The Global Calculator

Frequently asked questions

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Project background

1. Why was the Global Calculator built?

The purpose of the Global Calculator model is to help mobilise the support of businesses, NGOs and governments for ambitious action at the UNFCCC negotiations in December 2015. The global energy, food, land and climate system is very complex and the key issues are not widely understood outside of the technical expert community. For the first time ever, non-experts are able to explore the interdependencies between energy, land, food and climate and engage in the debate in a more informed way. Already, over 10 different organisations have specified their view of how the world should transition to 2°C and published these in the Global Calculator tool. This debate is critical to help mobilise support among a broad stakeholder group (businesses, NGOs, governments) for action to reduce greenhouse gas emissions.

2. Who was this model built by, and how long did it take?

The Global Calculator has been built by experts from a number of organisations around the world, including the UK's Department of Energy and Climate Change, Climate-KIC, the International Energy Agency, the Energy Research Institute (China), the World Resources Institute, Ernst & Young, Imperial College London, London School of Economics, Potsdam Institute, Climact, Climate Media Factory, Rothamsted Research, Walker Institute, the UK National Environment Research Council, the UK National Oceanography Centre, the UK Met Office and Université de Versailles St-Quentin-en-Yvelines.

In addition, over 150 experts from around the world were consulted during the course of building the model through a series of six workshops in London, Washington, Brussels, Beijing and New Delhi and a public call for evidence in July 2014. Following an initial scoping period, the model was built in 16 months (September 2013 to January 2015).

3. How much did it cost to build the Global Calculator?

Funding for the model came from two main sources:

- The UK Government spent £550,000 on the Global Calculator, as part of a wider project to support other countries in understanding the future of their energy systems.
- Climate KIC allocated £480,000.

Additionally Mott Macdonald covered all the costs of the London launch event.

4. What are the next steps for the project?

The Global Calculator team will decide on the next steps, based on the feedback we get. Initially the team is focused on promoting the tool and helping people to use. Beyond that, there are lots of directions the Global Calculator could go: for example, triggering new research; informing debates among previously less-engaged audiences; providing educational resources for schools and universities; inspiring new ways of visualising, modelling and exploring this subject.

5. What is the UK Government doing different as a result of the Global Calculator?

The model isn't a UK tool, but was developed through international collaboration. However the Global Calculator, along with other models within DECC, all help the UK Government to explain clearly why we need to act to support ambitious action on climate change, for example:

- Why we need a global deal in Paris 2015 - without action we face the most serious climate impacts. The model reinforces that mitigation is possible and consistent with economic development.
- Why it supports the Green Climate Fund – the tool shows the scale of action is very ambitious which suggests that the world's poorest will need support in this transition and in adaptation.
- The Global Calculator demonstrates that the UK's approach is consistent with a "2 degree" world - the tool also shows that a range of two degree consistent pathways have emissions per capita of 2 tonnes CO_2e, which is consistent with the UK's Climate Change Act 2008.

The Global Calculator will also help other governments, NGOs and businesses to better understand the case for tackling climate change and to more easily debate the options.

Strategy not short term policy: It's worth noting that the tool is deliberately simple to make it user friendly and open. User-friendliness and openness are vital for ensuring credibility and trust, but they mean that we can't capture lots of the complexities and detail of the world's energy system. This means it is not used for deciding individual policies, and instead makes it suitable for exploring and communicating broad trade-offs and to help improve understanding on the need for ambitious effort in policy.

Using the Global Calculator

6. How can the Global Calculator inform the debate on climate, energy, food and land issues?

Having seen the success of the 2050 Calculator approach in the UK, China, India and many other countries, we felt that a similar approach could be used at a global level to help people to explore these global links and interactions. We want more people to understand the link between lifestyle, energy and climate change. We believe that as people's understanding of these links grows, they will be more likely to believe:

- that it is possible to tackle climate change
- that it can be done while increasing the global standard of living
- that climate change is worth avoiding.

This can then lead to more conversations about the energy choices we face, and a more informed energy debate. While there are many debates about energy, these are not always quantitative - for example, the need to produce 'lots of' renewable energy. Since it was developed, the UK's own

country-level 2050 Calculator has helped people to have a more energy-literate debate about the UK's energy strategy, and we believe the Global Calculator can do the same globally.

In general, people have found the 2050 Calculator approach really useful and interesting because it empowers them to find out the truth for themselves. They can test out many of the biggest trade-offs involved with energy supply and demand, without having to read or talk to all the experts first. It helps with practical issues as people can look quickly at a set of numbers (for example, wind energy) in a practical way and find some top-level facts. The short summaries of each choice give useful facts and graphs on each technology, infrastructure or behaviour change, and these have proven to be very helpful background for people. There are other models that look at global emissions to 2050, however most are designed for expert audiences. In contrast, the Global Calculator is aimed at a wide range of people, whether working in business, government or NGOs, or if they have a personal or academic interest in energy, climate change and land use.

7. Will it be too complicated for me as a non-expert?

The tool is available for anyone to use, but it is particularly aimed at multinational businesses, NGOs and governments, so it helps if you have a rough understanding of some of the key issues around energy and climate change to get the most from the tool. It is slightly less aimed for the general public – although we have ensured that all concepts are documented (for example, see the short explanations of each lever by clicking on the "i" beside it). We therefore recognise that it may be quite complex for some people. We've tried to make it simple enough for non-experts to use, whilst retaining the trust of experts.

The Global Calculator website has user guidance and instructional videos. The team hopes that people will open the model, have a go, and even develop their own pathway. Some people from businesses, NGOs and governments may feel they lack the time to open the Global Calculator tool and explore it for themselves. So we have also produced the report *Prosperous living for the world in 2050: lessons from the Global Calculator* and accompanying video to summarise the key insights from the tool. These are also available on the website.

8. Can I submit an example pathway?

Yes please. To send your pathway to the Global Calculator team, please draft 200 words about the choices you have made, and send this and the URL to contact@globalcalculator.org

9. As a business, what can I use the Global Calculator for?

Businesses will find the tool useful for understanding how their sector will evolve at a global level in the transition to a low carbon 2050, the markets that will grow in the future, and how their company can take advantage of these opportunities and avoid potential risks.

For example, electricity generation firms could answer questions such as "What is the maximum potential role for renewables and nuclear by 2050?"; food producers could answer questions such as, "What might be the global demand for food in 2050 in different scenarios of population growth and dietary preferences?"; bioenergy producers could answer questions such as, "How could bioenergy production be affected by yield rates and co-cropping?"; and manufacturers could

answer questions such as, “What is the potential global demand for appliances (specifically TVs, washing machines, etc.) under different scenarios of future population, household size, and lifetime of consumer goods in 2050?”

Mott MacDonald, Shell and World Energy Council have already used the tool to inform their own views of how the world should transition to 2°C and they have published these in the tool.

10. As an NGO, what can I use the Global Calculator for?

NGOs such as green groups and humanitarian groups could use the tool to inform their own internal strategies and campaigns. For example, Friends of the Earth and Chatham House have already used the Global Calculator to inform their own views on how the world should reduce emissions and have published this in the tool.

11. As a government, what can I use the Global Calculator for?

National governments will find the Global Calculator useful for determining whether the plans for their countries are aligned with a global 2°C pathway using benchmarks from the tool. For example, governments could compare how the carbon intensity of their electricity generation or total emissions per head compares to the global average for 2°C pathways as set out in our report. The Chinese Government is already using the Global Calculator to analyse global sectoral emissions and they are publicly endorsing the work by hosting a Global Calculator launch event in Beijing.

12. As an academic/research institute, what can I use the Global Calculator for?

The Global Calculator could be used as a teaching tool on energy, land, food and climate issues. There are also lots of opportunities for future research: during the build of the tool, there were things that we wanted to do but did not have time. We would be delighted if researchers were interested in developing these aspects of the model for us. If you share your work with us, we might even be able to incorporate it into a future update of the Global Calculator.

13. How would you show current or planned policy using the Global Calculator?

The Global Calculator is not suitable for testing policy questions such as “what is the impact of a global carbon tax of $x per tonne on investment in electric vehicles?” This is because it is not an economic model - it does not model energy supply and demand using price and investment/spending assumptions. Instead it is a user driven, scenario tool, and so you can explore directly the impact that an x% penetration of electric vehicles would have on greenhouse gas emissions.

What the tool can do to show current or planned policy is provide the user with example pathways from analysis that has separately considered future policy. In our report, we refer to the IEA 6DS (approx.) as a business as usual pathway because it considers current policies only. But other alternatives include the IEA 4DS (approx.) and TIAM-UCL 4DS (approx.) which include current and

proposed policies. For more detail on these pathways, please see the example pathways section of the web site.

14. Why haven't you translated the Global Calculator into language X?

We'd love your help in translating it into any languages that are missing. Please email contact@globalcalculator.org for advice on how you can help us do this.

15. Should setting a lifestyle lever at level 1 be interpreted as higher economic growth and better quality of life than level 4?

No. For each lever, the level 1 is associated with higher consumption, but

- **It should not be interpreted as associated with higher GDP**. All the levels are designed to be consistent with GDP projections for the next thirty five years. For example, "product lifespan and demand" level 4 is a world in which the number of manufactured goods demanded is relatively lower because there has been a shift towards consumption of longer lasting, higher value goods (a less "disposable society"); TVs and washing machines last longer so there is less need to buy new ones. However, it is difficult to say if extreme scenarios with many level 4s on the demand side would have an impact on GDP.
- **It should not be interpreted as a better quality of life**. For example, level 1 for "calories consumed" and "meat consumed" would entail everyone in the world having the same diet as the average European today. But this diet is in excess of healthy eating recommendations, so would result in higher obesity and diabetes levels. Another example is "passenger distance" level 4 which involves people travelling fewer kms per year. However this may be linked with better city design, so people live closer to work or can travel directly to where they need to go.

16. What does the Global Calculator say about energy security?

The Global Calculator models energy at a global level, so it cannot provide regional or country level energy security implications directly. However users can explore two issues on energy security at a global level:

- **The diversity of the global energy mix:** for example, users can explore the full range of scenarios for reducing the world's dependence on fossil fuels
- **The availability of fossil fuel reserves:** users can explore what proportion of coal, oil and gas reserves and resources would be consumed up to 2050 for different pathways. As fossil fuel reserves decline, it might be imagined that their extraction costs would increase, prices would become more volatile and there could be conflict over how they are allocated (although this is not modelled in the tool).

For country or regional energy security implications, the tool contains example pathways. These are approximations of analysis from existing models. The analysis behind these pathways model energy at a country and regional level, and provide country and regional energy security insights that are publically available.

How the model works

17. Can I comment on the assumptions? How will you collect feedback and analyse the pathways?

One of our goals in making the work open-source is to make it easier to spot errors, propose solutions and seek views on the levels 1 to 4 for each lever. If you would like to give feedback to the team, analyse the pathways people have submitted or if you have found an error, please email contact@globalcalculator.org

18. Can I edit and adapt the Global Calculator for my own purposes?

We encourage users to edit and adapt the Global Calculator tool for their own purposes. The Global Calculator tool is published under the Creative Commons (attribution, non-commercial) licence. The underlying spreadsheet is published under the Open Government licence. But if you do edit the model, you must attribute it as your work. Any conclusions that you draw from your analysis are your own, and must be described as such.

Note that the non-commercial clause in the Creative Commons licence means that users are not able to adapt the tool for commercial purposes (e.g. adapting the tool and then selling it). However, if a commercial organisation such as a business wanted to adapt and use the tool for use as an internal tool to inform their own corporate strategy, this would be allowable. For full details, please see the licences, which can be found on the Global Calculator website.

19. How does the Global Calculator take into account regional differences?

The Calculator models energy and emissions at a global level - it does not represent different countries. This high level, global modelling approach is taken to ensure simplicity and to allow the modelling to work within a single Excel workbook without using complex functions such as “VBA” (Visual Basic for Applications - the programming language in Excel). However, regional/country considerations are taken into account as follows:

- **Transport**: Transport is modelled by different types of city or rural area: three types of urban area (automobile cities, transit cities and booming cities); two types of rural area (developed and developing); and two types of international travel area (slow and fast growth). See the transport documentation for more detail
- **Buildings:** The buildings sector includes two sub sectors, residential and non-residential buildings. The residential sub-sector models urban and rural residents, and divides each of these into those who have access to electricity and those who do not.
- **Renewables:** the levels 1-4 for renewables are informed by studies that have considered country and regional issues in renewables deployment
- **Urbanisation lever:** users can assert the degree of urbanisation as a proxy for development.

- **Climate impacts:** the webtool includes maps showing how a pathway's mean temperature rise range could translate into regional temperature, precipitation and ocean acidification impacts.
- **Example pathways:** the tool contains example pathways. These are approximations of analysis from existing models, for example see the International Energy Agency's "2DS" and the UCL-TIAM "4DS" in the tool. The models behind these pathways analyse energy and emissions at a country and regional level, and these insights are publically available.

However, the Global Calculator team want the tool to trigger people to think about their own countries. The UK Government has already helped around 20 countries and regions to develop similar tools for their situations using this open-source modelling approach. For more information, see www.2050.org.uk

20. What does the model say about how much developing countries should pay for wind power/solar power etc.?

The tool does not include country level detail and it is not for exploring "burden sharing" – there are already other models out there that do this. This tool fills a gap by being truly open and simple enough to allow non-experts to explore the global trade-offs and to see that tackling climate change is feasible and consistent with improving living standards (for example, increased travel demand and more comfortable homes).

21. What policies are assumed?

No assumption is made about which policies should be used to bring about the outcomes caused by the levers. The tool allows user to test scenarios without being prescriptive about what could cause them. For example, it is possible that the same uptake of electric cars could be achieved through a carbon tax as through subsidies or regulation. We do not want to alienate users who do not agree on specific policies underpinning scenarios - we want to let them focus on the types of outcome that have a bigger impact on global emissions.

22. Level 4 is unrealistic. Why bother having it?

We define level 4 as "extraordinarily ambitious and extreme". For each level 4, only a minority of experts will think it is achievable. The Global Calculator allows users to explore the full range of actions to reduce emissions in the global energy, food and land systems to 2050 because:

- If we exclude some actions people may not be able to represent their views; we want to promote a debate in which all people can contribute
- If we exclude some actions, people may feel the tool is biased against action in a particular sector and this could reduce their confidence in the approach
- For choices where a user doubts the plausibility of level 4 then they can choose other, less stretching levels in order to generate a pathway.

In the Global Calculator team's experience, some users find it interesting and helpful to explore extremes as a quick way of understanding the big actions. Others prefer pathways which include no level 4 choices at all, as they prefer to spread effort more broadly across the levers. The

advantage of a scenario-based model like the Global Calculator is that it allows people to use both approaches.

23. Why didn't you include: nuclear fusion, speculative technology x, or study x ambition for your level 4?

If you feel that we have missed something important, there are two things you could do:

- Tell us if it's wrong – email the analysis to contact@globalcalculator.org The aim of the tool is to include the full range of credible options to 2050. We did this by consulting as many experts as we could during its development. However, we are happy to receive further suggestions which we will consider.
- Change it yourself and see. We welcome people downloading the Excel model and changing the assumptions if you don't agree with them, and sharing your findings with us.

However, as a general point what we've found is that no one option can solve the problem of climate change. For example, we can't rely on low carbon electricity unless we significantly electrify transport, buildings and industry. So it's unlikely that any speculative technology will solve the problem in time, given the size of the problem of global emissions.

24. Why can't we see a U.S lifestyle?

The Global Calculator was built in consultation with many experts, with the aim of getting a full range of what experts felt could be possible in 2050 (level 1 to 4). As one example, the experts we discussed transport with couldn't see the average person driving as far as the average US citizen. This is because most of the world has different urban infrastructure and layouts from the US, which is much less population dense and more dispersed, so it would be meaningless for an average global person to travel that far. In our more detailed documentation for each lever, we have shown where possible, the current levels for the US or other countries, so this should help you when making your choices. However, if you are particularly interested in exploring the implications of everyone in the world having a "US lifestyle" by 2050, then you could edit the level 1 settings in the spreadsheet yourself.

25. Why does nuclear/any other technology look cheap when I've seen somewhere else that says that it's costly?

We used data from the University College London's "TIAM" model for point estimates, but we also include a range. You shouldn't focus too heavily on the point estimates because costs over the next 35 years are highly uncertain. If you have evidence that we should use different figures, please send it to us and we'll consider it when we update the tool.

26. Does the tool include feedbacks of climate impacts onto other sectors?

No. There is no interaction between the climate outcomes and the other sectors of the Calculator. This means that climate impacts are assumed to have no effect on crop yields, manufacturing capabilities, heating requirements, land availability, costs, or any other Global Calculator variable.

This is obviously a very crude simplification. Because of this simplification, the Global Calculator allows you to choose lever combinations which are implausible, such as very high crop yields despite a very large increase in global mean temperature. You should be aware of this when making lever choices: as with other aspects of the Global Calculator, the onus is upon the user to satisfy themselves that the pathway is feasible. Note that a warning message will appear if the user creates a pathway in which global mean temperature change is high and crop yields are high to alert you to the fact that this may not be possible.

27. Why is the temperature range so wide?

The “thermometer” graphic shows a range of temperatures for two reasons. Firstly, there is scientific uncertainty about how much the temperature of the planet would change, even if we had perfect knowledge of the emissions that would be produced. Secondly, the Global Calculator approach is limited by the need for it to produce output quickly, and by the decision to rely on pre-existing scientific results. We cannot run a climate model every time you change a lever; it would take too long. Therefore, instead of simulating the climate using your emissions pathway, we look at the existing evidence from IPCC models for how the climate changes in simulations which are similar to your pathway. This means that there is a wider range of possible outcomes.

28. What about impacts on water, or air pollution?

Water impacts are very local and hard to analyse at a global level. However, we would be delighted if someone took our open source work and added water impacts. While the Global Calculator does not model water use, there are ways you could start to explore the kinds of impacts that an increase in water stress could have on the world to 2050. To do this, you could choose the following:

- Crop yields: level 1 – you could interpret this as a fall in food yields owing to lower water availability
- Livestock yields : level 1 – you could interpret this as a fall in the carrying capacity of pasture land owing to lower water availability
- Bioenergy yields: level 1 – you could interpret this as a fall in bioenergy yields owing to lower water availability

Air pollution is not included within the model. Air pollution impacts are very local and hard to analyse at a global level. However, we would be delighted if someone took our open source work and added these impacts.

29. Why is there an unused bioenergy pathway I have chosen?

Pathways with very high livestock yields and low meat consumption can free up significant amounts of land. If you use this land for biocrops and have high enough bioenergy yields then you can oversupply bioenergy. A red warning will appear on the right hand side of the online tool if you have done this. If you use the surplus land for afforestation instead of bioenergy, by reducing your “surplus land” lever toward level 1, you will no longer produce unused bioenergy. Alternatively you could continue to use this land for bioenergy but reduce bioenergy yields, or you could avoid the surplus land issue by changing your food choices so that more land is required for food.

30. Why is there no GDP lever in the Calculator?

Historically, growth in GDP per head has been associated with higher energy consumption patterns, e.g. increase in distance travelled per person, increased consumption of manufactured products, etc. Therefore, why not have a GDP lever to control these in the Global Calculator? There are two reasons we propose not to do so:

- **A GDP lever would not be consistent with the idea that it's possible to decouple economic growth and energy consumption**. For example:
  - A reduction in tonnes of goods consumed per person could be caused by a reduction in economic output. But it could also feasibly be caused by a switch towards higher value, more durable products (e.g. consumers preferring to buy more expensive, but more durable, washing machines). The reduction in tonnes of goods consumed could also be caused by a switch towards lighter materials (e.g. graphene) or more efficient production methods.
  - A reduction in distance travelled per person could be caused by lower GDP, but it could also be caused by a switch towards more home-working, smarter city design, or a change in preferences towards holidaying close to home.
  - Meat consumption could decline because of a reduction in GDP, but it could also be caused by change in consumption patterns towards a vegetarian diet.
- **The Calculator allows users to explore tangible "what if?" questions**. If the Calculator had a GDP lever it would become an economic model. The purpose of the Calculator is to allow people to explore the physical actions and behaviours that could reduce emissions. The aim is to let the user drive physical things they understand (for example, whether people travel by car or train), rather than economic relationships (e.g. consumer responsiveness to price changes) which are harder to understand.

31. Do you assume a global electricity grid? That's mad!

The Global Calculator models energy supply and demand at a global level. This means that it cannot say where energy supply and demand are located. In pathways with high levels of renewables deployment, such as wind, the user must assert that it's possible to locate this near enough to demand without causing a higher rate of electricity distribution losses. To help the user, we have included global representations of example pathways that draw from analysis which has considered such regional issues. For example, we have the IEA's "2DS"; users can refer to the original "Energy Technology Perspectives 2014", which models at a country and regional level.

32. Where is fracking represented in the model?

You can see estimates of both gas reserves (economically viable) and gas resources (speculative, not economically viable) in the webtool. Pathways that eat into the resources will likely need to use unconventional sources of gas.

The report “Prosperous living for the world in 2050”

33. Your report suggests it’s possible for everyone in the world to have a “good” lifestyle in 2050 and tackle climate change. What do you mean by a “good” lifestyle?

In our report we have defined a "good lifestyle" to mean that world average lifestyle indicators around transport (e.g. how far people travel) and homes (e.g. how comfortably heated/cooled they are and how many appliances they have) continue to improve along a business as usual pathway (in this case the International Energy Agency's 6°C Scenario) from now to 2050. For diet, the world average food intake continues to increase as projected by the Food and Agriculture Organisation of the UN, which by 2050 would exceed the levels recommended by the WHO for a healthy, active lifestyle. In general, lifestyle indicators move towards the current levels seen in developed countries such as Europe.

Please note that as the Global Calculator looks at world averages only, this could mean that inequality has reduced by 2050 (with more people living close to this higher average lifestyle), or it could still mean that there is a lot of variation between countries as seen today (for example with over-consumption of food in some areas and under-consumption in others).

34. How does this compare to the New Climate Economy?

The New Climate Economy (NCE) and the Global Calculator have very different approaches but reach very similar findings. The NCE is a synthesis of a series of economic studies. The Global Calculator is an engineering-based energy, land, food and climate model. They also consider different time periods: the NCE looks to 2030, and the Global Calculator to 2050. However they both find that it is possible to secure global economic growth and tackle climate change. Both studies also find that the energy infrastructure costs associated with transition to a low carbon economy are comparable or only slightly more expensive than remaining fossil fuel dependent. In particular, the NCE report highlights three areas which will be critical in the transition to a low carbon economy:

- Smart cities: the development of compact and connected cities, built around mass public transport, will create cities that are economically dynamic and have lower air pollution and associated health benefits. The importance of smart cities is well illustrated in the Global Calculator by moving the “travel” levers or the “building size” lever (under the “lifestyle” heading).
- Land use productivity: boosting land productivity by restoring degraded agricultural land will increase food production and help to reduce and ultimately halt deforestation. The importance of boosting land productivity is illustrated in the Global Calculator using the “land and food” levers.

- Energy systems: these should be more efficient and low carbon. The importance of making our technologies more efficient and low carbon is shown in the Global Calculator using the "technology and fuel" levers.

35. Is the model (and the UK Government) advocating intensive farming? Eating less meat?

The model in general is not advocating any specific lever choices. The aim is to promote a more informed debate. The four example pathways used to generate the report show a range of scenarios for tackling climate change. It's about showing the trade-offs and enhancing our understanding of the options available. The model shows the consequences of issues such as high global meat consumption. The user can test out different choices around meat (for example the quantity or type of meat consumed) of choices around farming (for example, livestock intensity and crop yields), and see the effect they will have on energy, emissions and land use. The Global Calculator was produced by a collaboration of over 10 international organisations. It should not be interpreted as representing the views of the UK Government (or any of our partners). Rather, the levels 1 to 4 are intended to represent the wide range of what is possible, based on published credible evidence and the views of over 150 technical experts consulted during the model build.

Country/regional calculators

36. Can I use the Calculator approach to model a country or a region?

Absolutely yes! 20 countries and regions have done this so far and we've written a book about how to do it. This is available at: http://book.2050.org.uk For more information on the Country Calculators, see www.2050.org.uk

37. How do the Country Calculators compare to the Global Calculator?

Over 20 countries have developed (or are developing) Calculator models for their country. These models are great for illustrating the range of potential technological and behavioural solutions at the country level. For more detail on these tools, see www.2050.org.uk However the Country Calculators cannot show how everything adds up at a global level (for example, implications for global bioenergy use or the aggregate impact of emissions on the climate) and so we developed the Global Calculator.

The Country and Global Calculators have the same philosophy: they are scenario testing tools to 2050 based on the concept of level 1 to 4 action. However they are not "connected" in any way. They all operate as entirely independent models, although the international community of 2050 modellers do share best practice and learn from one another's efforts.