Measurement of energy productivity of industries

by Helmut Mayer*)

1. Energy productivity (EP) of an industry is measured by relating the energy consumption of an industry (input) to its output:

EP = output / energy input.

2. As **energy input** figures are often taken from the energy balances: consumption of final energy by sectors (manufacturing industries, service sector, transport sectors). In energy accounts – comprising all industries of the economy - usually "net energy" (or "primary energy") is taken. Net energy comprises, in addition to final energy, energy used for non-energy use, losses at the transformation of energy sources and energy use of the energy sector.

3. As **output** figure gross-value added (price-adjusted) is often used[1].
As an alternative to gross-value added (GVA) also physical output for certain industries are recommended, e.g. production of steel for the steel industry, transport performance for transport industries or electricity generation for that industry[2,3].

4. IEA differentiates by building both relations – for "energy indicators" the relation of energy consumption by industry sector to the corresponding value added (in constant prices), for "energy efficiency indicators" the relationship of energy consumption to the corresponding physical unit of production "if available"[4].
The first relation should "indicate the general relationship of energy use to economic development", the second "indicate(s) the relationship of energy use to physical production". The latter "at the disaggregated level can give a better measure of the technical efficiency of a particular production process"[5].

5. So, by IEA, a clear cut is made between a measurement of technical efficiency and a more "general relationship". This raises the question "where are the limits of both measurements and is there a favourable (for certain industries) one"?

6. The limits of the first measurement based on figures on physical output are due to the availability of (representative) figures for the physical output of an industry. The more limited and/or homogeneous the output of an industry the easier a measurement could be - if figures on that output are available (e.g. figures on electricity output, goods transport performance, steel production etc.).

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*) Federal Statistical Office of Germany – G2 (helmut.mayer@destatis.de)

[1] CF. SEEA-E (Draft), chapter 7 (presentation and use), E. Analysis of economic growth, §7.72-74

[2] IEA Working Paper (2011) – Trudeau, N., Murray, I.: Development of Energy Efficiency of Indicators in Russia, OECD/IEA 2011.

[3] Mayer, H. (2009): Reporting on sustainable development indicators in Germany: measurement of energy productivity, Paper for the EMAN conference 2009, see chapter 2.1. Energy productivity of the energy transformation sector.

[4] Cf. IEA 2011, table 2, p.17.

[5] Cf. IEA 2011, p.17.

7. For the transport sector and its sub-sectors on passenger and on freight transport, a bundle of physical indicators on transport performance is available[6]. Meaningful indicators for the sub-sectors - showing the trend in energy intensities - could be constructed on basis of the detailed data for different transport modes. A measurement problem arises when aggregating these sub-sectors to industries on a more aggregated level, e.g. divisions of NACE. How could one aggregate indices based on different physical output figures(with different units)?

8. For service industries volume figures for output will hardly be available, although - within the national accounts - for the volume measurement of non-market services a direct volume measurement is recommended. On the other hand price-adjusted gross value added figures for certain service industries are volatile, e.g. for financial industries, not indicating a pure 'economic development'.

9. For the manufacturing sector data on physical output is available from statistics on production. The problem is that output of certain industries might be heterogeneous and the various physical amounts of output are not summable in a meaningful way. Even if for some industries – with a limited number of outputs - a measurement would be feasible, the problem of building an overall measurement on energy efficiency (productivity) of the whole sector remains. **Is there a method available to aggregate special productivity measurements for industries based on different physical volume figures?**

10. Particular emphasis has to be given to the **energy generating industries**[7]. Looking at energy productivity of all industries productivity changes of the energy sector are very significant. Within an overall measurement these industries "consume" a major part of net energy. Net energy (input) of the energy sector comprises mainly losses of energy occurring at the transformation of primary energy sources to secondary energy sources, like electricity. An efficiency measure would hardly relate these losses to price-adjusted GVA but to the physical amount of energy generated by the particular industry.

11. There are **five severe handicaps for the use of price-adjusted GVA in the productivity measurement** of certain industries and for all industries (e.g. within a decomposition analysis):
- Volatile figures for certain industries (financial industries, energy industries like refineries or energy distribution) – not showing a pure economic development.
- GVA volume figures for certain industries based on hedonic measurement are hardly comparable with volume figures of other industries (because they include an explicit quality component).
- Time-series of GVA volume figures are not summable over all industries because they are chained.
- GVA volume figures do not contain pure (physical) volume, but also other parts, e.g. profits or subsidies, which have no physical counter-part.
-GVA volume figures are difficult to interpret because they are based on complex measurement (double deflation of nominal GVA).

[6] In IEA 2011 an overview is given on the availability of indicators by IEA member countries, see table 7 and 9, p. 30 and 33.
[7] Cf. Mayer (2009), p.5 f.

12. Therefore for certain industries with a clearly defined output, representing the whole industry adequately, a productivity measurement on basis of physical output figures has to be preferred to a measurement on basis of price-adjusted GVA.

13. Energy productivity figures for different industries based on different reference figures (e.g. price-adjusted GVA, tons of steel, vehicle-kms) could be aggregated by using GVA in current prices as weights.

14. If GVA of a base year is used for aggregating energy productivity (indices) of industries a Laspeyres-type of productivity index will be the result. If changes in industry shares in time have to be considered, e.g. within a decomposition analysis, Paasche or Fisher- type indices could be used.

15.In any case for the measurement of the effects of changes in industry shares GVA figures at current prices are to be preferred to GVA figures at constant prices.