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Forecasting the United Kingdom's supplies and demands for fluid fossil-fuels

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Abstract

A novel, but by now, well tried and tested approach to the mathematical modelling of the extraction life-cycle of any depleting fossil-fuel resource has been developed. It is a bottom-up technique for energy planning, whereby an integrated summation of the outputs from the various producing fields in the considered region is obtained. As the present paper will show, in the absence of political interference, this means for predicting the resulting future availabilities of the mineral fuels has been validated. Even in the event of a fiscal change, the model can be adjusted to take account of the new scenario. The evolved 'skewed-normal profile for the rate-of-extraction' *supply* model (i) yields a better representation than has been achieved with earlier approaches and (ii) is appropriate for use with rate-of-extraction data, that rise with time to a plateau, and then decline more slowly, but is unsatisfactory for use when the profile exhibits more than a single rate-of-extraction peak. Also, in many circumstances, the profile is less systematic in shape, often as a result of temporary political, economic or on-stream changes. Thus, for these situations, it is proposed that a 'skewed-normal profile extraction' supply model be used in conjunction with what is here described as the reverse-projection technique. The application of the model, without and with reverse projections for the UK crude-oil and natural-gas extraction-rates data, is demonstrated. Reasonable predictions, for both crude-oil and natural-gas rates of *demand*, can be achieved only for a country that is politically and economically stable. Even then, because of uncertainties and social factors, it is often difficult to formulate a wise policy concerning long-term fuel requirements. Nevertheless, it is only by understanding the implications of changing fuel-demands that a long-term strategy can be evolved for a country's economy. Thus, it is desirable to try to predict the future requirements for crude oil and natural gas, and so, as an additional tool, a 'modified logit-function' demand model has been developed for use with the usually readily-available historic consumption data. It is based on extrapolations, using reasonable-trend assumptions, for the appropriate energy-intensity (i.e. annual fuel consumptionl/annual gross domestic product (GDP)), population and GDP/capita likely future behaviours. © 2001 Elsevier Science Ltd. All rights reserved.

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Nomenclature

A	Amplitude coefficient in the skewed-normal-profile extraction equation
A_{opt}	The optimal value of A
a_0, a_1	Coefficients in the modified logit-function equation
B	Rate of increase of the dependent variable (e.g. GDP/capita, or population) with respect to time
$\acute{E}$	Rate of extraction from the resource reservoir; $= \mathrm{d}Q/\mathrm{d}t$, (Mtoe/annum)
GM_1, GM_2 and GM_3	The geometric mean values of a group of three concurrent datum-point samples, taken at each of or near (i) the beginning, (ii) the middle and (iii) the end, respectively of the datum range
g	The average annual fractional change in either the population or the GDP/capita, as stipulated
I, I' and I''	Integration by parts and subsequent successive integrations by parts
k_{max}, k_{min}	The upper and lower limit asymptotic-values respectively in the modified logit-function equation (in units of 10^{-6} toe/£ for UK natural-gas)
n	Shape factor in the skewed-normal-profile extraction equation
Q	Magnitude of the resource, (Mtoe)
R	Reserves remaining in the fossil-fuel reservoir, (Mtoe)
S_{err}	Sum of the squares of the errors
t	Period from the start of extraction, i.e. from t_{zero} (years)
t_{max}	Year of peak extraction
t_{zero}	Year immediately before large-scale extraction occurred
t_{∞}	Life period from t_{zero} to the onset of exhaustion of the resource, (years)
URR	Ultimately-recoverable part of the resource, (Mtoe)
URR_c and URR_e	Values of URR as *calculated* from the present equations and as *estimated* on technical and economic grounds respectively, (Mtoe)
x	Time, (years)
Y	The projected magnitude of the dependent variable (i.e. population or GDP/capita)
Y_0	Population or GDP/capita for the base year, t_0
$Y(t)$	Actual rate of extraction at time t, (Mtoe/year)