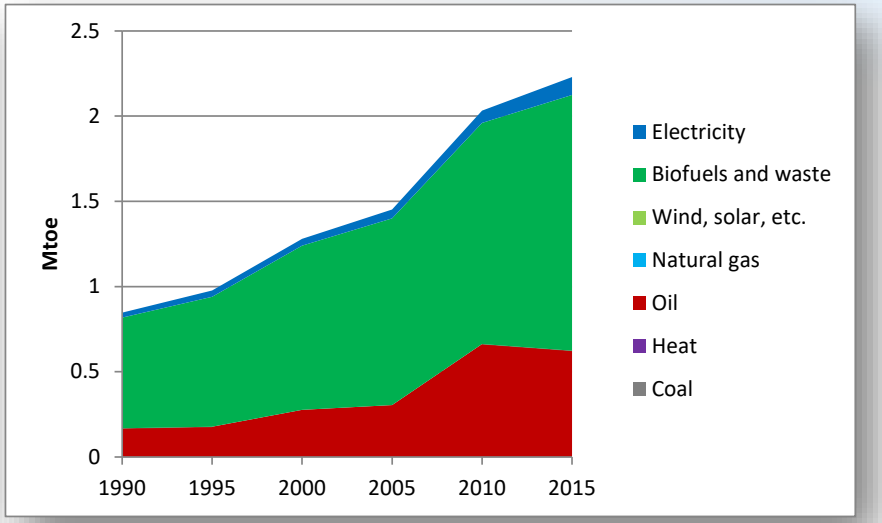

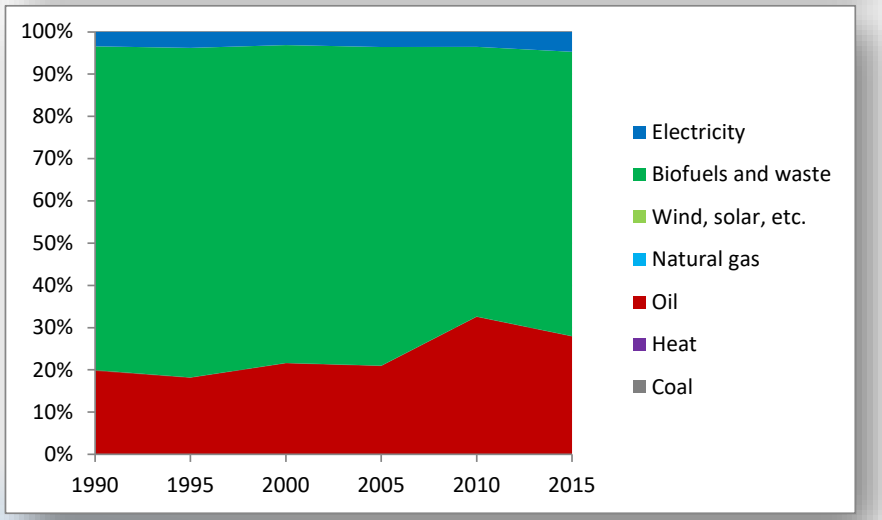

Role of renewables in energy system

- Available locally
  - Can increase self-sufficiency (reduction of energy import)
- Can reduce overall environmentally adverse impacts of energy systems
  - Assuming they are used sustainably (e.g. sustainable management of biomass use)
- Reduce dependency on fossil fuels and exposure to international market prices levels and volatility
- Can create local jobs
  - During construction phase (e.g. hydro projects) and for installation/servicing of smaller scale applications (e.g. solar PV, biofuel refineries…)

RES and Energy Statistics

- In developing countries renewables (mainly fuel wood) hold large share of final consumption and therefore an area of policy interest
  - Improving health, increasing efficiency, fuel switching, forest management…
- but… Renewable energy production and use are dispersed, not "metered", making data collection difficult, with many institutions involved
  - Definition and borders of products sometimes difficult to define (type of biomass, products for energy uses only…)
  - Quantities (how to measure?), calorific values, uses
- Lack of coordination between institutions
  - E.g. ministry in charge of agriculture/forests, statistical departments…
  - Need for formal and/or informal mandates and data sharing agreements
- No means to collect, store and share data on renewables
  - Lack of institutional memory, archiving and documentation processes
  - Limited staff capacity and experience with renewable energy statistics
  - Lack of financial resources

Uses of RES and Waste in Energy System

1. Products and technologies for electricity generation (e.g. hydro, solar PV, wind…)
2. Products that can be input into various transformation processes or used for final consumption, *but cannot be stored* (e.g. geothermal, solar thermal…)
3. Products that can be input into various transformation processes or used for final consumption and *can be stored* (industrial waste, municipal waste, solid biomass, biogases, liquid biofuels)

RES for electricity only

- Hydro, solar PV, wind, ocean/tidal
- For centrally/grid connected technologies, data on generation are relatively easy to collect (larger facilities and registered utilities/companies)
  - Usual issues (for electricity in general) are differentiation between net and gross generation, transmission/distribution losses (technical), mettered, consumed and billed amounts…
- However, it is important to collect data on distributed, smaller scale, isolated, off-grid capacities and generation (e.g. individual solar PV installations, smaller scale wind turbines, small/micro hydro, micro and mini grids…)
  - Collection of final consumption data discussed later
- Quantity of energy input assumed to be equal to electricity output
  - In energy balance visible as electricity production and breakdown into categories possible

Geothermal and solar thermal

- Geothermal can be used to produce electricity or can be used directly for thermal purposes (industrial and household/services applications)
  - When used for electricity assumed generation efficiency is agreed to be 10%
- Solar thermal is mainly used directly (drying in food production industries, pre-heating, hot water preparation…), but can be used as heat input into electricity generation (in this case it is treated as the first category, i.e. production of electricity is recorded and enters balance as primary electricity)

"Storable" RES and Waste

- Examples
  - Solid biomass (fuelwood and other wood residues, charcoal) – e.g. for cooking
  - Individual or large scale biogas production – e.g. for cooking or other uses
  - Use of bagasse in sugar industry (process heat and electricity generation), co-firing
  - Liquid biofuels and fuels blending

Biofuels

- Definition
  - Fuels derived directly or indirectly from biomass
  - Remark: Fuels produced from animal fats, by-products and residues obtain their calorific value indirectly from the plants eaten by the animals
- Sub-groups
  - Solid biofuels
  - Liquid biofuels
  - Biogasses

Solid Biofuels...

- ... are solid fuels derived from biomass
  - Fuelwood, wood residues and by-products (e.g. Wood pellets)
  - Bagasse
  - Animal waste
  - Black liquor
  - Other vegetal material and residues
  - Charcoal

Liquid Biofuels...

- ... are liquids derived from biomass and used as fuels
- Liquid biofuels comprise
  - Bio gasoline
  - Biodiesels
  - Bio jet kerosene
  - Other liquid biofuels
- They are used for transport, electricity generation and stationary engines

Biogasses...

- ... are gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass (including biomass in wastes)
- Biogases from anaerobic fermentation are composed principally of methane and carbon dioxide and comprise landfill gas, sewage sludge gas and other biogases from anaerobic fermentation.
- Biogases can also be produced from thermal processes (by gasification or pyrolysis) of biomass and are mixtures containing hydrogen and carbon monoxide (syngas) along with other components.
  - These gases may be further processed to modify their composition and can be further processed to produce substitute natural gas
- The gases are divided into two groups according to their production:
  - Biogases from anaerobic fermentation; and
  - Biogases from thermal processes
- They are used mainly as a fuel but can be used as a chemical feedstock

Waste

- Definition
  - Materials no longer required by their holders
    - Remark: For the purposes of energy statistics, waste refers to part of these materials that is incinerated with heat recovery at installations designed for mixed wastes or co-fired with other fuels
    - Heat may be used for heating or electricity generation
  - Certain wastes are mixtures of materials of fossil and biomass origin

Industrial Waste

- Non-renewable waste that is combusted with heat recovery in plants other than those used for the incineration of municipal waste
- Examples are used tires, specific residues from the chemical industry and hazardous wastes from health care. Combustion includes co-firing with other fuels.
- *The renewable portions of industrial waste combusted with heat recovery are classified according to the biofuels that best describe them*

Municipal Waste

- Household waste and waste from companies and public services that resembles household waste and which is collected at installations specifically designed for the disposal of mixed waste, with recovery of combustible liquids, gases or heat
- Municipal waste can be divided into renewable and non-renewable fractions

Main issues in RES/Waste statistics

- Units of measurement
- Calorific values
- Data collection (difficult/dispersed)

- Transformation to charcoal unreliable or not-reported (unknown transformation efficiencies, unknown fuel wood quantities…)
- Distributed generation data
- Consumption data missing (estimates must be used)

Units of measurement

- Due to its diverse forms, RES and Waste are measured in various units…
  - Solid
    - Volume (m^3) or mass (kg, tons)
  - Liquid
    - Volume (liters), mass (tons) or energy content (joules)
  - Biogases
    - Volume (m^3) or energy content (joules)
  - Electricity only RES
    - In kWh/MWh/GWh of electricity output
- While for data collection various units can be used (adopted to local circumstances), for reporting, a set of standardized units is recommended to facilitate processing and comparison

Calorific values

- How to convert from volume/mass to energy?
  - In practice, quantities of e.g. solid fuels can be expressed in various "user" units (depending on local practice)
  - For fuel wood or similar traditional fuels, major unknown variables are quantities used, density and water content (directly influencing calorific value)
    - Derive calorific values from known fuel wood and other biomass used in the country/area
    - Estimation/modelling can be used to verify assumptions (e.g. collect data on quantity of fuel wood used – surveys, estimate end-use needs, stoves efficiencies and calculate back average calorific values)

Calorific Values – Solid Biofuels (IRES)

SIEC headings			Net calorific values (GJ/metric ton)		
				Range	
			Default value	Lower value	Upper value
5		Biofuels			
51		Solid biofuels			
511		Fuelwood, wood residues and by-products	15.6	7.9	31.0
	5111	Wood pellets	17.3[b]		
	5119	Other Fuelwood, wood residues and by-products	13.9[b]		
512	5120	Bagasse			
513	5130	Animal waste			
514	5140	Black liquor	11.8	5.9	23.0
515	5150	Other vegetal material and residues			
516	5160	Charcoal	29.5	14.9	58.0

International Recommendation on Energy Statistics – IRES, UN, 2018

Calorific Values – Liquids and Biogases (IRES)

SIEC headings			Net calorific values (GJ/metric ton)		
				Range	
			Default value	Lower value	Upper value
5		Biofuels			
52		Liquid biofuels			
521	5210	Biogasoline	26.8[c]	13.6	54.0
522	5220	Biodiesels	36.8[c]	13.6	54.0
523	5230	Bio jet kerosene			
529	5290	Other liquid biofuels	27.4	13.8	54.0
53		Biogases			
531		Biogases from anaerobic fermentation			
	5311	Landfill gas	50.4	25.4	100.0
	5312	Sewage sludge gas	50.4	25.4	100.0
	5319	Other biogases from anaerobic fermentation	50.4	25.4	100.0
532	5320	Biogases from thermal processes			

International Recommendation on Energy Statistics – IRES, UN, 2018

Fuelwood Calorific Values (IRES)

	Percentage moisture content		Kilocalories per kilogram	Btus per pound	Megajoules per kilogram
	Dry basis	Wet basis			
Green wood	160	62	1 360	2 450	5.7
	140	59	1 530	2 750	6.4
	120	55	1 720	3 100	7.2
	100	50	1 960	3 530	8.2
	80	45	2 220	4 000	9.3
	70	41	2 390	4 300	10.0
Air-dried wood	60	38	2 580	4 640	10.8
	50[a]	33[a]	2 790	5 030	11.7
	40	29	3 030	5 460	12.7
	30	23	3 300	5 930	13.8
	25[b]	20[b]	3 460	6 230	14.5
	20	17	3 630	6 530	15.2
	15	13	3 820	6 880	16.0
Oven-dried wood	10	9	4 010	7 220	16.8
	5	5	4 230	7 610	17.7
	0	0	4 470	8 040	18.7

International Recommendation on Energy Statistics – IRES, UN, 2018

Fuelwood – volume to mass (IRES)

Fuelwood	Metric tons per solid cubic metre	Metric tons per cord	Stacked cubic metres (stere) per metric ton
General	0.707	1.71	2.12
Coniferous	0.570	1.38	2.63
Non-Coniferous	0.742	1.79	2.02

- Countries are encouraged to identify typical fuelwood mixes and average water content and to establish country-specific conversion factors between volume and mass

International Recommendation on Energy Statistics – IRES, UN, 2018

Charcoal

- Amount of biomass (mainly fuelwood) needed to produce one unit of charcoal depends on biomass density, moisture content and process used (e.g. traditional vs. modern kilns)

Fuelwood requirement for charcoal production by kiln type
(Cubic metres of fuelwood per ton of charcoal)

	Percentage moisture content of fuelwood					
Kiln Type	15	20	40	60	80	100
Earth kiln	10	13	16	21	24	27
Portable steel kiln	6	7	9	13	15	16
Brick kiln	6	6	7	10	11	12
Retort	4.5	4.5	5	7	8	9

International Recommendation on Energy Statistics – IRES, UN, 2018

PRIMARY PRODUCTION

Examples

- Quantities of electricity produced from hydro, solar PV, wind plants…
  - These quantities are reported in UNSD questionnaire under electricity, and in balance are summed under production of primary energy (electricity)
- Production can be as…
  - Main Activity
    - Companies producing electricity to be sold to grid/final customers
  - Autoproducers
    - Companies using electricity generation equipment and supplying its own demand (and potential sale of surpluses to the grid)
      - Sugar factories, industrial cogenerations…
    - Individual smaller scale producers (e.g. households, service sector, mini grids) – usually solar PV. For this category it is important to know/estimate generation (e.g. based on metering where available, or surface/installed power of solar PV facility)

Examples

- Primary biomass energy
  - Production of energy forms like fuelwood, animal waste, liquid biofuels (biodiesel, bio gasoline), bagasse…
- *Only energy use related quantities should be reported*

Fuel wood – "traditional biomass"

- Various types of wood are widely used, but statistics on its production and energy uses is rather poor
- Various units are used
- Wide range of water content (calorific values)
- In many countries fuelwood is not subject to market activities (e.g. private forests, unregister cuts, manual wood collection, industrial wood waste…) and therefore it is difficult to estimate total available amount
  - The most reliable approach is use of surveys – create household surveys in order to retrieve overall energy balance of a household

TRANSFORMATION

Examples

- Production of charcoal (next slide)
- Use of biomass for electricity and/or heat generation (including co-firing)
  - E.g. use of bagasse in sugar factories to produce heat and electricity. Depending on legal construct of a company it can be reported under main activity or as autoproduction

Charcoal

- Mainly produced for market trade, can be imported/exported (but sometimes difficult to record/track)
- Production sites difficult to monitor
  - Smaller scale production
  - Low efficiency (traditional kilns)
  - Important to estimate efficiency of transformation and report it in transformation (middle) part of energy balance
- Usually only surveys and modeling can provide good estimates

FINAL CONSUMPTION

Final consumption statistics

- "Detailed statistics" by consumption categories (households, industry, services, transport…)
  - End-use energy consumption (heating, cooking, hot water, cooling, non-thermal consumption, lighting)
  - Additional statistics to "feed" data into energy models (e.g. energy demand analysis and projections)
  - Energy (efficiency) indicators
  - Indicators for developing and monitoring energy policies
  - Energy poverty indexes, etc.
- No exact international standards, countries develop and apply own methodologies, models and estimates
- Much more detailed data must be collected in comparison to "main energy statistics" (e.g. annual energy balances)
- This type of statistics is still underdeveloped in many countries

Final consumption surveys

- Final consumption data (including renewables) can be collected through specially designed surveys
  - Alternative is to use data available from other regularly conducted surveys (e.g. household budget surveys, population census) or to adopt additional questions related to energy uses and energy-related life styles
- For households surveys are based on sampling, while for services and industries it is good to combine sample and targeted surveys (by activity and size)
  - Target is to collect all energy consumption data (all energy forms and energy uses – "energy balance" of a household, company…)
- Data collection process has to be carefully designed and conducted (adopted to local situation) and collected data verified (additional modelling needed)
- Data collection through surveys is costly, but may provide good quality data needed for planning and monitoring and is especially useful in developing countries where starting point is often unknown

Household survey – Example

- Energy consumption of households – all energy using activities related to private dwellings (individual houses and flats in buildings)
  - All energy forms – electricity (grid and off grid solutions like solar PV, diesel generators), LPG (if used in car should be reported separately), kerosene, fuelwood, charcoal, individual biogas production, animal waste…
  - All energy uses – cooking, lights, appliances, hot water, cooling (heating)… (consumption related to cars and agricultural activities or services should be reported separately)…
- For grid provided energy forms (e.g. electricity) use utility data for comparison, verification and up-scaling

Instead of conclusion

- Regarding data collection
  - One can decide not to do anything
    - Costs zero, produces zero outcomes
  - One can decide to collect data only when necessary
    - Can be very costly and requires long lead times, outcomes often limited to one time use
  - One can decide to collect and improve data regularly
    - Invest regularly into data collection and step-by-step process improvements (priorities, available data, coordination, legal framework)

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Thank you!

Terminology for Energy Commodities