Options for Resource Allocation in the Green Climate Fund (GCF)

Incentivizing Paradigm Shift Within The GCF Allocation Framework

Background Paper 2

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Disclaimer:

The views and opinions expressed in the paper reflect those of the author(s) and do not reflect the position of any institution.

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1 Introduction

For the operation of the GCF, it will be essential to define how the objective to promote paradigm shift towards low-emission and climate-resilient development pathways - as specified in the Governing instrument – will be operationalized.

This paper provides some detailed reflections for mitigation and adaptation to stimulate the ongoing discussion.

2 Mitigation specifics

We take the agreed objective of the UNFCCC to hold the increase in global average temperature below 2°C above pre-industrial levels as a starting point. This allows to derive a clear picture of what needs to happen to be able to achieve this objective[1,2].

We base our assessment on a comprehensive set of scenarios that were developed by a number of renowned institutes coordinated by IIASA, Austria. They have the explicit aim to assess the technological feasibility as well as the economic implications of meeting a range of sustainability objectives simultaneously[3]. The scenarios allow the assessment of feasibility of different technology choices and are also all designed to provide a 50-67% probability of staying below 2˚C. Additionally they also provide almost universal access to affordable clean cooking and electricity for the poor; limit air pollution and health damages from energy use; and improve energy security throughout the world. The sustainability aspects embedded in the scenarios, the wide range of different technology scenarios assessed and the high reputation of the involved institutes make the GEA pathways especially suited to the analysis at hand.

2.1 Defining paradigm shift for mitigation

Global emissions need to start decreasing before 2020 for all scenarios. Developing countries need to show reductions in absolute GHG emissions by 2020 for around half of the scenarios as well. But even those scenarios with increased emissions for developing countries only show moderate increases until 2020 and are on a downward trajectory by 2030. The main challenge is to achieve the required reversal of the trend with its expected dramatic increase in emissions under BAU.

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[1] For details on the analysis leading to these results please refer to Annex 2

[2] The GCF was set up as an instrument to incentivize enhanced action by developing countries and an expression of the responsibility and capability of developed countries, who replenishing the fund. Considerations of an equitable distribution of "mitigation effort" are most relevant for defining the required levels of domestic, i.e. unilateral reductions. Following these considerations we do not apply any principles of equity or CBDR and RC in the analysis. Starting point is the question what needs to happen to ensure the common agreed objective can be achieved and how limited fund resources can be used to maximize the contribution towards the objective.

[3] Unless explicitly stated, all numbers quoted related to mitigation in this report are derived from: Riahi, K., F. Dentener, D. Gielen, A. Grubler, J. Jewell, Z. Klimont, V. Krey, D. McCollum, S. Pachauri, S. Rao, B. van Ruijven, D. P. van Vuuren and C. Wilson, 2012: Chapter 17 - Energy Pathways for Sustainable Development. In Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp.1203-1306. [in the following cited as IIASA (2012) or GEA Scenario Database]

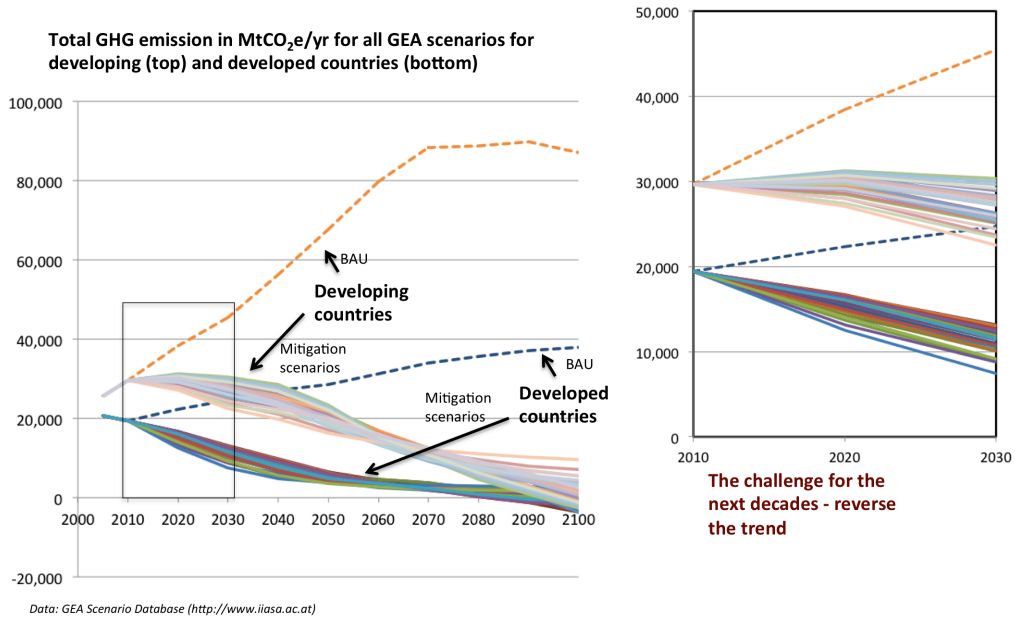

Figure 1: Total global GHG emissions for BAU and mitigation scenarios compatible with limiting warming below 2˚C

In summary a paradigm shift towards a low carbon economy requires:

- A complete phase-out of investment in conventional fossil fuel based technologies leading to complete structural changes in all sectors;
- A society-wide change in how we use energy based on a change in perception of the value of energy.
- An integrated approach to land use planning and management incorporating the sustainable management of forests, land use change and sustainable agricultural practices.

To achieve this within the required short time frame, it is essential to ensure

- The full incorporation of GHG emissions as an important factor in decision making at all levels of government, private sector and society;
- Integrated thinking that considers effects of decisions/actions on emissions of other stakeholders, sectors, countries or regions (for example excluding 'not in my back yard' thinking).

- Framework conditions are generated that create an environment where the large-scale deployment of low carbon technologies is preferred by decision makers (companies, households, individuals) over conventional fossil-fuel and energy intensive technologies. Individual investment projects will not allow achieving this fundamental change. Only policy-based and programmatic approaches will be able to deliver the needed change in direction of investment.

2.2 Translating paradigm shift to concrete actions

While it is clear that overall action needs to happen on all fronts as fast as possible, some clear priorities emerge, based on mitigation potential and effects on the structure of energy systems[4] in scenarios of a global transformation towards a low-emissions future.

The following sections provide insights on technological choices emerging from the scenario analysis. The first part highlights the most important areas of action regarding low carbon technologies. The following section discusses the need to phase out conventional coal technologies and the role of gas in low carbon pathways. The third section discusses the role of CCS.

2.2.1 Focus on specific low carbon technologies

Energy efficiency technologies: a rapid deployment of energy efficiency measures can reduce primary energy demand compared to "business-as-usual" (BAU) by 50% by 2050 and 66% by 2100[5]. The IEA confirms this by projecting that energy efficiency measures could half the growth in global primary energy demand by 2035[6]. Only rapid and strong reduction of energy demand will allow countries the flexibility to make technology choices on the supply side and still be able to achieve the climate objectives. Under lower efficiency scenarios all available low-emission technologies will need to be deployed, with the exception of nuclear power, which remains an option under all scenarios.

Efficiency measures also have huge co-benefits in energy security, economic growth and the environment, without requiring unexpected technological breakthroughs. The efficiency scenario in the IEA WEO 2012 estimates a net *gain* in cumulative economic output of $18 trillion, or 0.4% of GDP by 2035 through more efficient allocation of resources, including lower dependence on international fossil-fuel markets.

Despite these positive effects of efficiency measures huge potentials for efficiency improvements are currently not tapped, both in developing and developed countries. A wide range of barriers exist to the more rapid deployment of efficiency measures, including higher up-front cost of more efficient technologies which especially in developing countries often leads to low rates of deployment.

Industrial production is expected to grow rapidly in developing countries. With a current share of 45% in total final energy demand it is expected to slightly increase this share under BAU. Industry needs to contribute between 48% and 62% to total needed energy demand reductions. It therefore represents the largest potential for efficiency measures.

***Solar and wind energy technologies*:** Solar energy takes the leading role in primary energy supply in most of the assessed low carbon energy scenarios, especially in developing countries with a share in total primary energy of 9-21% by 2050 and 11-54% by 2100 in these countries in aggregate. To achieve this, deployment needs to deviate substantially from BAU, especially over the next 3-4 decades.

Wind energy becomes more important in developing countries as well. In total it will remain far below solar energy, with shares peaking at 8% of total primary energy. However, to achieve this, tenfold increases compared to BAU are required over the next 2-3 decades.

***Electrification of the transport sector*:** For all scenarios assessed, independently of final technology choices for the transport sector (conventional fuel based systems or advanced technology), electrification of the transport sector combined with fast shift to renewable electricity generation increases flexibility and reduces pressure on sustainable biomass.

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[4] All analysis is based on assessing both global data and developing countries data. Trends are overall the same although timing and rates of change can vary between developing countries and global scenarios.

[5] Unless explicitly stated, all numbers quoted are for developing countries (region 'South')

[6] IEA (2012). World Energy Outlook

The transport sector today only contributes 20% to total final energy demand, but is projected to see dramatic growth over the next decade. Already by 2030 it is expected to surpass the residential/commercial sector as the second most important demand sector. The sector requires the most ambitious reductions below BAU even for the lower efficiency scenarios, making it a suitable target for ambitious action.

Additionally measures to increase efficiency and especially the electrification of the sector, for private and public transport, provide substantial co-benefits related to health issues caused by transport emissions especially in the large urban centers around the globe.

2.2.2 No investment in fossil fuel technologies and encourage divestment

Phase-out of conventional coal: coal without CCS must be phased out rapidly. While some scenarios with high levels of efficiency achieved allow for a slight increase in coal use until 2030, the majority of scenarios require an immediate decrease[7].

Recognizing the importance of coal in contributing to climate change, the World Bank just decided to restrict financing of greenfield coal power generation projects to rare circumstances. Apart from its impact on GHG emissions, air pollution from fuel combustions, especially coal, is also responsible for a large number of premature deaths, increased incidents of illness as well as damages to crops and buildings[8]. A phase-out thus can provide multiple sustainable development co-benefits.

Currently around 1200 coal power plants are proposed or planned globally, with a capacity of 1,400 GW (WRI, Global Coal Risk Assessment, 2012) with additional plants already under construction. Given planning and construction time, the majority of these plants would come online after reductions from coal use would be required. Assuming a normal economic lifetime of 40-50 years they would also still emit for 10-20 beyond the required full phase-out of conventional coal use around 2060.

This implies that planned coal plants need to be stopped from construction or need to be equipped with CCS. Depending on efficiency gains realized and decisions in other sectors, existing plants may need to be taken offline before the end of their economic lifetime or retrofit with CCS.

Gas: for most scenarios gas plays a role as an intermediate bridging-technology until around 2050-2060. Gas without CCS starts to phase out for all scenarios between 2040-2050, while gas with CCS starts to pick up after 2030 with a peak use between 2050-2070. Overall gas use stays below BAU for all mitigation scenarios until 2030 and until 2100 for high efficiency scenarios.

It can be expected that these developments will be determined mainly by activities in other areas, like the required phase-out of coal without CCS, support of renewable power generation and enhanced efficiency measures. While investment in gas infrastructure is often seen as part of the mitigation activities this should thus not be part of the fund's portfolio.

2.2.3 Decisions on Carbon Capture and Storage (CCS) remain mainly political

For <u>high efficiency</u> scenarios CCS is a <u>choice</u>, for <u>high demand</u> scenarios a <u>must</u>. Even low leakage rates endanger the usefulness of the technology as a climate solution. It is also a single-purpose technology with little to no co-benefits. This should be taken into consideration when making decisions on deployment.

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[7] Additional to the GEA scenarios used for the main part of this analysis this finding is supported by a wide range of assessments, including the IEA's 450 scenario in its World Energy Outlook 2012 and papers modeling the RCP pathways for the upcoming IPCC's AR5, like Van Vuuren et al. (2011) RCP2.6: exploring the possibility to keep global mean temperature increase below 2°C, Climatic Change, 109:95-116. Even higher temperature RCP pathways start to reduce conventional coal after 2035 and completely phase out after 2065, see Thomson et al. (2011) RCP4.5: a pathway for stabilization of radiative forcing by 2100, Climatic Change, 109:77-94

[8] World Bank (2013) Toward a Sustainable Energy Future for All: Directions for the World Bank Group's Energy Sector, July 2013, Washington D.C.

Fossil CCS (coal and gas) acts as an optional bridging technology in the medium term, while biomass CCS (bioCCS)[9] increases in the long term, starting with implementation from 2020, reaching more significant levels between 2040 and 2060. Especially for scenarios with high energy demand and global emissions that are higher than "optimal" over the next 1-2 decades biomass CCS will need to increase dramatically between 2060 and 2100 to allow for global net-negative CO_2 emissions from around 2090[10].

Limited storage capacity at global and regional level suggests focus on CCS for industrial process emissions and bioCCS[11]. Filling of CCS storage capacity with fossil-fuel CCS would limit future storage capacity for bioCCS. This compromises the option to compensate later for high emissions in the near term.

2.2.4 Addressing regional differences

The above general considerations hold for all non-Annex I regions in aggregate. However, when going into more detail on specific activities and decisions for countries and regions, the differences in starting points and available resources need to be considered. This is specifically relevant for renewable energy sources with current deployment levels and local potentials, which can vary substantially from global and regional data[12]. These considerations need to be taken into account in the evaluation of proposals regarding their level of ambition, but going into country level is beyond the scope of this report.

Depending on the overall approach chosen (see section on prioritization below) it could be useful to assess the most important potentials and the highest ambition with respect to deviation from BAU, especially for renewable energy sources, at regional level, for larger countries preferably on country level.

2.3 Differences for 1.5°C pathways

To achieve reductions in line with 1.5°C pathways, energy efficiency and low energy demand is key. The GEA (IIASA 2012), and studies building on that, find many options to limit warming to below 2°C, also in future worlds with high energy demand. However, 1.5°C pathways are only found to materialize under a low energy demand future. This means that achieving such very stringent levels of climate protection relies on the introduction and transition towards advanced modes of (public) transport, urbanization, and livelihoods.

Delay of action by just a decade from now has a much stronger influence of the number of options that remain available for a 1.5°C pathway than for a 2°C target. This results from the fact that

(a) current warming is already closer to the target level of 1.5°C. Additional years of high emissions would thus add proportionally more to the still available carbon budget, and

(b) delay of stringent action strongly influences lock-in into inefficient, polluting, and/or CO_2 emitting infrastructure. While this is also true for 2˚C pathways required deeper reductions after 2020 make it even more important for 1.5°C pathways.

Exploring and effectively implementing measures to enhance the mitigation of non-CO_2 emissions, in particular methane from agriculture, will be important in the long term (by the 2050s and beyond) for 1.5°C pathways. In the short term, it is rather the active research into

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[9] Biomass CCS is seen to be a crucial option to achieve so-called "net-negative" CO_2 emissions: as biofuels grow the plants take up CO_2 from the atmosphere. If these biofuels are subsequently burned in electricity plants and emitted CO_2 captured and stored, the energy system effectively takes out CO_2 from the atmosphere.

[10] See also the UNEP Gap Reports 2011 and 2012 which come to the same conclusion

[11] See for example van Vuuren et al (2012) The role of negative CO2 emissions for reaching 2 °C—insights from integrated assessment modeling

[12] For some examples of these differences see the Annex 2

finding new ways to achieve globally implementable measures that can provide a breakthrough in mitigation action in this sector (agriculture).

2.4 Approaches for prioritization within the GCF

The proposal on initial 'result areas' of the fund as discussed at the June board meeting provides a valuable discussion of design considerations. The proposed priority areas for mitigation however fall short of being able to provide much guidance for concrete allocation decisions. The proposed result areas include more or less all relevant mitigation activities in the different sectors. Excluded are merely activities in the waste sector and more integrated material efficiency/integrated life-cycle approaches for industry. At the same time some of the proposed areas cover very different sets of measures with very distinct mitigation potential, co-benefits and measures how to achieve the potentials. This makes strategic choices for the board even more difficult.

To support further deliberations, we discuss two different approaches to prioritizing activities. Both approaches have the potential to trigger large-scale transformational change, taking into consideration the restrictions provided through availability of funds, technical capacity and time. Both are highly compatible with direct access models. The insights from this discussion could either directly feed into the discussion on focus areas at the GCF board or could be used subsequently to refine and operationalize decisions taken on result areas.

There are no obvious technical arguments in favour of one of the approaches. The decision will be a political choice. The next sections provide an overview of how the approaches could work and discusses advantages and disadvantages.

The proposals do not cover REDD+ activities, as these are addressed separately and we assume that there will be a clear REDD+ window within the mitigation window of the fund.

Proposal 1: Focus area approach

An alternative approach to prioritize funding allocation would be to concentrate on a very small number focus areas - maximum of three, potentially even only one - for which clear targets can be set. Unlike the very broad definition of results areas proposed for the June board meeting, the goal here is to provide a very targeted approach. The limit to one or few target areas aims to enable truly transformational impact at global level for the chosen areas.

The areas could be set with a clear time frame and reviewed after that. Proposed areas are[13]:

1. *Energy efficiency in industry*: potential target - limit growth of final energy use in industry to 20% by 2020 compared to 2010 levels.
2. *Support the phase out of coal*: potential target - no new conventional plants going online after 2017. This would require a fundamentally different approach to climate finance in supporting countries to identify alternatives to planned new coal developments, to implement alternatives and potentially leverage coverage of incremental cost of alternative solutions.
3. *Support solar and wind energy technologies*: potential target - increase solar and wind energy use in developing countries 10 times by 2020. This type of target area would require more in-depth research at regional and country level to identify where the respective potentials and ambition levels are highest, which could lead to different priorities for different regions/countries.

[13] These are based on the activities identified as transformational above. More detail on potentials of these activities can be found Annex 2. Theoretically this list could be longer or contain different focus areas. Longer lists would water down the advantages of the approach and lead to a hybrid model as suggested in proposal 3. The choice of focus areas would finally lie with the board based on technical input and political considerations.

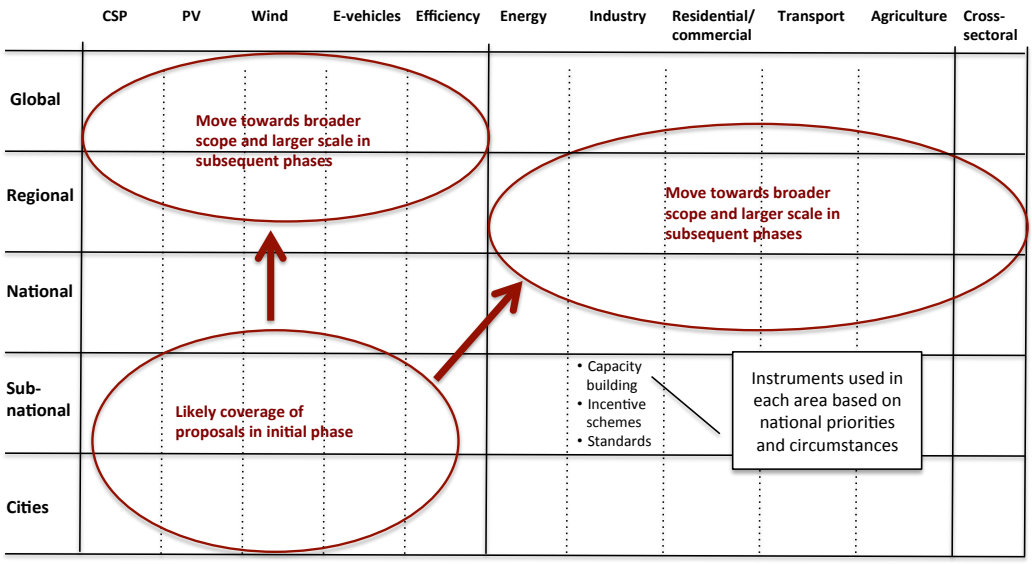
Advantages of this approach are that available resources could demonstrate a truly transformative impact. At the same time individual proposals can be evaluated according to their contribution to achieving the set concrete targets, which may be easier than evaluating the contribution to the overall objective. Required technical expertise within the fund and in host countries would be more targeted and could be built up more rapidly. Implementation would be fully driven by national priorities and circumstances. Depending on the situation in country activities would be tailored to respective needs with the goal to achieve agreed national targets in line with the overall goal.

Disadvantages are posed through a highly top-down approach reducing room for GCF funding of national priorities outside the focus areas. Other large potentials could not be tapped until the focus areas are revised and potentially changed or expanded.

Proposal 2: Portfolio approach

This approach would aim to build up a portfolio of activities covering different geographic scopes (subnational, national, regional, global), different technology areas and different types of measures. Together this forms a matrix with the geographic coverage on one side and the technologies and sectoral coverage on the other. Each 'square' of this matrix would represent a combination of regional coverage and sectoral/technological scope (see Figure 2)[14].

The matrix can be seen as a puzzle, where over time all squares are filled to provide a full picture. For each square only a small number of proposals would be funded. This allows demonstrating feasibility of concepts for a wide range of activities at a large scale with high global learning effects. At the same time it provides a very strategic and targeted incentive to move towards larger regional and sectoral scope as the "easier" parts of the puzzle are filled and no longer available.



Notes: CSP: Concentrated Solar Power, PV: Photovoltaic power

Figure 2: Principles of a portfolio approach

The choice of technologies would largely be determined by proposals based on an agreed negative list of technologies that would not be eligible for funding as they don't contribute (gas) or have negative impact on the defined objective (conventional coal, oil, other fossil technologies). All sectors would be included in the portfolio matrix.

[14] See Annex I for more detail on this approach

Within each combination of sectoral coverage and geographic scope a number of different types of activities could be deployed to achieve a transformative change within the defined scope. Minimum requirement is that activities address the full geographic scope, for example the region, and aim at ambitious deployment of the targeted technology. This will rule out individual installations or small-scale projects.

Box 1

Moving towards transformation in the portfolio approach: examples

At the 'lower' end of the ambition scale within the portfolio approach a large city could aim to promote solar thermal water heaters. If this would be deemed transformational would depend on the size of the city and the envisaged level of ambition. Potential measures could include the introduction of regulation with subsequent enforcement, or of incentive schemes combined with information campaigns.

At a 'medium' level of ambition a larger region within a country could aim to address emissions from its industrial sector. Activities would likely include a larger number of different activities targeted at different types of industries and different technologies. It could also include introduction of price signals, for example through an emissions trading scheme or a carbon tax at regional level.

At 'higher' levels of ambition activities would be at national level and address at least a complete sector, for example targeting the energy supply sector. This would include a range of measures to address the transformation of generation capacity towards low carbon technologies, but also issues connected to transmission and grid infrastructure as well as pricing.

In all cases the GCF could fund the activities required to generate the appropriate framework conditions.

The goal would be to achieve broad coverage of different programs to stimulate replication and demonstrate feasibility at large scale.

Advantages of this approach are that national priorities and circumstances can be accommodated while preserving a minimum degree of focus.

The approach allows continuous development over time. Requirements for proposals could start with slightly lower levels of ambition at a subnational level targeting deployment of individual technologies. As more complex programs targeting whole sectors at the national level will take time to be developed this would allow to have transformational impact at smaller scale but with shorter lead times. Over time minimum requirements could move towards sector-wide, national or even cross-national scope. Through the broad scope there is a high potential to demonstrate feasibility of transformation with resulting replication across many sectors, cities, countries and regions.

For the different 'squares' of the portfolio matrix strategic partners could be identified to help leverage the impact of GCF funds and allow a quick start by taking advantage of existing initiatives (e.g. renewables support programs by various development banks, transport pilots by EMBARQ, city initiatives, etc.)

Disadvantages include the fact that large technical expertise in many areas is required to evaluate proposals. The fund would need to build up this capacity internally or through a network of experts, which both will take some time and potentially increase administrative cost of the fund. How successful the approach will be in achieving a balanced portfolio between different types of activities will highly depend on the proposals that are put forward by countries.

Table 1: Comparison of proposals

	Proposal 1 Focus area approach	Proposal 2 Portfolio approach
Scope	Narrow	Broad but with strategic element
Focus	Global transformational impact in selected focus area(s)	Demonstration effect of large scale transformation
Complexity	Moderate, easy to communicate	High
Approach	Top-down determination of focus areas based on technical analysis and political negotiation	Mixed: Bottom-up process based on country proposals with limitations set through top-down decisions on number of proposals per matrix element and minimum requirements
Instruments	Based on national circumstances and preferences	
Technical expertise required	More focused, easy to build up	Broader with changing focus over time

3 Adaptation specifics

The moral circumstances differ between mitigation and adaptation activities in non-Annex-1 countries. Mitigation action is a voluntary decision by a non-Annex-1 country that leads to both national and global benefits. Financial flows for mitigation can be determined through discussions that balance benefits across all parties with costs as discussed in the previous section.

However, adaptation action is a response to changing conditions largely created outside non-Annex-1 country and especially so the less developed and less populous ones. Many see support for adaptation more akin to recompense for damages already occurring, or about to occur. Thus, these countries can claim a right for support, related to their needs, for the additional costs of ensuring that future development is climate resilient. This inextricably intertwines support streams for adaptation and development making it difficult, and often inefficient, to identify an incremental cost of climate resilient development. Many developing countries have insufficient capacity, institutions and resources to cope with current climate variability and thus suffer what is sometimes called an 'adaptation deficit' (or probably more accurately a 'development deficit'). Whatever it is called, successful adaptation will need to address such deficits.

The above issues mean that there will be significant differences in both recognizing transformative adaptation and in allocating resources between adaptation and mitigation.

3.1 Defining paradigm shift for adaptation

Despite a growing literature there is still no agreed definition, or even an agreed description, of what would constitute a paradigm shift, or a transformative change, in adaptation actions. Usually transformational adaptation is contrasted to the current dominant approach of incremental adaptation, where the central aim is to maintain the integrity of existing system and processes by small corrective changes. In contrast transformational adaptation seeks to change the fundamental attributes of a system in response to experienced and anticipated climate impacts. Fig. 1X shows that decisions about transformative change are pat of the process of decision making about incremental change. It shows how the decision about transformative change becomes part of the ongoing decisions about improved adaptive actions; how sometimes the need for transformation is recognized but must await appropriate conditions; and that once a transformational change is made the new activities become subject to an ongoing process of incremental improvements.

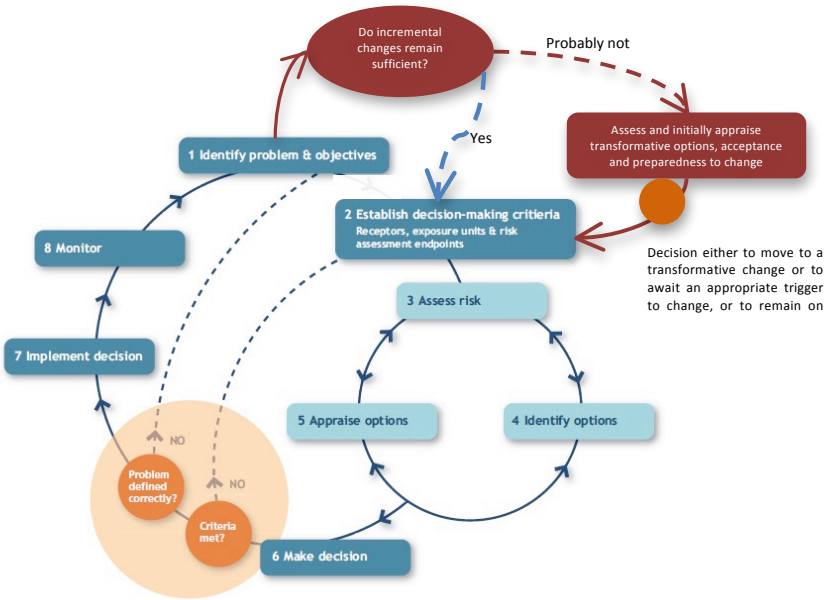


Figure 3: Traditional incremental adaptation cycle with transformational considerations added

Note: Adapted from Willows, R. I. & Connell, R. K. (2003) Climate adaptation: risk, uncertainty and decision-making. UKCIP technical report. UKCIP, Oxford

Transformational changes may be achieved by adopting policies, measures, institutional constructs and activities that are new, at least to the location, thus crossing thresholds and creating discontinuity in practices (Fig. 4 a) or, it can involve a major expansion and diversification of activities, either by individuals or across communities (Fig. 4 b), or it can even involve providing the support for successful adaptive actions to self replicate across a much larger range of communities (Fig. 4 c). Transformative change needs to be a deliberately planned activity taking into account the sometime major impacts on the people involved and the positions of a full range of stakeholders. However, significant action on the ground may have to await triggering circumstances that allow the new paradigm to be put in place. An example would be a decision to remove high value infrastructure from flood plains (i.e. a 'room for the river' approach), replacing attempts to provide physical protection through channels, levees etc. An initial decision, supported by the affected community, may immediately implement actions such as limiting approval for new structures and providing incentives for voluntary re-location. But major actions to achieve transformative change will most likely be implemented during the reconstruction and relocation following a major flooding event.

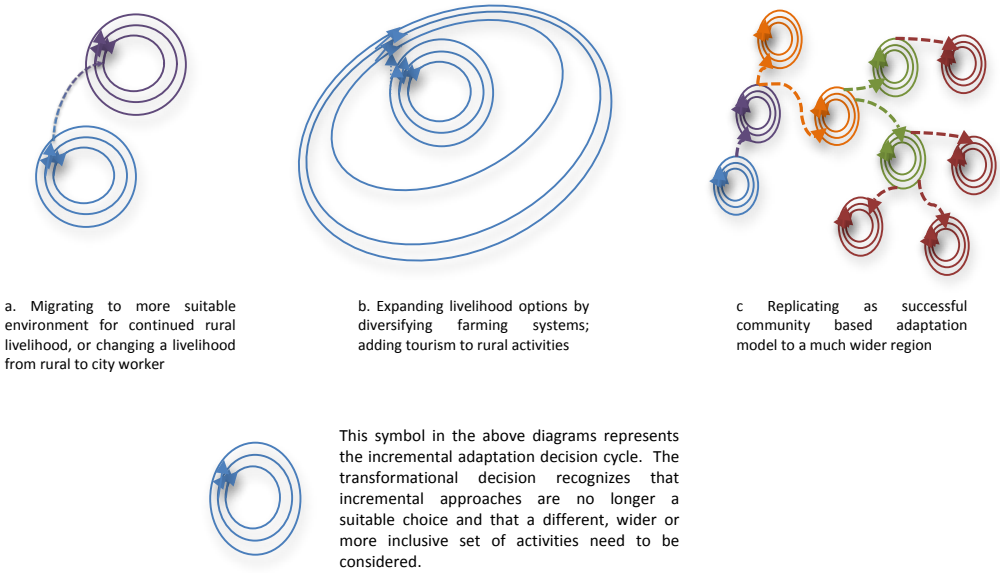


Figure 4: Examples of some forms of transformative adaptation

3.2 Identifying transformative change in adaptation

There is a continuum from incremental to transformative adaptation activities and little agreement among either the scientific or policy communities as to where one becomes the other.

The decision that a proposal is transformative will likely to have to be left initially to the proponent to demonstrate this to the GCF. Criteria could include:

Identification of the adoption of clearly new activities for the target location, such as support for new livelihoods, or relocation of, small scale farmers in marginal lands who are becoming increasing vulnerable to climate variability, exacerbated by climate change and other social and economic factors.

Significant shift in the scale of previous actions (e.g. the scaling up of successful CBA (Community Based Adaptation) catchment management actions through establishing a national, or at least regional, program to foster and support community catchment management groups; altering institutional structures to allow community groups to effectively shared decision making and work with local governments; incentives for private entrepreneurs to provide technology and services to the groups etc).

Transformative adaptation is usually at a greater scale than current incremental adaptation activities (relative to a country's size, population and resources). Support for adaptation activities over the past decade has tended to be less than USD10 million per project and this will have to increase both to support transformative change and for the efficiency of operation of the GCF.

Cross-cutting issues

Activities with regard to changing land use practices, including REDD+, as well as subnational activities have a high potential for integrated approaches as many activities need to consider both adaptation and mitigation aspects simultaneously. For example in designing parameters for urban planning (e.g. zoning) the optimization of travel distances, availability of public transport and services and densification of the building stock need to be considered regarding their impact on emissions as well as distance to and elevation above shorelines, water drainage systems and suitability of planning parameters for extreme climate events.

Annex 1: Further conceptual considerations on mitigation

General considerations for prioritization

There are different options how to prioritize activities given the complexity of the overall task. All of these can be used to identify priorities a priori. Some of them will also serve as indicators to assess individual proposals, but this evaluation and the importance of individual criteria and indicators will highly depend on choices made regarding to priorities of the fund.

Choice by target area

- *By sector*: focus on individual sectors within a country and support all types of activities within a country that are required to promote a sectoral transformation in line with the identified requirements
- *By technology*: focus on specific technologies and support all types of activities within a country/region/city that are required to promote the deployment of the technology at an ambitious level
- *By type of activity*: direct investment, enabling environments, incentive structures

Choice by fund considerations

Where to have the most "transformational" impact with limited resources?

- *Focus on leverage*: small public investment can trigger larger private investment
- *Focus on the public domain*: no change is likely through market developments
- *Focus on operationalization*: clear specific sectoral / technology goals can be set
- *Focus on outcome*: activities that maximize total mitigation potential (medium- to long-term) with high ambition (deviation from BAU)
- *Focus on demonstration effect*: activities that demonstrate feasibility of action at large scale

Options for prioritization

Proposal 1: Portfolio approach

The approach aims to combine the different choices by target area with different options for geographic coverage. With increasing scope at the activity level and at the geographic level the potential for truly transformational activities increases, but so do funding requirements and likely project times, both for preparation and implementation. The latter can have important implications for the administration of the fund. Another factor influencing the administrative feasibility of the project portfolio is the overall number of projects to approve and manage, which decreases with growing scope. See Figure 5 for a visualization of this concept.

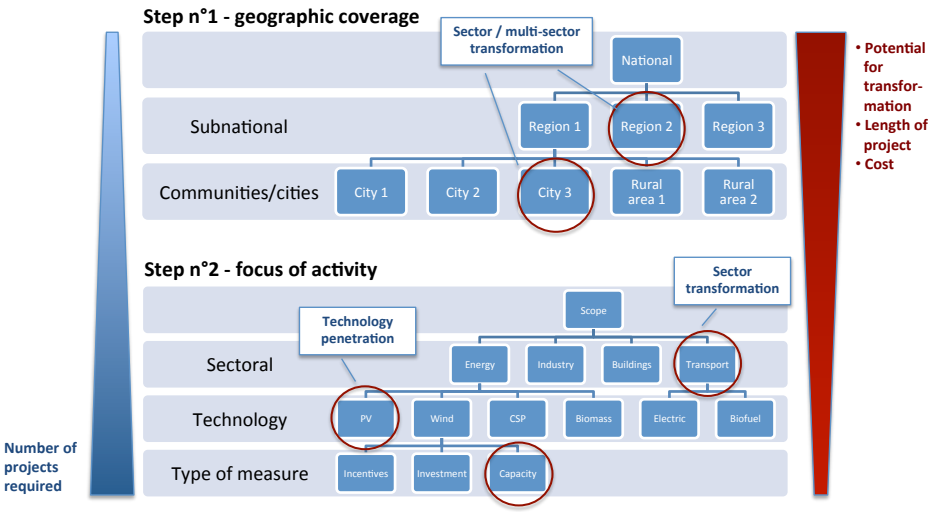


Figure 5: Different options for priorities

National scale activities covering all sectors are likely only feasible for very small countries but would be interesting for the fund to demonstrate feasibility of economy wide paradigm shift.

Regional / sub-regional activities covering all or a number of sectors are likely specifically interesting for urban centers.

Sector transformation would cover all technologies and instruments required to enable a low carbon transformation of the sector, at national, regional or sub-regional level. Supporting this process through the GCF could be feasible for small to medium sized economies.

Focus on *technology penetration* of individual technologies is interesting for medium and large economies with specific technology needs and high potentials. Depending on national circumstances this could include a portfolio of activities required to promote deployment or focus on individual aspects as identified by the country.

The idea of the approach is to allow for all of these activities within the fund, but with a strategic goal to demonstrate feasibility and success in all areas and provide incentive for replication without funding a large number of similar projects. As a general rule the smaller the geographic region the larger the sectoral coverage should be, and the more specific the technology the larger the geographic coverage should be (see Figure 6). The goal should therefore be to move activities towards these areas. This also needs to take into account the difference in size of countries.

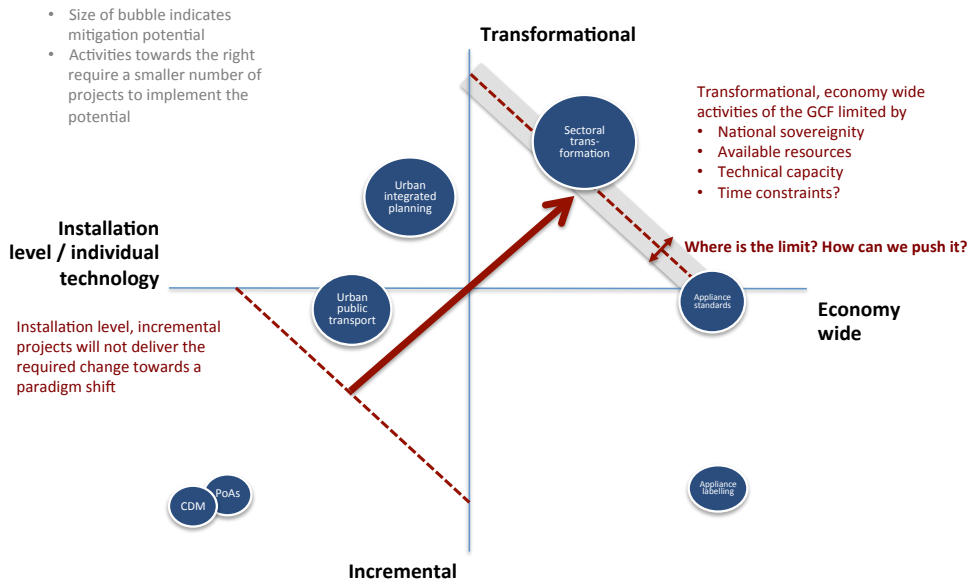
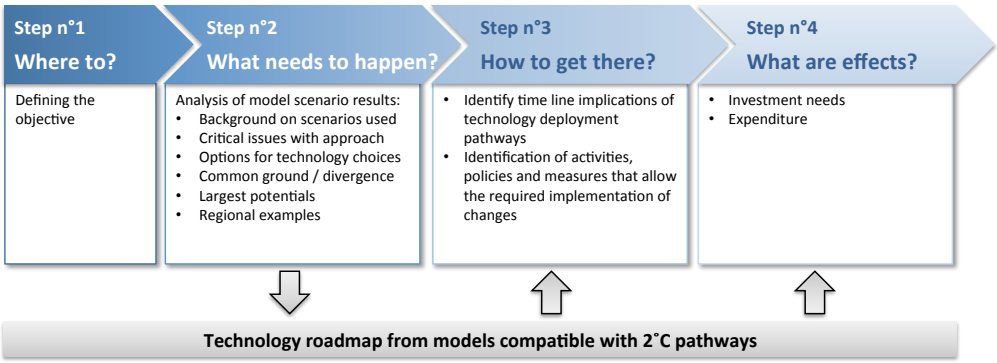


Figure 6: Required direction in a portfolio approach

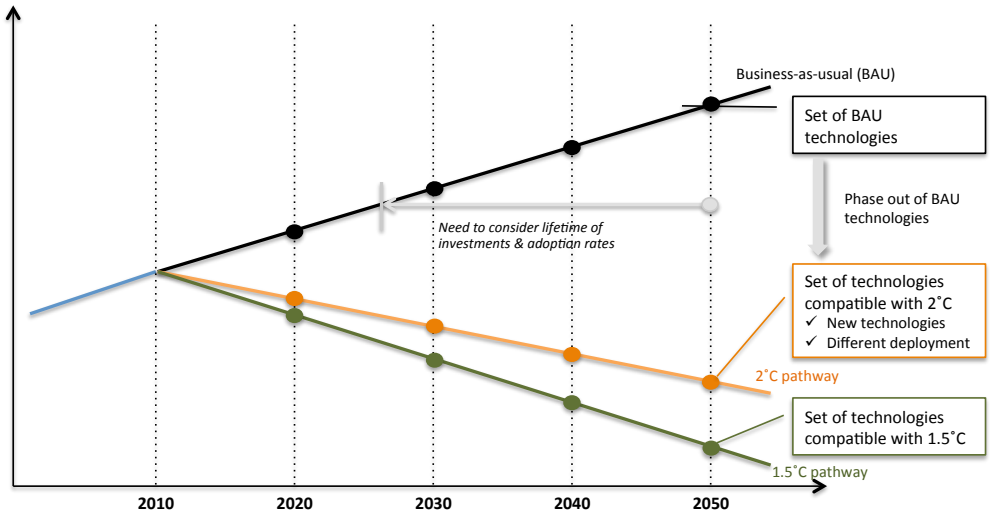
Annex 2: Detailed results of the scenario analysis

This annex includes a number of selected slides that summarize the findings from the scenario analysis leading to the findings in the main part of the report. The full set of slides is available as Powerpoint presentation.

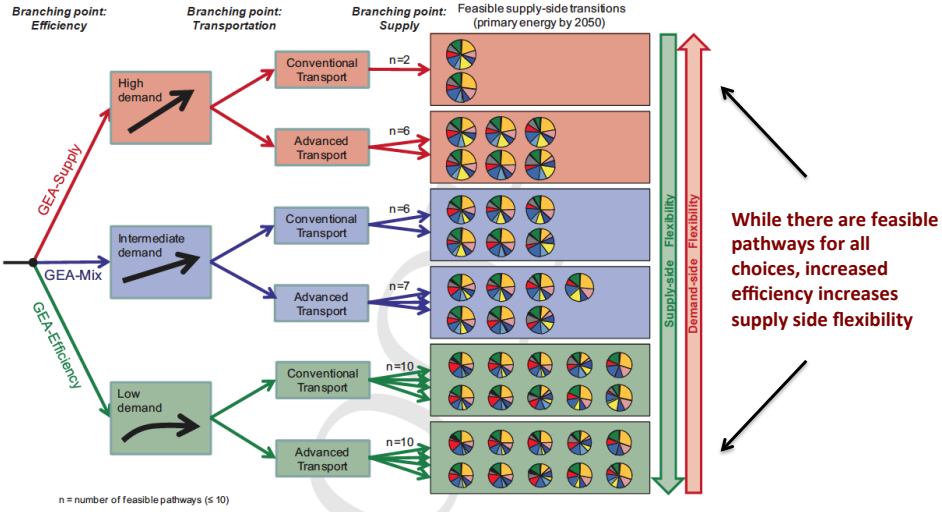
Analysis process leading to the results



Framework for determining a technology roadmap



The GEA scenarios include a number of pathways depending on some fundamental choices:



Issue n˚1 General limitation of energy system modeling

- Models cannot predict the future, but are tools to better understand the consequences of decisions
- Results highly depend on assumptions and input data used: small variations in assumptions can have large impacts on results
- If not all cost elements, like environmental costs, existing fossil fuel and technology subsidies, and fossil fuel price risk, are incorporated results are distorted, as relative cost between technologies is a main driver for results
- Models cannot incorporate unexpected events, like the Fukushima disaster or the economic crisis or changes in governments that lead to different political priorities

➜This is why we use a range of scenarios within one model, which provides a minimum sensitivity assessment

Issue n˚2 Geographic focus

While we can extract some high-level clear messages from models on what needs to happen (and what not) at a global and regional level this has **limitations** when it comes to evaluating concrete funding proposals at national/subnational level.

Additional to the overal guidance we can derive from aggregate modeling we need to take into account:
- Differences in starting point
- Differences in potentials / available natural resources (e.g. RE potentials)
- Different capacities
- Policies in place / institutions

Example
Share of renewable energy in electricity production under BAU and in the GEA supply scenario (data for Brazil from Greenpeace Energy Revolution Scenario)

BAU	2010	2050	2100
Global	20%	28%	54%
LAC	61%	60%	67%
Brazil	88% (2005)	88%	

Supply	2010	2050	2100
Global	20%	52%	63%
LAC	61%	74%	87%
Brazil	88% (2005)	88%	

➜ **Possibility to reconcile top-down technology-based approach with bottom-up country approach through assessment at national level**

Issue n˚3 Non-climate factors for technology choices

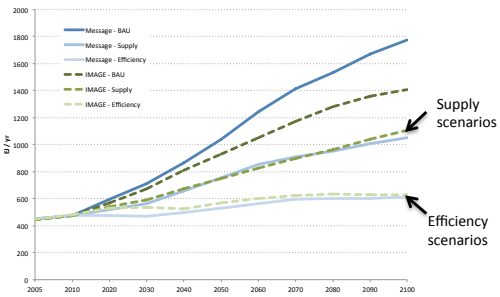
Fundamental choices for or against certain technologies depend on a range of considerations, including non-climate related factors such as:

- Energy security
- Other environmental considerations (local pollution, waste, etc.)
- Economic implications
- Political considerations
- Power structures (lobby)

Different national circumstances will lead to different choices. The important factor is to be able to differentiate **choices that still allow a pathway compatible with the objective** and **choices that result in pathways outside this range**.

Choice n°1 Supply or demand focus

Message and IMAGE model scenarios **compatible with 2°C**



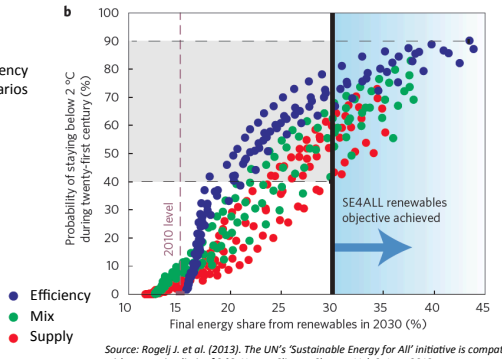
Data: GEA Scenario Database (http://www.iiasa.ac.at)

Differences in total primary energy under BAU, but similar levels of energy use under supply focused and efficiency focused scenarios

BUT

- Generally lower probabilities for supply focused scenarios
- Probability for lower temperature scenarios (1.5°C) even lower
- High co-benefits of efficiency measures
- For many required changes long lead times needed

➜ **Both areas needed for sustainable transformational change**



Source: Rogelj J. et al. (2013). The UN's 'Sustainable Energy for All' initiative is compatible with a warming limit of 2 °C. Nature Climate Change, Vol. 3, June 2013

Choice n°2 Demand side technology choices

	Buildings	Industry	Transport
Common elements supply and demand scenarios	Strict building codes and retrofit standards *All countries:* **Retrofit rate ≈3%/yr** (tripling from historic)	*Developing countries*: Energy intensity in industry per capita increases in the supply scenario to **17-33** GJ/cap in 2050 (from 3-17 GJ/cap in 2005)	Increased transport needs in developing countries compared to today *Developing countries*: Fuel use for mobility per capita increases in the supply scenario to **5.9** GJ/cap in 2050 (from 2.4 GJ/cap in 2005)
Efficiency scenario	Reduced centralized energy use through: • solar water heating • solar heating • heat pumps (with PV) • biomass heating *Developing countries*: Share of buildings with advanced technology in 2050 **75-96%** (up from <1% in 2005) Reduced heating demand in 2050 **45-75%** compared to supply scenario	Reduced centralized energy use through: • adoption of best available technology for new investments; • retrofit of existing plants to improve energy efficiency; • optimization of energy and material flows through systems design, quality • improvements, lifecycle product design, and enhanced recycling; and • further electrification and a switch to renewable energy. *Developing countries*: Energy intensity per capita increases to **15-26 GJ/cap** in 2050 (from 3-17 GJ/cap in 2005)	Reduced energy use through: • technical efficiency improvements across all modes • shift to public passenger and freight transport • limits to car ownership • reduced travel (e.g. videoconferencing) *Developing countries*: Fuel use for mobility in 2050 **4.6 GJ/cap** (2.4 GJ/cap in 2005) Fuel use for freight in 2050 **2.8 GJ/cap** (2.4 GJ/cap in 2005)

Choice n˚3 Transport technology

	Conventional transport	Advanced transport
Technologies deployed	Conventional technologies based on liquid fuels (some oil, biofuels, LNG, biogas, natural gas)	Advanced technologies based on electricity and hydrogen
Consistency with 2˚C	*Both technology choices consistent with 2˚C* *Important to consider close linkage with supply side choices and effects on other sectors (e.g. land use)*	
Implications for action	Focus needed on: • vehicle efficiency • development of next generation biofuels • flexibility of engines for multiple fuel types	Focus needed on: • infrastructure investments • vehicle technology • storage technology

Choice n˚3 Supply side technology choices

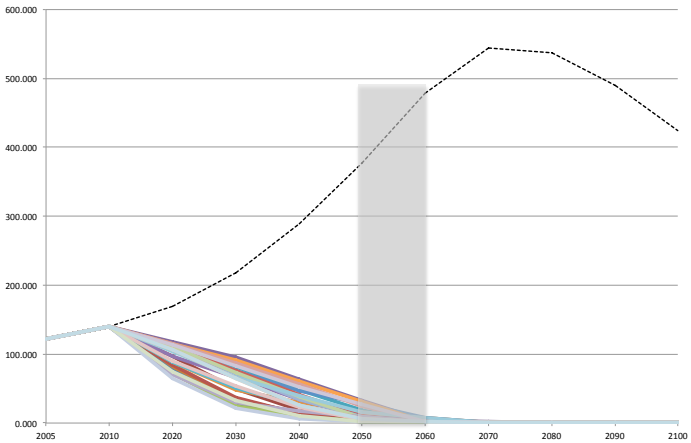
Options for restricted supply side portfolio:
- No CCS
- No BioCCS (CCS + Bio-energy)
- No Sinks
- No Nuclear
- No Nuclear & CCS
- Limited Renewables
- Limited Biomass
- Limited Biomass & Renewables
- Limited Biomass, No BioCCS & No Sinks

Question: can a feasible supply side solution be found compatible with the objectives of the GEA pathways under the technology restrictions outlined above?

Answer: **NO** - for high demand scenarios there is limited scope for opting out of some of these technological choices. Only for efficiency scenarios supply side solutions for all restricted portfolios can be found.

Common ground — Complete phase out of conventional coal starting immediately

Primary energy supply from conventional coal in EJ/yr for all GEA scenarios



Data: GEA Scenario Database (http://www.iiasa.ac.at)

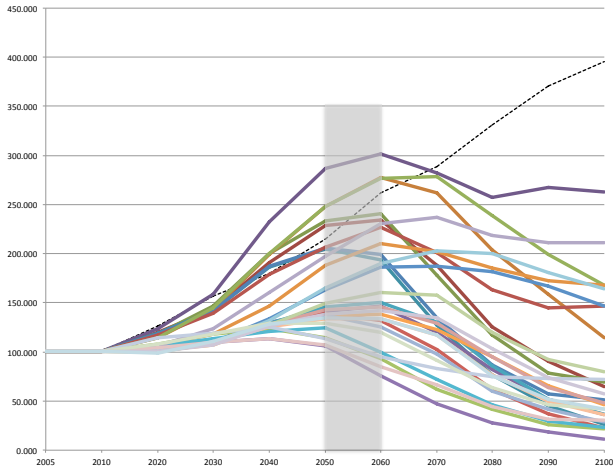
All scenarios start to phase out conventional coal immediately* and reduce to zero between 2050 and 2060

➔ consistent picture across industrialized and developing countries

* The models only show results in 10 year steps. 2020 values therefore need to be seen as end points from current levels. Delays in deviation from BAU will result in steeper required reductions at the end of the decade to achieve the desired end point.

Common ground — Gas as bridging technology until 2050-2060

Primary energy supply from gas in EJ/yr for all GEA scenarios

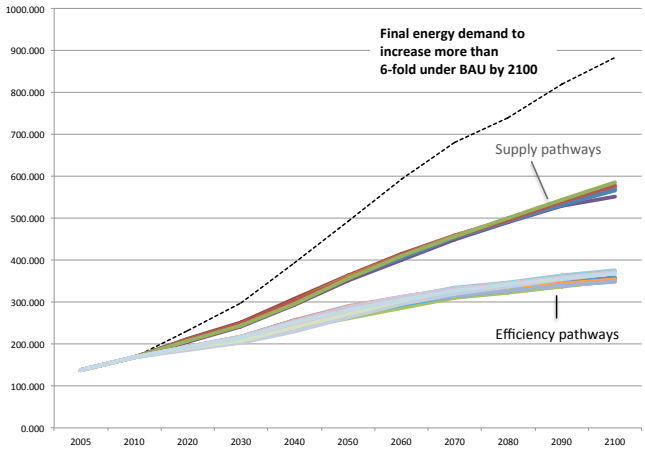


Data: GEA Scenario Database (http://www.iiasa.ac.at)

Most scenarios use gas as a bridging technology, but start phasing out somewhere between 2050 and 2060 (with some exceptions)

Efficiency Required efficiency improvements in developing countries

Final energy demand in EJ/yr for all GEA scenarios - developing countries only



Reductions below BAU*:
2020 - 10%
2050 - 27%
2100 - 35%

Reductions below BAU*:
2020 - 18%
2050 - 44%
2100 - 59%

Ambition for transformational change should be towards the efficiency scenarios:

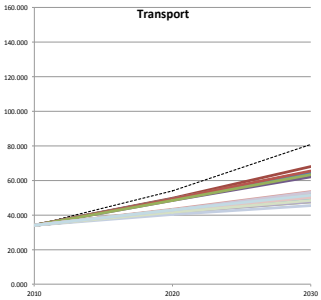
- **greater flexibility in technology choices**
- **high development benefits, e.g. reduced energy cost for households**

Data: GEA Scenario Database (http://www.iiasa.ac.at)

* Average across the scenario group

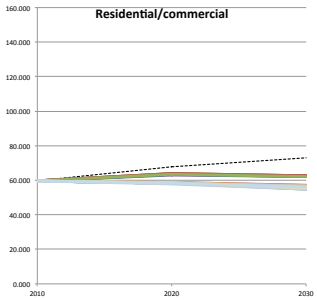
Efficiency Required efficiency improvements by sector

Final energy demand in EJ/yr for all GEA scenarios - developing countries only

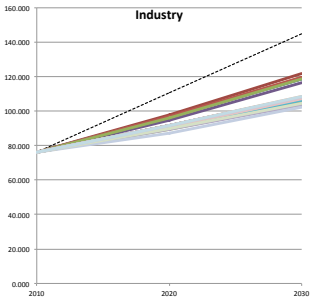


Reductions below BAU*:
2020: 20-25% 4-13 EJ/yr
2050: 55-69% 53-99 EJ/yr
2100: 68-77% 113-221 EJ/yr

Largest deviation from BAU required



Reductions below BAU*:
2020: 13-15% 4-10 EJ/yr
2050: 31-37% 19-39 EJ/yr
2100: 47-50% 38-82 EJ/yr



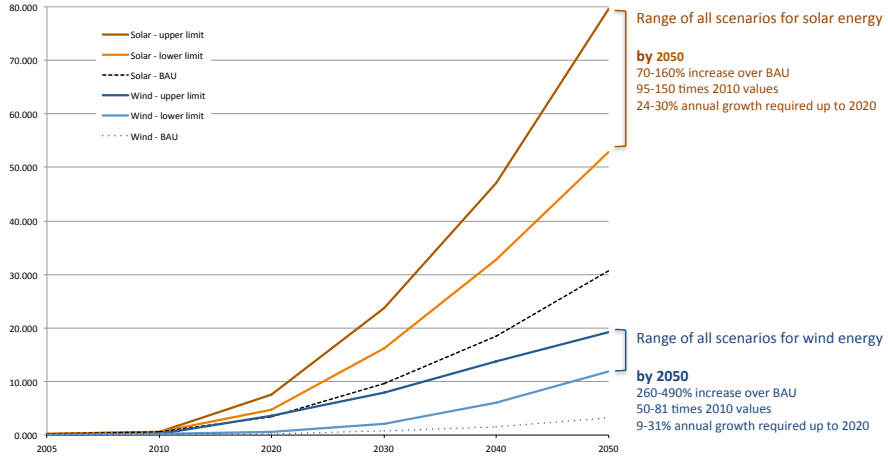
Reductions below BAU*:
2020: 17-21% 13-29 EJ/yr
2050: 36-41% 56-100 EJ/yr
2100: 52-55% 148-239 EJ/yr

Largest total potential

* Range across the efficiency scenario group

Renewables Solar to become most important energy source

Primary energy demand in EJ/yr for selected scenarios for wind and solar - developing countries only



Range of all scenarios for solar energy

by 2050
70-160% increase over BAU
95-150 times 2010 values
24-30% annual growth required up to 2020

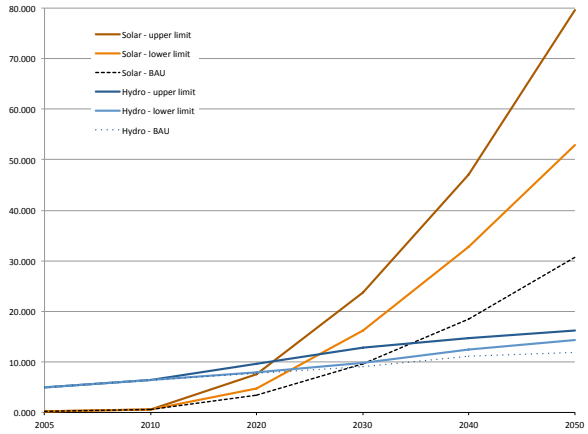
Range of all scenarios for wind energy

by 2050
260-490% increase over BAU
50-81 times 2010 values
9-31% annual growth required up to 2020

Data: GEA Scenario Database (http://www.iiasa.ac.at)

Renewables Hydro remains close to BAU in most scenarios

Primary energy demand in EJ/yr for selected scenarios for hydro and solar - developing countries only



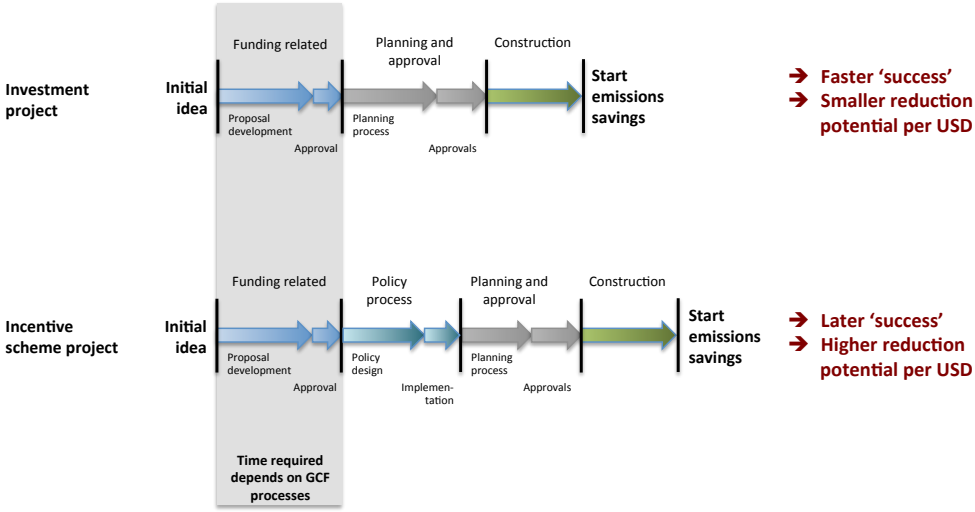
➔ **Focus on support for solar and wind:**
- **largest potential**
- **largest deviation from BAU**

Range of all scenarios for hydro energy

by 2050
22-37% increase over BAU
2.3-2.5 times 2010 values
2-4% annual growth required up to 2020

Data: GEA Scenario Database (http://www.iiasa.ac.at)

Step n˚3 Principles of time line implications for different types of activities



Step n˚4 Required additonal investment cost compared to BAU in developing countries

Total invesment cost

- Total additional investment needed is higher for supply scenarios than for high efficiency scenarios
  - Supply 2020: +107 to 369 billionUS$2005/yr
  - Efficiency 2020: -48 to 274 billionUS$2005/yr

Demand side invenstment

- Supply 2020: 65 to 89 billionUS$2005/yr
- Efficiency 2020: 103 to 164 billionUS$2005/yr

Supply side investment

- Supply 2020: +42 to 280 billionUS$2005/yr
- Efficiency 2020: -152 to 110 billionUS$2005/yr

Energy expenditure

- Supply oriented strategies increase energy expenditure by 108 to 450 billionUS$2005/yr by 2020
- Some high efficiency strategies achieve savings of up to 40 billionUS$2005/yr by 2020 while others also increase expenditure up to 346 billionUS$2005/yr

Larger portfolios entail lower investment cost and lower additional energy expenditure. For supply oriented strategies especially assumptions on limitations to renewable energy availability increase cost.

Data: GEA Scenario Database (http://www.iiasa.ac.at)