Exploring the production of natural gas using ACEGES

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Abstract

Due to the increasing importance of natural gas to modern economic activity, and gas's non-renewable nature, it is extremely important to try to estimate possible trajectories of future natural gas production while accounting for uncertainties in resource estimates, demand growth, production growth and other factors that might limit production. In this study, we develop future scenarios for natural gas supply using the ACEGES computational laboratory. Given the estimated EUR, the 'Collective View' and 'Golden Age' scenarios suggest that the peaks of median global production of natural gas may happen in the broad vicinity between 2045 and 2052 while the asymmetrically weighted upper frontier might peak between 2050 and 2065.

Keywords: natural gas production, natural gas scenario generation, ACEGES, expectile smoothing, GAMLSS

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1. Introduction

Secure, sustainable and competitive energy is of fundamental importance to the individual countries' economy, industry and citizens and a core goal of their policy. To achieve this goal, the policymakers need adequate instruments to act within their borders and to promote their interests in relation to third countries.

Energy (particularly oil and gas) is a global business. This means that countries face growing competition for fossil fuel resources, including from emerging countries and energy producers themselves. Growing population and rising standards of living could push global energy demand up. Rising energy demand is pushing up global prices, bringing energy poverty to many and playing havoc with countries where fossil fuel subsidies are prevalent.

Natural gas is widely used around the world for a variety of usages such as power generation, transportation, residential use, and feedstock for chemical industries. The global natural gas market is likely to undergo a dramatic change. Indeed, the natural gas is perhaps one of the most intriguing developments in global primary energy markets. Nearly all projections of future demand for natural gas assume a substantial increase in the coming decades, despite any likely conservation measures or gains in energy efficiency.

Whilst there are several studies that explore the outlook of crude oil production (e.g., Hallock *et al.*, 2004; Caithamer, 2008; Nashawi *et al.*, 2010), forward-looking outlooks of natural gas production has been not explored with the same level of intensity despite the growing importance of natural gas to fuel socio-economic activities. Having said that Table 1 shows several studies of long-term projections of future natural gas production, including the estimated ultimate recoverable resources (EUR), forecasted peak year, and production at the peak year. Most of the studies estimate that the peak year comes before 2025 (Al-Fattah and Startzman, 2000; Al-Jarri and Startzman, 1997; Guseo, 2006; Imam *et al.*, 2004; Laherrere, 2007). Edwards(1997), Mohr and Evans (2011) and Zhang *et al.* (2010) show the peak in later years. The longest is the high-EUR case of Mohr and Evans (2011), which is around 2065. Comparing the current production with the estimated peak production, the current production has already been larger than the level estimated in some of these studies.

Scenarios of natural gas production are based upon different type of models such as variants of the Hubbert model, the generalized Bass model and the demand-production interaction model. However all these models belong to

Table 1: Conventional natural gas projections (in Trillion cubic feet -Tcf)

Sources	EUR	Peak Year	Peak Production
Edwards (1997)	11625	2040	120
Al-Jarri and Startzman (1997)	7060	2011	103
Al-Fattah and Startzman (2000)	10000	2014-2017	99
Laherrere (2002)	10000	2015	NA
Aleklett and Campbell (2003)	10000	2015-2040	130
Imam *et. al.* (2004)	9215	2019	88
Guseo (2006)	7332	2008-2014	100
Laherrere (2007)	10000	2020	135
Campbell and Heapes (2009)	9886	2021	108
Zhang *et. al.,* (2010)	NA	2030-2035	130
Mohr and Evans (2011)	9952-17027	2025-2065	112-151

the general family of non-linear (parametric) regression models. The scenarios presented here are based upon the ACEGES (Agent-based Computational Economics of the Global Energy System) model proposed by Voudouris *et. al.* (2011). The key advantage of ACEGES model is that a high degree of heterogeneity is easily incorporated in the scenarios while the macroscopic explenanda (world natural gas production, which is the consumer-grade natural gas) emerges from bottom-up rather than pre-defined by the Walrasian Auctioneer in the form of an gas mountain with specific statistical and mathematical properties. This means that key uncertainties (such as EUR, demand growth, production growth and state of depletion at peak) are country specific and can be explored by i) parametric and/or non-parametric distributions based upon historical observations and/or ii) subjectively defined by the users based upon personal experience and 'forces in the pipeline'. To the best of our knowledge, this is the first time that the agent-based modelling and simulation (ABMS) framework is used to explore forward-looking scenarios of natural gas production.

Section 2 outlines the ACEGES model, particularly the decision rule of the agents (countries). Because the ACEGES model is a *realistically-rendered agent-based model*, it also discusses how the model is initialised with observational data and how heterogeneity is introduced in the scenarios. This section also introduces the *Expectiles* statistical technique, first introduced by Newey and Powell (1987) and Eilers (1987), as a way of summarising the scenarios of natural gas production. Section 3 presents the results of the Collective View Scenario and the Golden Age Scenario. Section 4 concludes.

2. Method

2.1. The ACEGES Model

The ACEGES model is an agent-based model (ABM) for exploratory energy policy. ABM is a novel and flexible modelling framework for the computational study of socio-economic and natural processes. ABM conceptualises, in this instance, the global natural gas market as a complex adaptive system of interacting agents (countries) who do not necessarily possess perfect rationality and information. ABM models require detailed specifications of structural conditions (natural gas originally in place before any extraction), institutional arrangements (e.g., long-term trade agreements), and behavioural dispositions (e.g., decision rules of natural gas production).

The current implementation of the ACEGES:Gas model follows the same specifications as the ACEGES:Oil model detailed in Voudouris *et. al.* (2011) with the following enhancements:

- Uniform distribution U(a,b) has been augmented with country-specific parametric and non-parametric distributions based upon historical observations

- For the USGS (United States Geological Survey) EUR we use P-splines to approximate the distribution of undiscovered natural gas in order to represent the USGS EUR as a random variable=cumulative production at time t + known reserves at time t + a randomly selected value for undiscovered resources.

Figure 1 shows the graphic user interface (GUI) of the ACEGES model. The "Model" tab enables the scenario team to set-up the key driving forces of the scenarios such as the EUR of natural gas from USGS and the demand growth for natural gas. The graphic representations shows the simulated scenarios of a single run (each run can simulated, for example, 100 years). The GUI gives access to model data, plays, stops, pauses, and steps the simulation. Once the user runs a large number of simulations, say 10,000 simulations, the results can be summarised using the GAMLSS (Generalised

Additive Models for Location Scale and Shape) framework introduced by Rigby and Stasinopoulos (2005) and/or the Expectile Smoothing discussed below in section 2.2.

The ACEGES model allows key decision makers to interactively develop scenarios and elaborate their consequences. Although the process of developing scenarios is primarily a non-mechanistic mental process, the ACEGES can facilitate the scenario development by relying upon interactive graphics and the ABM framework. Effectively, the ACEGES model builds a virtual world in a computer and populates it with artificial intelligent agents that interact with one another and with the environment, which is composed of the most important and uncertain driving forces.

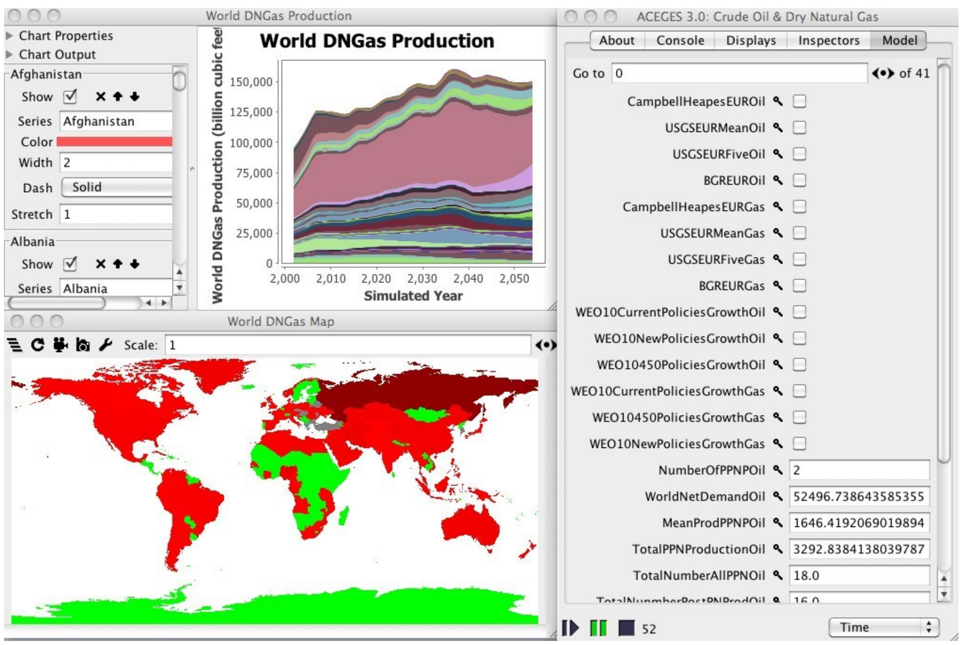

Figure 1: The GUI of the ACEGES model

2.2. Expectile Smoothing

The name ’expectiles’ was coined by Newey and Powell (1987) who proposed them as a least squares alternative to quantiles. In fact, Least asymmetrically weighted squares, LAWS, is used for the estimation of expectiles.

As discussed by Schnabel and Eilers (2009), by combining LAWS with P-splines (Eilers and Marx, 1996), it is possible to estimate flexible curves in any region of the data.

In this article we use smooth expectiles estimation. We propose this smooth expectiles statistical technique in addition to the centile approach used by Voudouris *et. al.* (2011). A key difference with the centile approach is that while centiles only knows whether an observation is below or above the curve, expectiles make use of the distance to data points in estimating a curve. Both centiles and expectiles are useful for decision-making under uncertainty as they represent different (but not conflicting) concepts. In fact, Jones (1994) argues that there is a relationship between expectiles and quantiles.

The expectile e_p for the Y (natural gas production) is estimated by minimising the following equation:

$$S = \sum_{i}^{n} \sum_{j}^{J} w_{ij}(y_i - \mu(x_i, p_j))^2 + P, \tag{1}$$

where $\mu(x_i, p_j) = \sum_k^K \sum_l^L a_{kl} b_{ik} \breve{b}_{jl}$, P is a penalty $P = \lambda_x \|D_d A\|_F + \lambda_p \|A\breve{D}_d\|_F$ with $\|U\|$ the Frobenius norm of matrix U (the sum of squares of all its elements), D_d a difference matrix of order d, $A = [a_{kl}]$ the fidelity coefficients and λ a penalty to control the smoothness of the curve. The weight w_{ij} is the weight for observation i with $p = p_j$ defined by:

$$w_{ij} = w_i(p) = \begin{cases} p_j & \text{if} \quad y_i > \mu(x_i, p_j) \\ 1 - p_j & \text{if} \quad y_i \leq \mu(x_i, p_j). \end{cases} \tag{2}$$

Note that $B = [b_{ik}]$ is the n by K basis of the B-splines $B_k(x)$ on the domain of x (ie year in our case). For a basis on the domain of $p, 0 \leq p \leq 1$, let $\breve{B} = [\breve{b}_{jl}]$ be a J by L basis matrix of B-splines $\breve{B}_l(p)$ (for a detailed description, see Schnabel, 2011, section 5.3.1).

To aid the interpretation of expectiles in section 3, the empirical expectile equation can be defined as:

$$e_p = \frac{(1-p)\sum_1^{n_1} y_{1i} + p\sum_{n_1+1}^{n_2} y_{2i}}{(1-p)n_1 + pn_2}, \tag{3}$$

where n_1 is the sample of observations below e_p, n_2 is the sample of observations above e_p, y_{1i} is an observation below e_p, y_{2i} is an observation above e_p and p is the asymmetric weight. Note that n_1 can be different from n_2 while $n_1 + n_2$ is equal to the total number of observations.

From above, a particular expectile can be interpreted as the *asymmetrically weighted mean* while the expectile curve can be interpreted as the *asymmetrically weighted frontier* (not to be confused with the maximum frontier defined by Data Envelop Analysis). In the special cases that:

- $p = 0.5$, the expectile is the (symmetrical weighted) arithmetic mean of natural gas production (expected frontier)
- $p \approx 1$, the expectile is very close to the maximum of natural gas production (upper frontier)
- $p \approx 0$, the expectile is very close to the minimum of natural gas production (lower frontier)

Frontiers based upon expectiles values are equivalent to the Stochastic Frontier Analysis. A natural gas production frontier characterises the maximum output producible under the assumption of LAWS over time and/or based upon various (bundle) inputs such as demand.

This formulation of frontiers are stochastic due to random variation in the operating environment of the agents. Therefore, the asymmetrically weighted frontier is interpreted here as a fuzzy region. As we will see in section 3, for $p \approx 1$ most of the simulated natural gas production will be located under the asymmetrically weighted frontier, but some of the simulated points are found above the asymmetrically weighted frontier due to unusually (but not impossible) favourable above and below ground factors.

2.3. Data for Natural Gas

Natural gas is a gas consisting primarily of methane found naturally in basins around the world. There are two categories of natural gas, namely conventional and unconventional natural gas. Conventional natural gas is extracted from oil fields (associated gas) and gas fields (non-associated gas). Unconventional natural gas is the gas produced from the places where conventional gas is not produced, and includes tight-sand gas, coal-bed methane, shale gas, biogas, and methane hydrates.

Because ACEGES model is a realistically rendered agent based model, the model requires setting a base year which in this paper is 2001. This means that each of the 218 countries modelled in ACEGES model is initialised with the real-world data as of 2001. Since the base year is before the current year (2011), historical natural gas production can be checked against a conceptual population represented by smooth expectile curves as shown in section 3.

ACEGES is initialised with the following data for each country depending on the requirements of the scenario:

(i) The domestic demand of dry natural gas in 2001 from the US Energy Information Administration (EIA).

(ii) The projected growth rates of natural gas demand using the three scenarios (i.e. the Current Policies, New Policies, and 450 Scenarios) of the World Energy Outlook (WEO) 2010 and 2011, the International Energy Agency (IEA).

(iii) The volume of natural gas originally exist before any extraction (i.e. EUR) from (a) Campbell and Heapes (2009): Data available for 62 countries with global EUR of 9649Tcf; (b) US Geological Survey (USGS) World Petroleum Assessment 2000 and National Oil and Gas Assessment: Data for 97 countries with global EUR of 9228 (95% likelihood)-17855 (5% likelihood) Tcf (including reserves growth); (c) Federal Institute for Geosciences and Natural Resources (BGR) Reserves, Resources and Availability of Energy Resources 2010: Data for 132 countries with global EUR of 18553Tcf; and (d) Sum of the cumulative production (see (v) below) and the latest proved reserves from EIA for countries not included in the above sources. These values are almost in the range of the estimates in the literature as discussed in section 1. Note that EUR estimated by the method (d) does not include the undiscovered natural gas. However, this process is essential to take into account the production aspect of as many countries as possible in the model. That is to say, the model has a more accurate picture of the net demand for imports which is what is being apportioned among the pre-peak net producers, by modelling more countries in the world, and having both production and demand for them. Having said that, this estimate should not be used alone since it is potentially a large underestimate of actual EUR.

(iv) The dry annual production of natural gas in 2001 from EIA.

(v) The cumulative production at the beginning of 2001. The cumulative production (1900- 2001), although the starting point is different by country because of the data availability, based upon (a) (Mitchell 1998a,b,c) from 1900 to 1979; and (b) EIA from 1980.

(vi) Estimates of natural gas remaining at the beginning of 2001 which is (iii) - (v)

(vii) The maximum allowable projected growth rates of natural gas production. This defines the constrained natural gas production from t to t+1. This is defined based on literature review and our own calculations.

(viii) Assumed peak/decline point of natural gas production (e.g. 0.5 of EUR). This is defined based on literature review and our own calculations for post-peak countries.

We use two observational data sources to obtain the cumulative production. Although the definition of natural gas used in this paper, the definition used in Mitchell (1998 a, b, c) are not specified. Actually, comparing the overlapping period between EIA and Mitchell (1980-1993), some differences are observed. These differences might also be attributed to semantics. Therefore, we adjust the Mitchell's data based upon the data provided by the EIA. We calculate the country-specific conversion factor as follows:

$$cf_i = \frac{\sum_{t=1980}^{1993} prodE_{it}}{\sum_{t=1980}^{1993} prodM_{it}}, \quad (4)$$

where cf_i is the country-specific conversion factor, $prodE_{it}$ is the country-specific production data from EIA at time t, and $prodM_{it}$ is the country-specific production data from Mitchell at t.

By multiplying the conversion factors to the production data in Mitchell, we assume the definitions of the two are harmonized. The data above is just an indication of how the model can be empirically initialised and standardised.

It is important to note that because of the use of dry natural gas, we are really testing whether the EUR estimates, in the form of dry natural gas, generate results consistent with the empirical data.

3. Results

Here we present two scenarios, namely:

- *The 'Collective View' Scenario*: The Monte Carlo process is used for all the four key uncertainties: i) EUR, ii) demand growth, iii) production growth and iv) peak/decline point. The results of this scenario is interpreted as the 'equally weighted collective view' of the agencies of the data sources reported in section 2.3.

- *The 'Golden Age' Scenario*: This scenario assumes the demand growth rates of 'Current Policies' from the recently published WEO 2011. The Golden Age scenario also assumes the high EUR estimates of the BGR. Both the production growth rate per year and the peak point are selected from a Monte Carlo process with the exception that the production growth is assumed to be a random number between 10% and 15% because of the favourable investment conditions for upstream operations.

Although the process of developing scenarios is primarily a non-mechanistic mental process, the ACEGES model can facilitate the exploration of plausible developments in the future by means of computational experiments. Therefore, the ACEGES model can be used for thought experiments by interactively adjusting the most important and uncertain parameters of the model (see figure 2).

Figure 2 shows that the key uncertainties are not necessarily restricted to a limited set of values (usually 3) but are defined by highly flexible probability distributions using the GAMLSS framework (or subjectively defined by the user based upon personal experience). Using the simulation engine of the ACEGES, these country-specific distributions are used to explore the full probabilistic space of the scenarios.

It is important to note that by using ACEGES model with Expectiles Smoothing and GAMLSS we suggest a move from the *multi pathway scenarios*, a key innovation in the 1967 when Shell's Group Planning shifted away from single-line forecasting (Jefferson and Voudouris, 2011; Jefferson, 2012), to *continuous scenarios* as a way of emphasising the uncertainty around the outlooks of natural gas. Furthermore, the use of continuous scenarios avoid suggesting a degree of precision that would be spurious and are appropriate when exactitude is elusive while being approximately right is helpful for policy making and long-term strategy.

The two scenarios reported below are a very small sample of the full range of scenarios that can be developed and tested.

3.1. The 'Collective View' Scenario

Figure 3 shows the smoothed asymmetrically weighted frontier of natural gas production for different values of p. The black line is the historical natu-

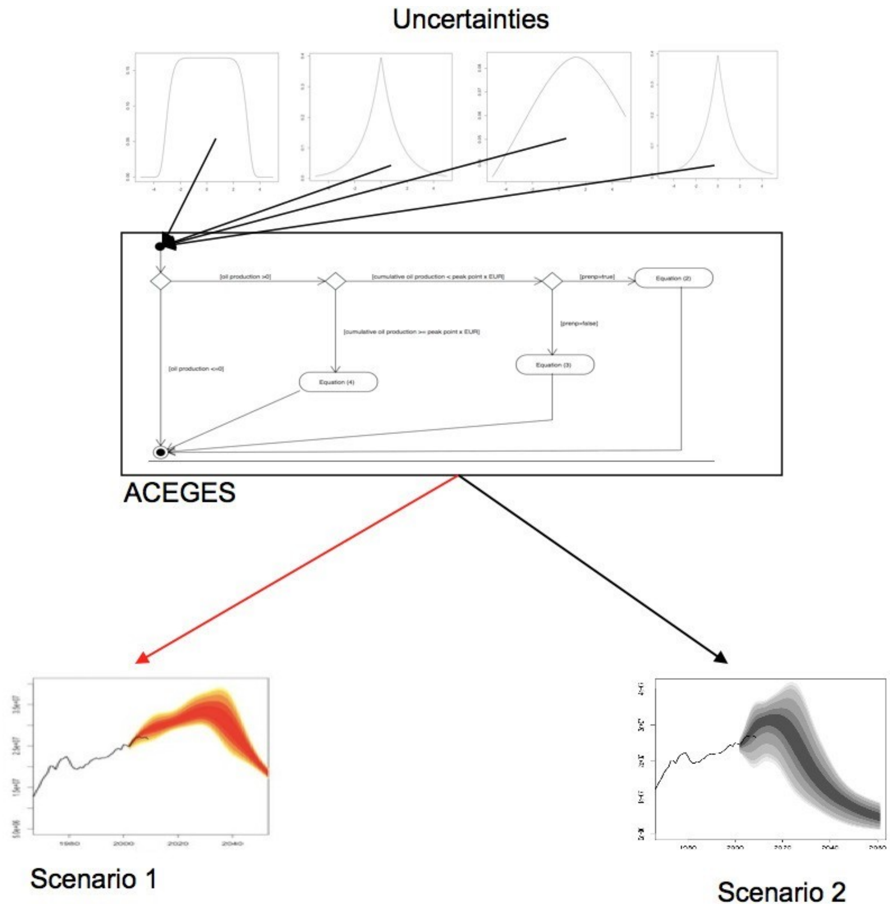

Figure 2: Scheme of ACEGES-based scenarios

ral gas production. For $p = 0.9999$, we get the upper frontier which peaks in the vicinity of the time region between 2060 and 2065. An interesting observation is that the lower frontier ($p = 0.0001$), which is the ”lower attainable” production of natural gas, continuous to increase until the broad vicinity of 2020. The expected production ($p = 0.5$) is peaking between the broad vicinity of 2040. The asymmetrically weight mean ($p = 0.9999$) natural gas production peaks at about 215 Tcf - this is not the maximum production of the 1,000 simulations generated by the ACEGES model for the Collective View Scenario. The absolute maximum production was about 243 Tcf. It is very important to note that the $p = 0.9999$ must not be interpreted as the centile for 0.9999, meaning that there is only 0.01% to get a production above the 215 Tcf. As an example, with reference to the Gaussian distribution, the $p = 0.9999$ means that there is not a 0.13% to get a production above the 215

Tcf. Clearly, by changing the reference distribution (e.g., log t distribution), the probability of 0.13% might change substantially (this probability might also change over time if the shape of the distribution changes). In our view, the expectiles should be interpreted with reference to equation 3 to avoid confusion with centiles and must not be interpreted as probabilities. If there is a need to associate levels of production of natural gas with probabilities, then centiles should be used (see figure 5).

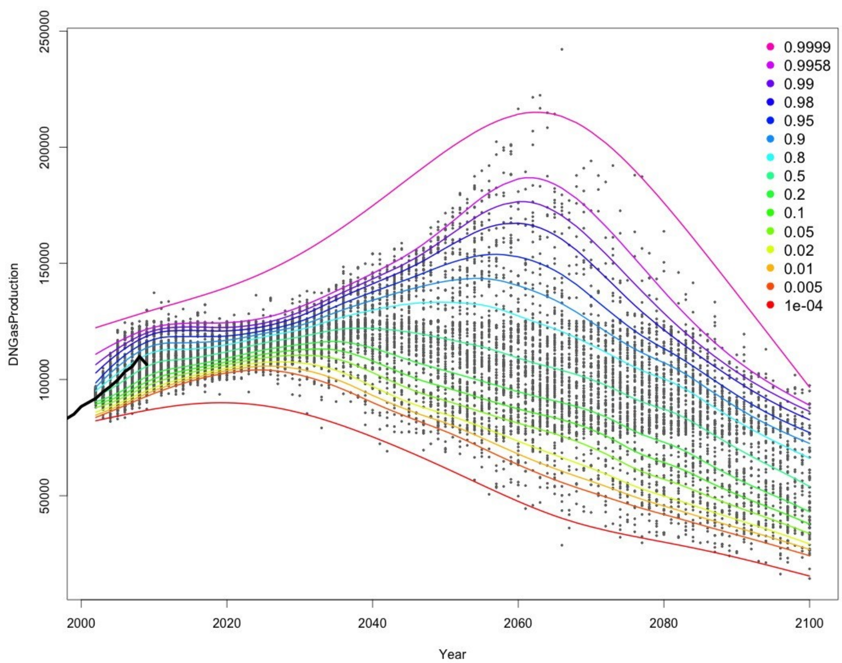

Figure 3: Collective View - Smoothed expectiles of natural gas production

Figure 4 shows the smoothed median production (black line) of natural gas over time while the blue dots are the simulated natural gas production based upon the Collective View scenario. The median production was estimated using the SHASH distribution within the GAMLSS framework. The median production peaks in the vicinity of 2050 with the maximum production below 150 Tcf. Although the median production has an intuitive interpretation that there is 50% chance to have the actual production above the median production, as the median production of natural gas declines and the demand of natural gas increases the likelihood of balancing the demand

and supply declines (see also figure 5). Note also the asymmetry between the first period of the natural gas age and the second period of the natural gas age. To visualise the uncertainty around the median production, particularly as we move towards the 2060, we superimposed the conditional distributions. An interesting feature here is that the shape of the distribution changes dramatically between 2020 and 2060. In fact, we observe a high degree of uncertainty in the broad vicinity of 2060. Note also the negative skewness of the distribution of natural gas production in 2040. The skewness gives us an estimate of the balance of risk in terms of balancing the production-demand of natural gas.

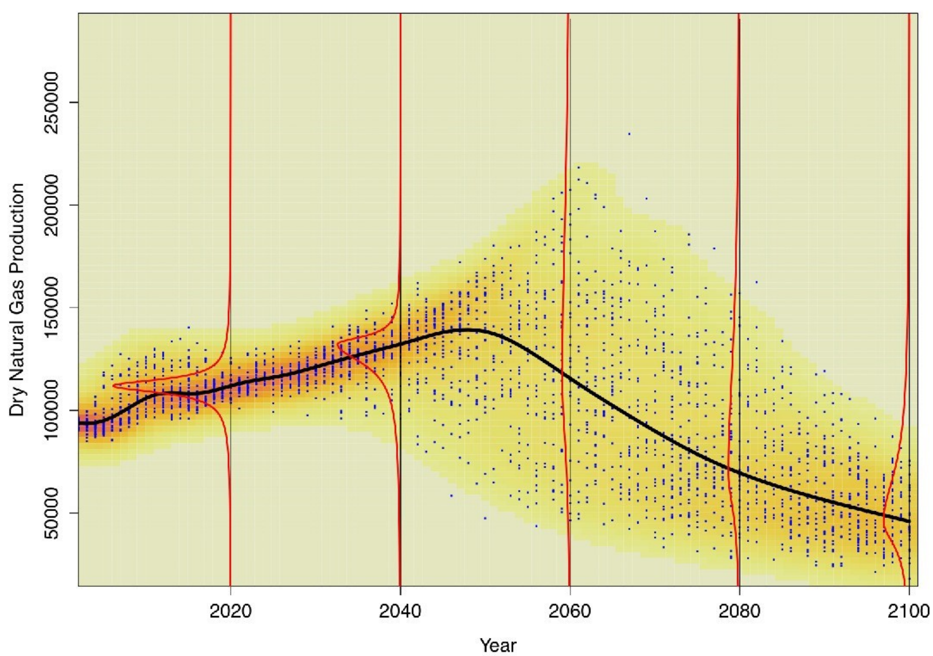

Figure 4: Collective View - Median and conditional probabilities of natural gas production

Figure 5 shows the relationship between the natural gas production against unconstrained natural gas demand. The dashed line represents the balancing between supply and demand (a line with intercept of 0 and slope of 1) while the thin black curve represents the median natural gas production given the natural gas demand. Note that when the balanced supply-demand line crosses the median there is a 50% chance of a supply shortfall. When the balanced demand-supply crosses the upper centile, there is only 1% chance that the supply will meet the demand. Therefore, as the balanced supply-demand line crosses the upper centiles the chances of meeting the demand declines. Note that the central 50% of projections are shown by the darkest red area. The grey dots represent a random sample of the simulated projections of the Collective View scenario. Note also that the graph shows a subset of the time-line of the Collective View scenario as we used as a cutting point the year 2065.

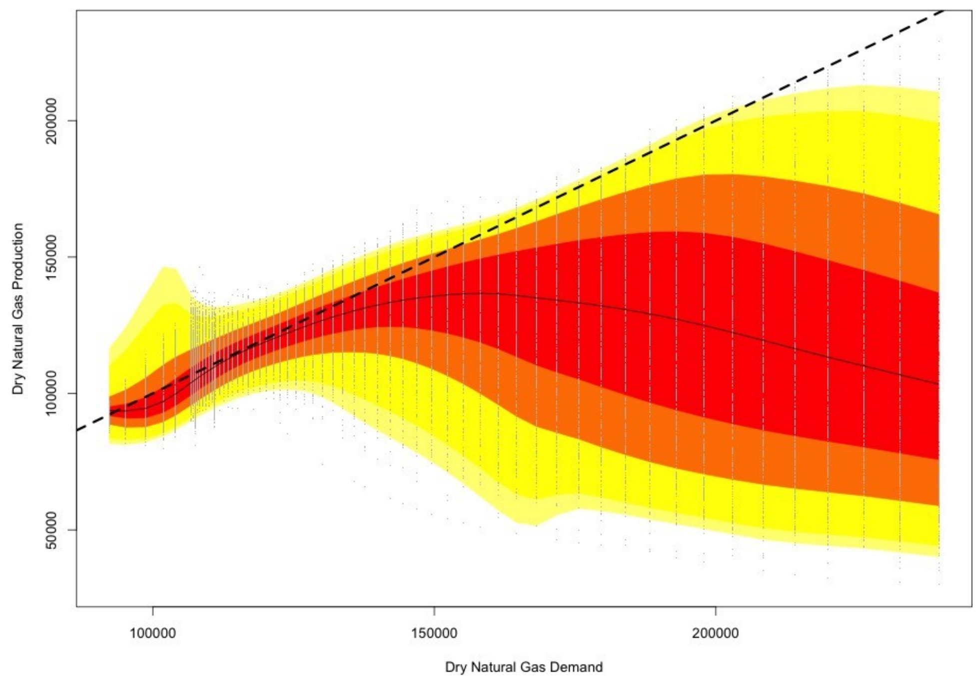

Figure 5: Collective View - Smoothed centiles of natural gas production against demand. Centiles of 0.1, 0.2, 0.10, 0.25, 50, 75, 90, 98, 99

3.2. The 'Golden Age' Scenario

Figure 6 shows the smoothed asymmetrically weighted frontier of natural gas production for different values of p. The black line is the historical natural gas production. Although the historical production follows one of the lower frontiers ($p = 0.005$), this should not suggest that the scenarios is pathological. The recent decline of natural gas production might be affected by the recent great recession rather than fundamental problems with the upstream operations of gas production. It is interesting to observe that the lower asymmetrically weight frontier increases until 2040 while a number of other frontiers suggest a relatively plateau period from about 2040 to 2060. The mean production of 240 Tcf ($p = 0.5$) peaks at 2050. The asymmetrically weighted upper frontier peaks at 305 Tcf in 2052. Not surprisingly, given the high volumes of production and the finite EUR, the peak year is earlier compared with the Collective View scenario.

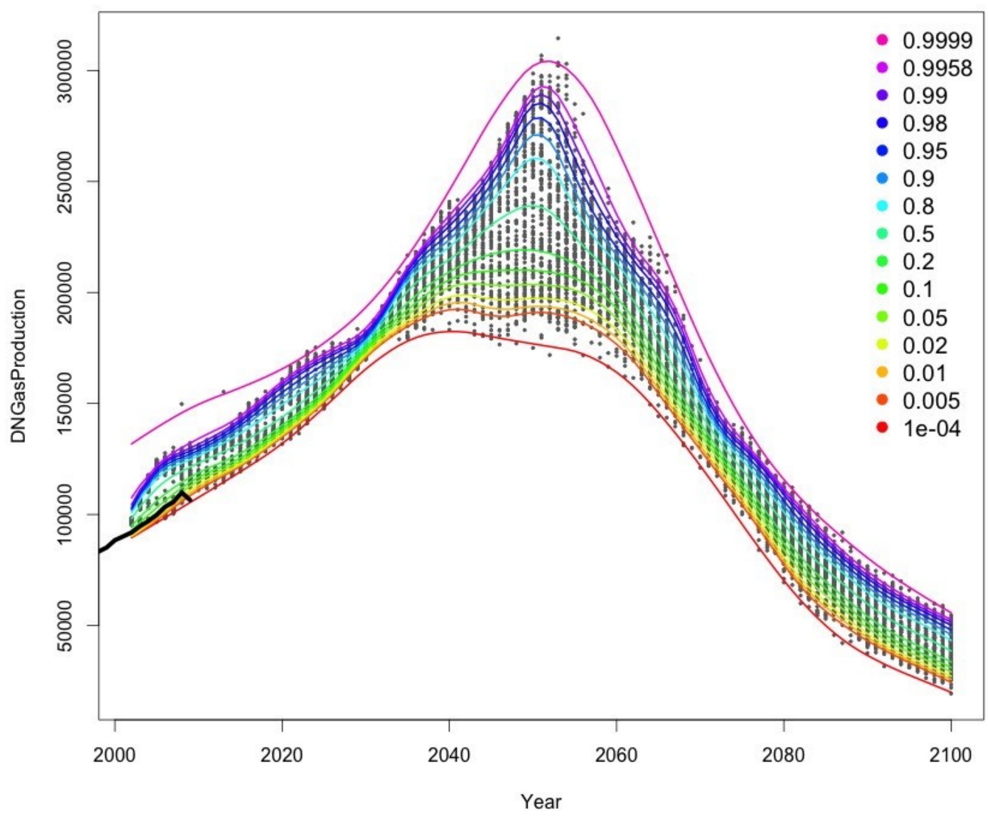

Figure 6: Golden Age - Smoothed expectiles of natural gas production

Figure 7 shows the smoothed median production (black line) of natural gas over time while the blue dots are the simulated natural gas production based upon the Golden Age scenario. The median production was estimated using the SHASH distribution within the GAMLSS framework. The median production peaks in the vicinity of the time region between 2046 and 2052 with the maximum production approximately 235Tcf. Although the median production has an intuitive interpretation that there is 50% chance to have the actual production above the median production, as the median production of natural gas declines and the demand of natural gas increases the likelihood of balancing the demand and supply declines (see also figure 8). Having said that because of the magnitude of the median production this is not likely to be a problem before 2044 (unless there is a significant shift in the demand for natural gas). Note again the asymmetry between the first period of the natural gas age and the second period of the natural gas age. To visualise the uncertainty around the median production, we superimposed the conditional distributions. An interesting feature here is that the shape of the distribution do not change with a notable exception in the vicinity of 2020 and towards the end of the century.

Figure 8 shows the relationship between the natural gas production against unconstrained natural gas demand. An interesting feature with the Golden Age scenario is that the balanced supply-demand line crosses the median production of natural gas when the demand is above 200 Tcf while there are good chances that we will not observe a supply-demand shortfall until then. At the crossing point there is a 50% chance of a supply-demand shortfall. When the balanced demand-supply crosses the upper centile (here 99), there is only 1% chance that the supply will meet the demand - this is happening in the vicinity of 300 Tcf. The grey dots represent a random sample of the simulated projections of the Golden Age scenario. Note also that the graph shows a subset of the time-line of the Golden Age scenario as we used as a cutting point the year 2065.

It important to note that although the ACEGES framework can account for political factors that can constrain production by means of subjectively specified stochastic processes, the scenarios presented here assume that production will continue to increase unconstrained by factors such as deliberate withholdings, military conflicts and social unrest.

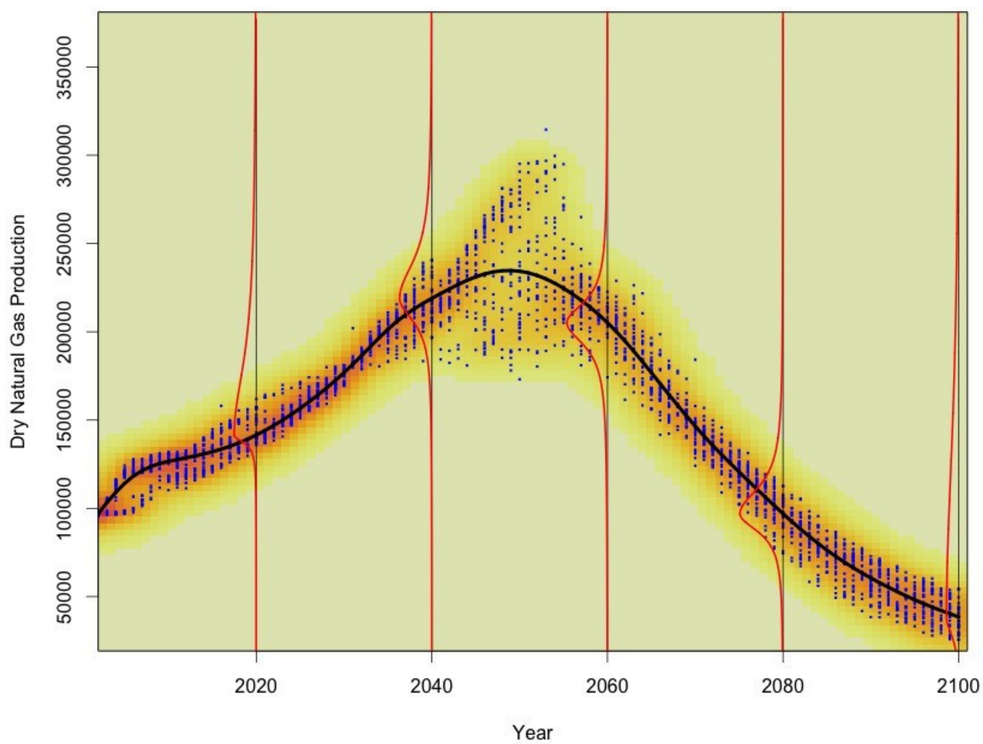

Figure 7: Golden Age - Median and conditional probabilities of natural gas production

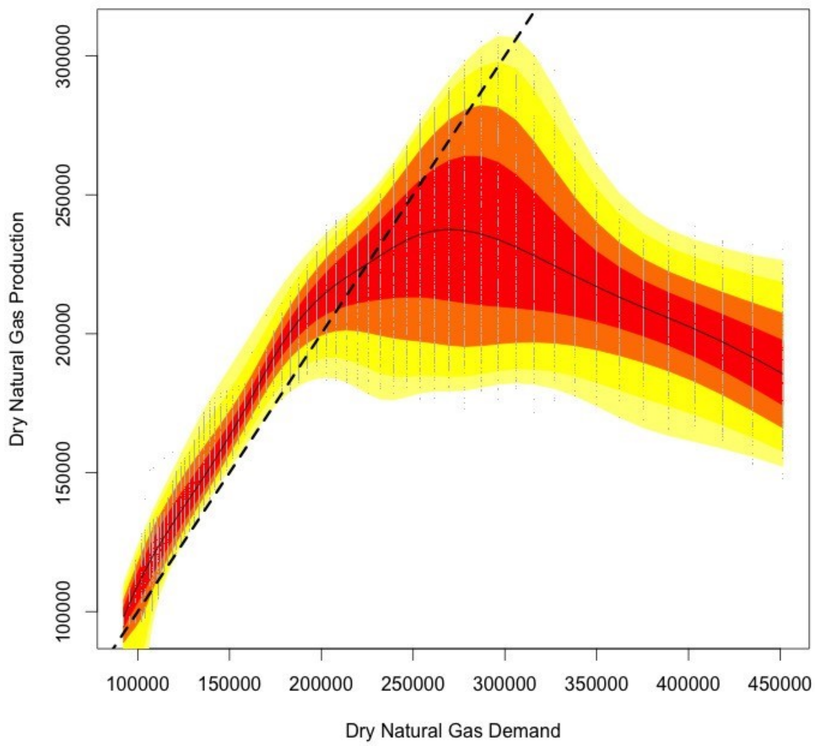

Figure 8: Golden Age - Smoothed centiles of natural gas production against demand. Centiles of 0.1, 0.2, 0.10, 0.25, 50, 75, 90, 98, 99

4. Conclusions

We recognise that to predict the exact future evolution of the natural gas market is nearly impossible to say at least. However, we think that it is realistic to provide continuous scenarios based upon the information available at time t. The information used in designing scenarios should be based upon the history and the current forces in the pipeline. Scenarios should not be based on wishful thinking but alternative opinions should be explored by means of controlled computational experiments.

It is demonstrated that the ACEGES model offers a new and novel way for the exploration of plausible futures of the dynamics of the natural gas market. We have also introduced a relatively new statistical technique, expectile smoothing, as a way of analysing and visualising asymmetrically weighted means (called frontiers) of natural gas production.

The ACEGES model can simulate a very large number of scenarios by adjusting any of the most important and uncertain driving forces of the scenarios. We presented two different continuous scenarios of natural gas production. Given the estimated EUR, the Collective View and Golden Age scenarios suggest that the peak of median global production of natural gas may happen in the broad vicinity between 2045 and 2052 while the asymmetrically weighted upper frontier might peak between 2050 and 2065. Furthermore, at the peak of the upper frontier for the Collective View scenario, a shortfall between supply and demand of about 30 Tcf (approximately the total consumption of natural gas in North America in 2010) might be observed based upon the Collective View Scenario. This 'gap' will be additional pressure on marginal natural gas production fields. An interesting consequence of the results presented here is to investigate the relationship between the asymmetrically weighted frontiers and the level and speed of upstream investment required to move the actual natural gas production towards the upper frontiers. For the Golden Age scenario, the supply is able to meet the demand until the demand reaches approximately 305 Tcf provided appropriate levels and speed of investment and not deliberate withholdings.

Our longer-run goal for the ACEGES model is a computational laboratory that rings true to industry participants and policy makers and that can be used as a research and training tool for long-term planning and investment processes.

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