Ten years after the Stern Review on the Economics of Climate Change: Looking Back, Looking Forward

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The defining challenges of this century

Managing climate change and overcoming poverty:

If we fail on one, we will fail on the other

- **If we fail to manage climate change**: we will create an environment so hostile that lives, livelihoods and ecosystems will be destroyed.
- **If we try to manage climate change in ways that put barriers to overcoming poverty**: we will not have the coalition we need to manage climate change.
- These challenges are at the core of the **Global Agenda of 2015**: Sustainable Development Goals (New York, Sept), Paris (COP 21, UNFCCC, Dec).
- We can indeed rise to these challenges; we have in our hands a new, sustainable and inclusive model of development and poverty reduction. **The window of opportunity is closing.**

Structure

- **Part 1: Key messages of the Stern Review**
- Part 2: Understanding the issues, changing perspectives
- Part 3: The role of economics in guiding and fostering radical and rapid change
- Part 4: Beginnings of action
- Part 5: Criticality of sustainable infrastructure
- Part 6: Seizing the global opportunity

Contents of the Review

- The Review was of the **"Economics of Climate Change"** (6 parts, 27 chapters, 700 pages). Focus on understanding risks and on policy.
    - Science; economics; ethics,
    - Impacts and modelling potential damages,
    - Policy responses including prices, taxes and regulations for mitigation,
    - Costs/investments for mitigation; structural change; technical progress,
    - Policy responses for adaptation in developed and developing world,
    - Collaboration and international action.

Key messages of the Stern Review

- **All countries will be affected by climate change**, the poorest countries will suffer the earliest and most severely. Potential scale of damage is very large.
- "The costs of action" **are far less than** "the costs of inaction".
- **Delay in action is dangerous.**
- Climate change is the **greatest market failure** the world has ever seen.
- Well-designed **policy can deliver strong results**.
- **Global collaboration** and action required.

These messages have stood the test of time; indeed have become still stronger.

What has changed: 10 years on from the Stern Review…

- The **science is clearer** and the risks are greater than previously thought.
- **GHG emissions have risen** from around 40 $GtCO_2e$ per year to around 50 $GtCO_2e$ per year
- Increasing acknowledgment of the economics of climate action and the **opportunities for low-carbon growth** (Better Growth, Better Climate, September 2014).
- Large **technical progress and falls in cost** (solar, wind, electric car, energy storage…)
- Political progress has not moved as rapidly as hoped, but **pace is finally picking up**, e.g. Paris Agreement at COP21 (Dec 2015), Kigali Agreement on HFCs (Oct 2016) and COP 22 (Nov 2016).
- Bottom up and independent **action is being taken by sub-national actors** and the private sector.
- What follows from January 2017? See part 6.

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The science is still clear, and more robust

- Science is built on **two centuries of theory and evidence. The evidence grows ever stronger that risks are immense and still larger than previously thought.**

- Many of the effects coming through **more rapidly than thought** (loss of ice sheets, glaciers etc.). 16 of the 17 warmest years on record have now occurred since 2001. 2016 warmest year on record. Already at 1°C of warming.

- CO_2e concentrations continue to rise, now around **450ppm** of CO_2e.
    - Adding CO_2e at a rate of over 2.5ppm per year (likely to accelerate with little or weak action). This is up from 0.5ppm per year 1930-1950, 1ppm 1950-1970 and 2ppm 1970-1990.

- Inaction or weak action could take us to **over 850ppm CO_2e** over a century: strong possibility of eventual temperature increase of more than 4°C or 5°C (increase in global average surface temperature above second half of the 19th century).

- **Risk intensifies as the world gets warmer.** Seeing strong effects now; yet small relative to the potential risks at **4 or 5°C (not seen for tens of millions of years).**

What to do to hold warming below 2°C

- Can do a little more earlier and a little less later and vice versa but **shape of feasible paths similar.**
- Stabilising temperatures **requires stabilising concentrations, which will require net-zero emissions**. The lower the target temperature, the earlier the necessary achievement of net-zero; balancing sources and sinks.
- **Paths to achieve under 2°C likely to require:**
  - **zero total emissions** well before the end of century.
  - **Net negative emissions in major sectors** well before end of century (because some sectors likely to be positive).
- Total current Paris pledges (INDCs) are for emissions of around 55-60 $GtCO_2e$ per annum in 2030. Whilst improvement on BAU (ca. 65-68 $GtCO_2e$ per annum), need to be around **40 $GtCO_2e$ or less per annum by 2030.**

Further delay in action is dangerous

- The **window for making the right choices is uncomfortably narrow**. Remaining carbon budget is shrinking rapidly.
- **Further delay in action to learn more would be a profound mistake:**
  - The **"ratchet effect"** from flows of GHGs to concentrations (CO_2 hard to remove)
  - **Dangers of "locking-in"** long-lived high-carbon capital/infrastructure. This involves **either** commitment to high emissions **or** early scrapping of capital/infrastructure.
  - Rapid urbanisation and building of infrastructure.
  - Potential devastating impacts on ecosystems, biodiversity, forests, water, air quality; tipping points.
- **Delay increases reliance** on unproven future technologies (e.g. negative emissions) or more ambitious action in future (politically feasible?).
- **Holding temperature to below 2°C requires immediate action** across whole economy; **focus on cities, energy and land**.

The "costs of action" and investing in growth

- With hindsight Stern Review **under-estimated the risks and costs of inaction**.
- The notion of "costs of action" is being **transformed by rapid technological advances**:
  - Efficiency, demand management; renewable energy (solar, wind) and energy storage technology.
  - Continuing rapid technical progress in digital, materials, bio-tech…
  - Design of cities (infrastructure for autonomous vehicles, cycling, walking…)
- Better **understanding of dynamics of change** and leaning; and of the consequences of dirty infrastructure (e.g. air pollution from burning fossil fuels).
- No longer a story of simple-minded trade-offs as embodied in the United Nations Framework Convention on Climate Change (1992). **Action is now the growth story of the future.**
  - Shift from a focus on the **"costs" to one of "investment".**

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The role of economics in guiding action on climate change: fostering rapid and radical change

- **Economics has a key role to play in guiding action, but it has to ask:**
  - What should be our approaches and criteria for managing risks of climate change?
  - How much risk to accept?
  - How big does the response have to be?
  - How do we create policies to foster rapid, equitable and effective change?
  - What are the roles of different players?

- But many "standard" economics approaches badly distort the issues. We **have to bring new and dynamic analyses** to the management of radical change when **urgency, pace and scale are of the essence**.

Modelling the economics of climate change risks

- Economists tend to use the familiar tools of growth models and analysis of modest or moderate perturbations from given paths.
- But climate risk in its scale and nature is very different. Potential impacts (e.g. submergence of large areas, desertification of others, destructive weather events, migration, conflict…) are **not consistent with long-run story of a given underlying growth rate or economic structure**
- **On the damage side, marginal change applied to growth models misses the scale and nature of risks.**
    - Damage functions usually relate GDP loss to current temperature changes (ignores, e.g., damages to capital stocks or growth rates).
    - Models are calibrated to absurdly low levels of loss (e.g. only a 50% loss of GDP from 18°C increase above 1900 levels; or 5-10% at 5°C)
    - There is limited incorporation of the ethics of climate change.
    - Models do not value the "co-benefits" from a low-carbon transition (e.g. reducing air pollution, more resilient ecosystems)
- **On the policy side, marginal models miss the dynamic public economics of systemic change.**
    - Ignore the inherently systemic nature of transformative change.
    - Fail to model benefits of innovation and impacts on future prices or technology options.

The ethics of climate change: must face explicitly

- Challenge gives rise to fundamental normative questions that economics cannot avoid addressing, including the need to think about immense damages, conflict, loss of life in the future, possible reversal of development, profound distributional change, justice and rights.
- All major approaches to moral philosophy seem to point in same general direction: **strong action to reduce emissions is morally required. (WAWW, Chapter 6)**
- **Intergenerational ethics: *How can we compare the value of goods and lives today vs in the future?***
    - Ethics discourse in economics has focused heavily on intergenerational equity (discounting).
- **Intra – generational ethics: *distribution of damages and which countries should do what and when?***
    - **Double inequity** – rich countries major responsibility for past emissions. Poor people hit earliest and hardest; also within countries.
    - Arithmetic implies **faster cuts for rich countries**. With more than a billion people in mid-century a 2°C path will require average per capita emissions around 2 tonnes CO_2 p.a. If few people below there can only be a few above.

Discounting

- Discounting is the process of adjusting the value attached to a unit of some good accruing in the future to compare with the value of a unit of that good if available today.
- That relative value is the discount factor (and its proportional rate of fall is the discount rate) will usually vary across time, good and person. Depends on future development of the economy and on the good chosen for accounting. **Future generations maybe much worse off with badly managed climate change**, thus could place higher weight (involving negative discount rates) on extra goods at that time.
- Some argue that relevant discount rates can be 'read-off' from market interest rates or rates of return. This is a mistake: **markets do not reflect ethical decisions**; capital markets over long term are full of imperfections; discounting depends on future living standards (highly endogenous and difficult to predict).
- **Pure-time discounting** of future welfare or lives places lower weight on a future life which is otherwise identical in all relevant circumstances. This is **discrimination by date of birth**. Very hard to provide any ethical justification.
- **Risk and uncertainty best treated explicitly**, e.g. via expectations of social welfare or avoidance of catastrophic outcomes rather than "rolling into" discount rates.

Market failures go beyond the fundamental issues of damage from emissions

- **Six key market failures relating to climate change**. Different failures point to different instruments, but the collection is mutually reinforcing**:**
  - **Greenhouse gases:** carbon taxes / cap-and-trade / regulation.
  - **R,D&D** (research, development and deployment): tax breaks, feed-in tariffs (FIT) for deployment, publicly funded research. Learning, and its pace, critical part of story.
  - **Imperfection in risk/capital markets:** risk sharing/reduction through guarantees, equity, feed-in tariffs, floors on carbon prices. FIT straddles first 3 imperfections. **Green/infrastructure development bank**: reduces policy risk, provides leverage, longer-term horizon, power of example.
  - **Networks:** electricity grids, public transport, broadband, recycling, community-based insulation schemes. Government frameworks needed.
  - **Information:** for consumers labelling and information requirements on cars, domestic appliances, products more generally; awareness of options. Similar issues for producers.
  - **Co-benefits:** valuing ecosystems and biodiversity, valuing energy security, regulation of dirty and more dangerous technologies. Pollution damages from burning fossil fuels are immense, US$ 3-4 trillion p.a. (IMF, 2015).

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Progress internationally in 2015/2016: a new global agenda

- 2015 and 2016 **breakthrough years for global collaboration** around climate change and development. **First shared global agenda since agreements after WW II.**
- **Agenda for action has been set** with agreements on:
  - Financing for development in Addis (July 2015)
  - Sustainable Development Goals (Sep 2015)
  - Paris Agreement on Climate Change (CoP 21) (agreed Dec 2015, entered into force in Nov 2016; very rapid ratification)
  - Kigali Amendment to the Montreal Protocol on HFCs (Oct 2016)
  - New Urban Agenda (Oct 2016)
  - Marrakesh Action Proclamation For Our Climate And Sustainable Development (Nov 2016)

Based on an increasing recognition of the growth story of the future

- **Growth, sustainable development, poverty reduction and climate action** are complementary and interwoven. "Better Growth, Better Climate" (NCE, 2014); "Why are we Waiting?" MIT Press, Stern, 2015, "Delivering on Sustainable Infrastructure for Better Development and Better Climate"; Bhattacharya, A., Meltzer, J., Oppenheim, J., Qureshi, M.Z. and Stern, N, 2016)

- **Opportunity to:**
  - Boost shorter-run growth from increased investment in the low-carbon transition (sustainable infrastructure);
  - Spur innovation, creativity and growth in medium term;
  - Offers the only feasible longer-run growth.

- A growth story that delivers: **alternative paths of economic development; rising living standards, cities where we can move and breathe; stronger communities; ecosystems that are more productive and resilient.**

- Action is starting to occur across the whole economy; **focus on cities, energy and land**.

Progress in nations, cities and regions has been slow, but momentum is building

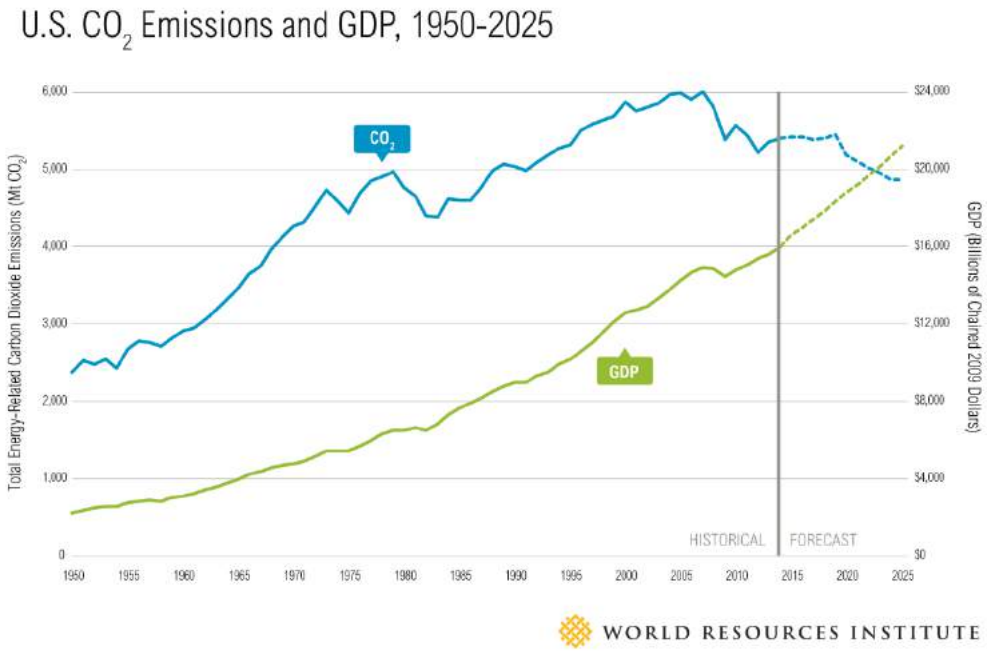
- Already, about **40 national jurisdictions and over 20 cities, states, and regions** are putting a price on carbon.
  - More are in the pipeline: China National ETS (2017), South Africa (2017), Chile (2017), Canada (2018),…
- **Importance of policy credibility :**
  - By the end of 2014, there were **804 climate change laws and policies** amongst 99 countries, compared to 426 in 2009.
- **Cities are also beginning to realise the opportunities:**
  - **7,100 cities from 119 countries** have committed to the Compact of Mayors for Climate & Energy.
  - Increasing recognition of the **role of ecosystems services and infrastructure for resilience and public services** (1,069 cities are signatories to the Durban Adaptation Charter by the end of 2015)
  - **Support for renewable energy and energy efficiency** in buildings and heating (e.g. Oslo aiming to phase out fossil-fuel heating in homes and offices by 2020).
- Paris/Marrakech continue notwithstanding the change of federal administration in the US. Many US cities, states, firms will carry on (as in Canada under decade of Harper as PM).

Action is also being taken by many private sector firms and investors

- Increasing **momentum from institutional** investors around climate change and sustainability:
  - Swedish National Pension Fund (AP4) has made the **biggest low-carbon commitment of any institutional investor to date**, US$3.2 billion in passive investment funds designed by MSCI. Intend to decarbonise $14.7bn global equity portfolio by 2020.
  - PKA, Denmark's fourth-largest pension fund, with €35.5bn in assets, has asked 53 companies that generate between 25 - 50% of their revenues from coal to **provide plans on how they will reduce their exposure to the fossil fuel.**

- **Many firms are also using climate change concerns to guide decision making.**
  - **IKEA** has pledged **€1bn on renewable energy** and climate change efforts.
  - **Unilever aims to be 'carbon positive'** in its operations by 2030, committed to sourcing 100% of total energy across its operations from renewables by 2030,
  - Around 430 companies are pricing carbon internally, including Disney (US$10 -20 per tCO_2), WPP (US$29 per $tCO_{2)}$, some oil and gas majors (ranging from US$ 40 to US$ 80 per tCO_2)

Decoupling economic growth and GHG emissions is possible



- Between 2000 and 2014, more than 20 countries managed to **reduce annual GHG emissions while growing their economies.**
- This has been led by countries within the EU, including the UK, France, Germany, Austria, Ireland and Denmark. UK economy up 60% since 1990, emissions down 40%.
- The USA has also managed to reduce GHG emission by 6%, while increasing GDP by 13% in real terms between 2000 - 2014 .
- China peaked coal use in 2014. Climate action at heart of 13th five year plan.

Need to ramp up action quickly and decisively

- Total **global greenhouse gas (GHG) emissions continue to increase**. Currently over 50 $GtCO_2e$ (UNEP, 2016).
- The Paris commitments (NDCs) put the **world on a target of 55 $GtCO_2e$ plus in 2030**, need to be around 40 $GtCO_2e$ to meet 2°C pathway.
- Current **NDCs offer 10% increase in GHG emissions for 2030 as compared to today**. We need a 20% decrease. Even steeper for 1.5°C path.
- If fully implemented, the unconditional NDCs are only consistent with staying below an increase in **temperature of 3°C or more by 2100**, if conditional pledges are included then still around 3°C path. (UNEP, 2016)
- Remember, we have not seen 3°C for around 3 million years: **very dangerous**.
- **Radical acceleration in action over next 10 – 15 years is required if we are to have any chance of holding to 2°C.**

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Next 10 to 20 years are of crucial importance

- **Long-lasting infrastructure investments on large scale** will need to be made in our cities, energy and water systems and in transport systems.
- **These anticipated investment needs are driven by:**

  a. aging infrastructure in advanced economies will need repair and replacement.
  b. higher growth and growing weight of emerging/developing countries in global economy.
  c. structural change in EMDCs including rapid urbanisation from around 3.5bn now (50% of 7+bn) to around 6.5bn by 2050 (70% of 9+bn).

- World economy will likely more than double by 2030, so too will infrastructure needs. **Once in history transition**.
- Altogether $80-$90 trillion in infrastructure investments required over next 15 years - ***more than the current existing stock***.

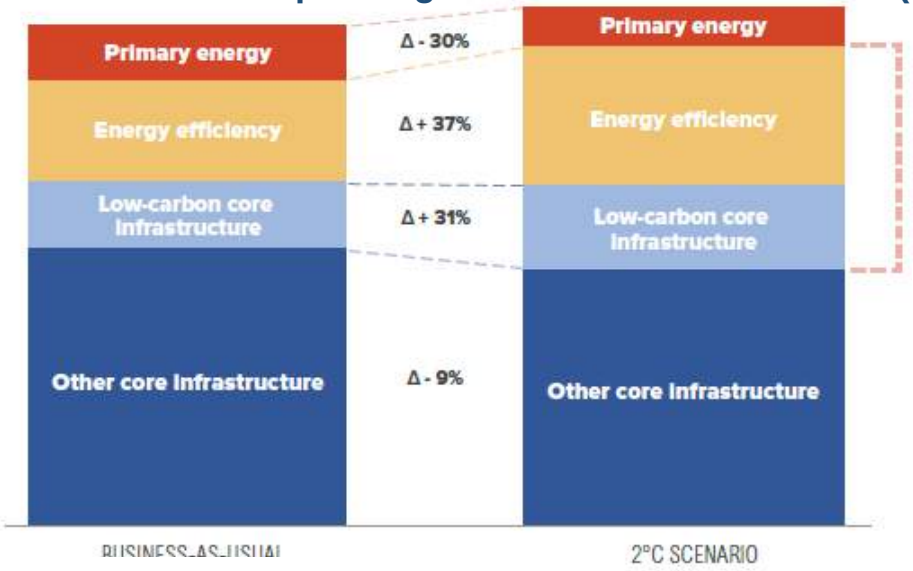
Great opportunity to embark on new, attractive and sustainable path; but dangers of "lock-in" if action delayed

- Current development **paths are towards dirty infrastructure**, congested and polluted cities, destruction of forests and ecosystems. Creating grave danger of lock-in of high-carbon infrastructure and irreversible effects.
- Expected future emissions from ***existing* power plants** alone will take us over 2°C with 50% probability (Pfeiffer et al., 2016).
- **Have to recognise that mitigation, adaptation, development are intertwined**: agriculture, water, transport, energy, buildings, cities…
- Investment in **sustainable infrastructure is at the heart of meeting the global challenges**, must average **$5-6 trillion p.a.** over the next 20 years.
    - Around 70% will be required in developing countries.

Sustainable infrastructure is central to the story

Investing in sustainable infrastructure requires a shift in investment but does not need to cost much more

Infrastructure spending needed for a 2°C scenario (2015-2030, percentage change)



- Primary energy: extraction of oil, gas and coal
- Energy efficiency: buildings, energy and transportation
- Low-carbon core infrastructure: renewable energy, nuclear, CCS, low-carbon transport (e.g. light rail and Bus Rapid Transit systems), climate-proofed water and sanitation including some adaptation infrastructure (e.g. sea walls and flood protection)
- Other core infrastructure: standard water/sanitation, high-carbon transport (e.g. roads), energy production, and telecommunications

Source: Global Commission on the Economy and Climate, 2016 and 2014, and Bhattacharya et al., 2016

Moving from “billions” to “trillions”

- There is no shortage of world savings but major obstacles in **transforming investment opportunities into real investment demand** and major difficulties in bringing forward the **right kind and scale of finance at the right time.**
- **Most effective way is to augment the financing capacity of the MDBs.**
    - Allows developed countries to meet their commitments on climate finance and can ensure that this finance has the maximum development and climate impact.
- MDBs will need to increase their infrastructure lending **five-fold over the next decade** (from around $40 billion per year to over $200 billion per year) (Bhattacharya, Oppenheim, & Stern, 2015).
- Together MDBs, along with ODA/climate finance and export credit agencies, could be used to **mobilise a much larger sum of private capital**.

The necessary expansion of the role of MDBs

- **Key role for MDBs** around supporting investment by enhancing the quality of the project, reducing risk and **crowding in private finance.**
- **Their presence can impart confidence, reduce risks, bring relevant instruments and encourage participation of other sources of financing.**
- **This can bring down the cost of capital:** crucial for volume and sustainability (quantity and quality).
- They are **trusted conveners** that can help coordination and help establish **replicable and scalable** models.
- MDBs can also help to catalyze change through **further strengthening their priorities**:
  - Currently a priority for regional development banks, World Bank and IMF; also FSB. Both growth and stability.
  - NDB (new "BRICS" bank) financing entirely RE projects with first funding round,
  - AIIB " a clean and green" bank, committed to not invest in coal.
  - Establishment and capitalisation of the GCF. Now beginning to distribute.

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Delivering on the global challenges: growth, infrastructure and sustainability

- **Three central challenges facing the world community:**
  - How to **reignite global growth**?
  - How to **deliver on the Sustainable Development Goals (SDGs)**?
  - How to **take strong action on climate change**?
- **Three forces present us with a special opportunity:**
  - Historically **low interest rates and search for growth** offer the opportunity to finance the transition (sustainable infrastructure is key).
  - **Rapid technological change** offers optimism for the future (digital, materials, biotech…).
  - International agreements have **provided political direction** and evidence that collaboration is possible.

Strong investment requires clear and credible direction and policies

- Spurring low-carbon, climate resilient growth requires the redirection of investment and financial flows over long periods. Have to act quickly **but be consistent.**
- Market forces will not correct these failures by themselves, policy makers have to set the **clear, long-term direction of travel**. **Government-induced policy risk is the biggest deterrent to investment worldwide.**
- Be '**predictably flexible**'. Circumstances will change and there will be learning and technological advance - indeed a key objective. As these changes occur policies will need revision but approach to and criteria for revision should be clear.
- **Foster confidence** through commitments and institutions: climate change legislation and committee, development banks, international agreements…

Leadership and commitment in a new world order

- COP22 in Marrakech sought firm commitment to implement the Paris Agreement with **strong focus on delivery** (notwithstanding US election results of November 2016).
- Accelerating action in the private sector: see **"Better Business, Better World"**
- **China's leadership** has been remarkable. Embodied in 5 year plans, peaking coal in 2014, driving rapid ratification and coming into force of the COP21 agreement. President Xi's speech in Davos, January 2017.
- Modern, clean, smart, resilient infrastructure will be a **core driver of growth**.
- US unlikely to be a leader at federal level, but cities, states and firms likely to drive forward. **How US behaves internationally remains to be seen**.

Next decade requires strong policy for innovation and investment if we are to grasp the opportunities of the next 20 years.

- If we do not take the opportunities now, **2°C will be out of reach and we will risk reversing development gains, having cities where we cannot move or breathe, ecosystems that collapse.** The gains are potentially immense, but so too are the risks of delay.
- **Urgency and scale** insufficiently understood, we are winning the arguments but action still far too slow.
- The actions of the **next 20 years are decisive** and are shaped by our actions and policies in the next 10 years.
- **Requires powerful innovation** across the board: cities; energy; land; technology; public policy and institutions; finance and MDBs; international collaboration; private sector.
- **Political will fundamental** for such radical change: leadership nationally and internationally; private sector; civil society; faith groups and young people.

We know what needs to be done, we know how to begin, and we will learn along the way.

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What we need to do to hold warming "well-below 2°C"

- Can do a little more earlier and a little less later (and vice versa) but shape of feasible paths similar.

- Stabilising temperatures **requires stabilising concentrations, which will require net zero emissions**. The lower the target temperature, the earlier the necessary achievement of net-zero. Net-zero is balancing sources and sinks.

- **Paths to achieve under 2°C likely to require:**
  - **zero total emissions** well before the end of century.
  - **Net negative emissions in major sectors** well before end of century (because some sectors likely to be positive).

- Forests, land, agriculture, oceans will be crucial.