ETSAP

ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAMME

ETSAP ETechDS

Data Normalisation Project

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Objectives and Target Users

- Homogenise and update technical-economic data on energy supply & end-use technologies in the ETSAP Energy Technology Data Source (ETechDS);
- Build a transparent database on costs and performance aimed to technology comparison, projections and scenario analysis;
- Provide TIMES users with a tool to input a consistent set of energy technology data into their own models;
- **Target Users**: not only TIMES users, but also energy analysts, investors, policymakers ...

Basic Approach

- Normalize (i.e. homogenize to a common basis) the key parameters that characterise technical and economic performance of energy technologies (e.g. efficiency, capacity factor, lifetime, emissions, costs, interest rate, discounting, etc.);

- Review the well-known *levelized electricity cost,* (LEC) method to apply, with appropriate amendments, to all supply and end-use energy technologies (i.e. energy conversion, transport, industry, buildings).

ETechDS Technology Characterization

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- Key materials use
- Water use
- Land use

ENERGY INPUT

- Ren. energy and/or
- Biomass fuels
- Fossil fuels
- Nuclear energy
- Electricity
- Heat

Supply/end-use Energy Techs

(efficiency, capacity factor, lifetime, emissions, costs, …)

OUTPUT

- Electricity [kWhe] or …
- Heat [kWht]
- Fuels [MJ]
- Industrial goods [t, units]
- Transp. services [km, p-/t-km]
- Buildings serv. [kWhe, kWht]
- plus… by-products, if any

- CO2/GHG emissions
- Air pollutants
- Waste
- Residual heat

Homogenisation of Key Parameters

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Key Parameters	Energy Sectors			
	Energy Conv.	**Transport**	**Industry**	**Residential**
Net energy efficiency (output/unit of energy in)	kWh/MJ in, MJout /MJ in	km/MJ, p/t-km/MJ	t/MJ, unit/MJ, goods/MJ	kWhe/MJ, kWht/MJ
Gross energy intensity (energy in/unit of output)	1/energy efficiency			
Emission coeff. of energy input	gCO2/MJ in, if any			
Emission coeff. of tech process	gCO2/unit of output (kWh, km, t, units, …), if any			
Plant/device size	kW, GJ/y	kW	t/y, unit/y, …	kW, unit/y
Lifetime	years			
Capacity factor	hours/y	km/y	t/y, unit/y, …	energy use/y
Annual production	kWh/y, GJ/y	km/y	t/y, unit/y, …	energy use/y
Overnight capital cost	$/kW, $/GJ/y	$/kW	$/t/y, $/unit/y	$/unit
O&M cost	$/kWh, $/MJ	$/km	$/t, $/unit	$/unit of en. use
Fuel, emissions & other costs	$/kWh, $/MJ	$/km	$/t, $/unit	$/unit of en. use
Levelized production cost	$/kWh, $/MJ	$/km	$/t, $/unit	$/unit of en. use

Economic Approach - LEC Method

Costs[1] of energy technologies are assessed using the levelized electricity cost (LEC) method, with appropriate amendments to apply to all technology sectors (energy conversion, transport, industry, buildings..)

LEC is the ratio of total (*discounted*) lifetime costs ($\sum_i$ Ci) incurred by the investor to supply electricity to the grid to the total amount of electricity generated by a power plant ($\sum_i$ Ei) over its lifetime LT

$$\mathbf{LEC = \sum_i Ci / \sum_i Ei} \quad \Rightarrow \quad \mathbf{\sum_i Ci = LEC * \sum_i Ei}$$

LEC is also referred to as the minimum electricity price that repays the investor for all (*discounted*) costs ($\sum_i$ Ci) incurred for plant construction and operation over lifetime (LT), with no profit.

1) Include capital, financial, O&M, fuel, CO2 emissions, waste, decommissioning, production and other accountable costs

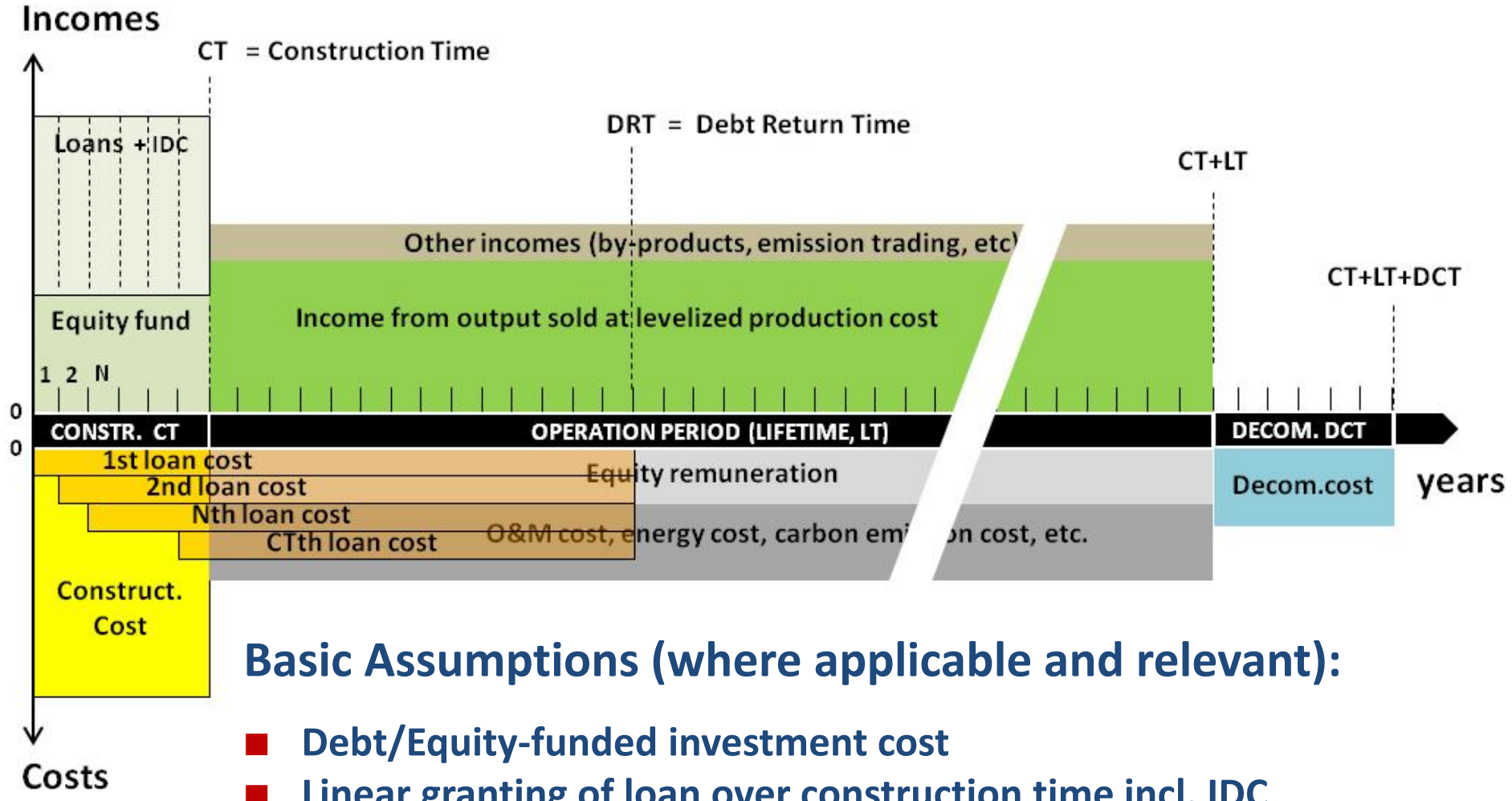
LEC method applications ...

- **Widely used to assess electricity cost from different power technologies, e.g.:**
  - **IEA-NEA** - Projected Costs of Generating Electricity 2010 (next release 2015)
  - **IRENA -** Renewable Power Generation Costs 2012
  - **IPCC -** Ren. Energy Sources & Climate Change Mitigation - Special Report – 5th Assessment Report (AR5), WG III Climate Change 2014
  - **US NREL & DOE -** Levelized Cost of Energy Calculator (nrel.gov; en.openei.org)
  - **US EIA** - Levelized Cost and Levelized ***Avoided*** Cost of New Generation Resources in the Annual Energy Outlook 2014; Assessing the Economic Value of New Utility-Scale Gen. Projects
  - **FRAUNHOFER** (Institute for Solar Energy - Germany) - Levelized Cost of Electricity - Renewable Energy Technologies, 2013
  - **plus many other applications …**
- **Results vary significantly as a function of basic assumptions and applications**
- **Comparing results is often difficult because of pore information on basic assumptions (e.g. debt/equity funding, interest and discount rate, debt return time, depreciation, interest during construction …)**
- **Rare applications to non-power energy technologies**

This approach's key features …

- Applicable to supply and demand energy technologies;
- Investor-side cost analysis to reflect real market, awap;
- Full transparency for users to change technical-economic inputs;
- Flexible project financing structure (debt/equity ratio);
- Linear loan over construction time (if applicable);
- Interest during construction (if applicable);
- Cost discount, with different discount rates;
- Accounting for capital, financial, FixOM, VarOM, fuel/energy, emissions, waste management, production taxes and decommissioning costs;
- Credit for income from avoided emissions, subsidies, by-products;
- Variable annual production to account for ageing;
- Variable fuel/energy & emissions costs to account for fluctuations;
- Levelized cost based on un/discounted production;
- Investment return time (if any) based on expected market prices.

Typical cash flow/balance



Basic Assumptions (where applicable and relevant):

- Debt/Equity-funded investment cost
- Linear granting of loan over construction time incl. IDC
- Debt return time (DRT) ≤ lifetime (LT), based on market/regulatory
- Equity remuneration during the operation period
- Annual-based production and costs

ETechDS Normalisation Model

- Four .xls files (energy conversion, transport, industry, buildings);
- Several sheets per file, one per technology cluster, e.g. nat. gas-fired power plants incl. GT, GTCC, GTCC+CCS, …
- Five model columns (normalization) per sheet, with VBA macros;
- Normalized data for technology variants on other columns;
- TIMES-relevant data for each technology sector are then transferred to a spreadsheet in a suitable form for TIMES input;
- Ongoing numerical testing and validation, all sectors.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	1	2	3	4	5										
2															
3	POWER SECTOR - GAS FIRED POWER PLANTS					GAS TURBINE COMBINED CYCLES - GTCC						GAS TURBINE COMBINED CYCLE			
4	PLEASE NOTE:					Data Sources:						Data Sources:			
5	MODEL ROWS WITH VB CELLS; DO NOT INSERT/DELETE ROWS/COLUMNS IN THE MODEL AREA: ROWS 1 to 230, COLUMNS 1 to 5					C:\Users\giorgio\Desktop\NORM 16a						C:\Users\giorgio\Desktop\NORM 16a			
6	KEY INPUT DATA in RED; OPTIONAL DATA in BLUE; CALCULATED DATA in BLACK;				CommandButton1										
7	ILT = 5, 10, 15, 20 .... LT MAX = 60 YEARS; 1kWh = 3.6 MJ														
8							2015			2030			2015		
9			CO-RELATION	UNIT	MODEL	ref. value	min	max	ref. value	min	max	ref. value	min	max	ref. va
10	INPUT/OUTPUT				VBA CELLS										
11	(energy) input	I			nat gas										
12	lower heating value (energy content)	LHV		MJ/m3	36.50										
13	CO2 emission factor	CEF		kgCO2/MJ	0.06										
14	CO2 emission factor	CEF	LHV*CEF	kgCO2/m3	2.01										
15	other GHG emission factor	GHGEF		kgCO2eq/MJ	0.00										
16	output	O			electricity										
17	by-product	BP			none										
18	PROCESS AND SERVICE														
19	main process fluids	MPF			fluegas/steam										
20	max process temperature	MPT		°C	1300/540										
21	max process pressure	MPP		bar											
22	service	SER			intm/baseload										
23	ENERGY STORAGE														

THANKS for your attention

Comments and suggestions to improve the model and better meeting the needs of TIMES users are more than welcome

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