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Renewable energy assets:
Measuring the unaccounted wealth of nations

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Part I

Including renewable energy assets in national economic accounting standards:

Propose guidance

Measuring renewable energy resources as assets: scope and motivation

- Renewable electricity (hydro, wind, solar, geothermal) resources are economically too important to omit from national economic accounts
  - Fastest growing sector of electricity sector
  - Already account for 30% of global electricity generation according to the International Energy Agency
  - Hydro resources alone likely worth trillions of dollars worldwide according to pilot empirical work by the World Bank*
  - Solar, wind, geothermal likely to be worth even more as markets evolve and climate policies internalize external costs of fossil fuels
- When resources become productive to this extent, their measurement as economic assets merits consideration
  - Not to do so risks creating an imbalance in economic statistics
- Non-renewable energy resources like oil and coal are already recognized as assets because of their economic importance
- The current revision of national economic accounting standards offers a chance to get this right

*See: Smith R., A. Ilas, J. G. Inon and G. Peszko, 2021, "Renewable Energy: Unaccounted Wealth of Nations", in *The Changing Wealth of Nations 2021: Managing Assets for the Future*, Washington: The World Bank.

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Current treatment of renewable energy resources in national statistics

- Current international statistical guidance is neither complete nor internally consistent
- National economic accounting guidance (SNA)* has little to say
  - What is said implies renewable energy resources are not assets because ownership rights cannot be enforced
    - Yet, ownership rights clearly are exerted by both public and private entities
- Environmental accounting guidance (SEEA-CF)** is extensive but incomplete
  - Renewable energy resource values are expected to be captured in the value of the associated land: “Opportunities to earn resource rent based on sources like wind, solar and geothermal should be expected to be reflected in the price of land” (SEEA-CF ¶5.228)
  - This ignores renewable energy production that occurs on land without other economic value and the fact that renewable energy markets are rapidly evolving

*System of National Accounts, 2008

**System of Environmental Economic Accounting, Central Framework, 2012

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Exploring the assumptions behind the current treatment of renewable energy resources*

- Three issues regarding the current treatment of renewable energy resources in the SEEA-CF deserve discussion:

1. Property rights often do not include the rights to the economic benefits flowing from any associated renewable energy generation

2. Much land associated with renewable energy production has no economic value in the SNA

3. Markets for renewable energy production are rapidly evolving

*These arguments are laid out in detail in this guidance note prepared as an input to the 2025 revision of the SNA: shorturl.at/lXYZ8.

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1. Property rights to renewable energy resources

- Property rights to renewable energy resources are mostly held by governments
  - Hydro, offshore wind and geothermal rights are nearly always held by governments
  - Solar and onshore wind rights are also held by governments when production occurs on public land
  - Only rights to solar/wind production on private land (e.g., solar rooftop or windmills on farmland) vest in private hands
  - Note that utility-scale solar/wind (accounting for most current growth in installations) is generally on public land (e.g., former surface mines, otherwise contaminated lands or deserts) rather than private land

Thus, in most instances, property rights are such that renewable energy production will not influence the value of land recorded in the SNA

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2. Land value in the national accounts

- National economic accounts only value private land or land associated with public infrastructure or buildings
  - Public land with no “productive” use is not recorded (e.g., forest, rivers, lakes, seabed, deserts, barren land, etc.)
- Thus, only in the case of renewable electricity production on private land is there a measured land value that could be influenced
  - Production of all hydro, geothermal, off-shore wind, and on-shore wind and solar on public land occurs on land not generally valued in economic accounts
  - For example, the UK Crown will earn billions of pounds from off-shore wind farms on seabed that has no recorded value

Only solar/wind production on private land is apt to influence land values

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3. Renewable energy resource values and land prices

- In theory, where property rights vest in landowners, property values should reflect value of renewable energy resources, as SEEA-CF suggests
  - In practice, this applies only to solar/wind on private land
- Empirical evidence in the peer-reviewed literature shows inconsistent capturing of solar/wind resources in private property values
  - Studies show that property values increase in some cases where renewable energy production occurs, but the amount of increase is inconsistent across markets
- Such inconsistent capturing of values reflects the evolving legal/regulatory contexts and technology/cost structures that characterize renewable energy markets

Private land values inconsistently reflect solar/wind resource values

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Summary of concerns with existing accounting treat of renewable energy resources

- SNA treatment is limited and unclear
- SEEA-CF treatment is clear but applicable, even *in theory*, only in restricted circumstances (production of solar/wind electricity on private land)
- The SEEA-CF treatment is *not applicable at all* for hydro, geothermal, off-shore wind and utility-scale solar/wind, which account for the majority of production

An alternative approach is required

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Recommended approach to renewable energy resources as assets

- We recommend renewable energy resources be recognized as a new category of non-produced, non-financial assets in the revised SNA
- Requires addition of a new natural resource category to the SNA
  - To avoid confusion, the current category “Mineral and energy resources” should be renamed (see table)
- For consistency, the SEEA-CF asset classification should be similarly revised at the time of its next update

Proposed new classifications of natural resource assets in the SNA and SEEA-CF

SNA	SEEA-CF
Land	*Mineral resources*
Mineral reserves	*Non-renewable energy resources*
Non-renewable energy resources	*Renewable energy resources*
Renewable energy resources	*Land*
Non-cultivated biological resources	*Soil resources*
Water resources	*Timber resources*
Other natural resources - *Radio spectra* - *Other*	*Aquatic resources*
	Other biological resources
	Water resources

Note: New asset categories are shown in green and renamed categories are shown in red.

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Defining renewable energy resources

- We propose to follow the recommendations of the United Nations Framework Classification for Renewable Energy Resources to define renewable energy resources
- Renewable energy resources are the cumulative energy captured by existing renewable energy projects (e.g., hydro stations and wind farms) over their lifetimes
  - This is consistent with the SNA/SEEA-CF definition of fossil fuel resources, which are the energy stored in reserves recoverable under current economic and technological conditions
  - Renewable energy projects can be as small as a single roof-top solar installation or as large as major hydro station
- For example, solar energy resources in a country would be the sum of all solar energy captured by existing solar panels over their expected lifetimes
  - These resources could be measured in joules, GWh or barrels of oil equivalent
- As technology improves (e.g., better solar panels), a nation's renewable energy resources will expand by this definition
  - This is also consistent with fossil fuel resources, for which reserves also expand as extraction technologies improve

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Recommended classification of renewable energy resources

We recommend the revised SNA recognize the following renewable energy resource types as assets

Renewable energy resources
Water energy resources
River water energy resources
Tidal energy resources
Wave energy resources
Solar energy resources
Wind energy resources
Geothermal energy resources
Other renewable energy resources

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Advantages of the recommended approach

- Ensures consistency in treatment of all natural resource assets in the SNA
  - Other commercially important natural resources (fossil fuels, minerals, timber, etc.) are already recognized as assets
- Reflects the fact that the asset value of renewable energy resources is already large based on pilot empirical studies and is likely to grow substantially in the future

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Possible disadvantage of recommended approach

- Could lead to double counting if some private land does in fact reflect the value of renewable energy resources
- Such double counting would likely be small, since it would apply only to solar/wind production on private land, which is the smallest production category
- Double counting could be avoided in practice by applying an approach similar to that used by national accountants to separate the value of land and structures from property prices

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Valuation of renewable energy assets

- To value renewable energy assets, we recommend the residual value approach (RVM)
  - This approach is already recommended in the SNA and SEEA-CF for other natural resources
- RVM sets asset values equal to the discounted value of future rent streams
- Rent is estimated as revenues from resource production, less costs of production (net of subsidies), including normal returns to fixed capital and depreciation
- RVM requires choice of a discount rate and a decision regarding the expected pattern of future rents
  - Both SNA and SEEA-CF already offer guidance on these points for mineral and fossil fuel assets and we recommend applying that guidance to renewable energy resources with some exceptions (see later)

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RVM – conceptual and practical issues

- Conceptual
  - Markets need to be close to equilibrium
    - Renewable energy markets remain distorted, but they are moving in the “right direction” and distortions are less severe than in past
    - Where distortions remain severe, least-cost alternative method can be used instead of RVM
- Practical
  - Some rent variables may be challenging to estimate with existing data, notably fixed capital costs
  - Future rent patterns
    - SNA and SEEA-CF recommend assuming constant future rent
      - Likely OK for hydro resources
      - Solar/wind/geothermal resource markets too dynamic to assume constancy however
        - Approaches may be required to model future revenues and costs

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Part II

World Bank pilot national accounts for renewable energy assets

10/19/2022

The Changing Wealth of Nations 2021

- Pilot accounts of renewable energy assets for 15 countries (1990-2017) using RVM to calculate resource rents from operating projects and asset value as NPV of future rents
- Cover 70%-87% of globally installed renewable capacity
- Policy-contingent future value of renewable energy assets modelled in 2 countries

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Calculating renewable energy resource rent from surplus of power plant operator (RVM)

REVENUES
LESS OPERATING COSTS
intermediate inputs at purchasers' prices including taxes
labor costs
other taxes on production plus subsidies on production
EQUALS GROSS OPERATING SURPLUS
LESS SPECIFIC SUBSIDIES ON EXTRACTION
PLUS SPECIFIC TAXES ON EXTRACTION
EQUALS GROSS OPERATING SURPLUS FOR THE DERIVATION OF RESOURCE RENT
LESS USER COST OF PRODUCED ASSETS (DEPRECIATION + RETURN TO PRODUCED ASSETS)
EQUALS RESOURCE RENT

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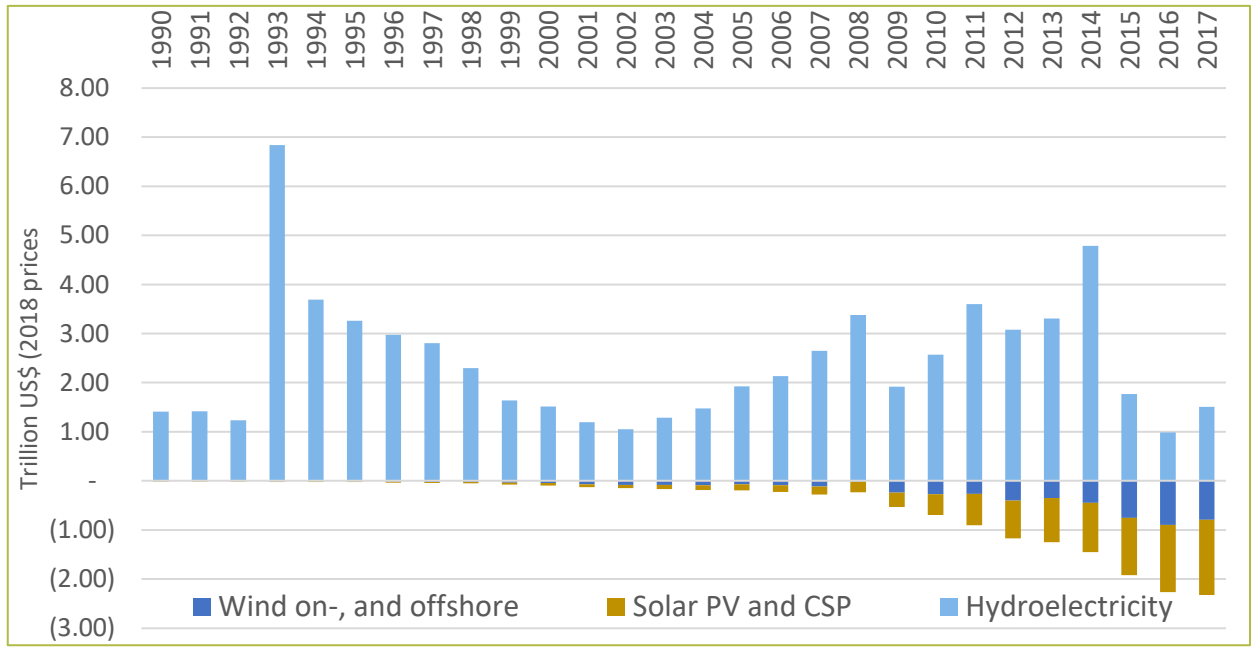
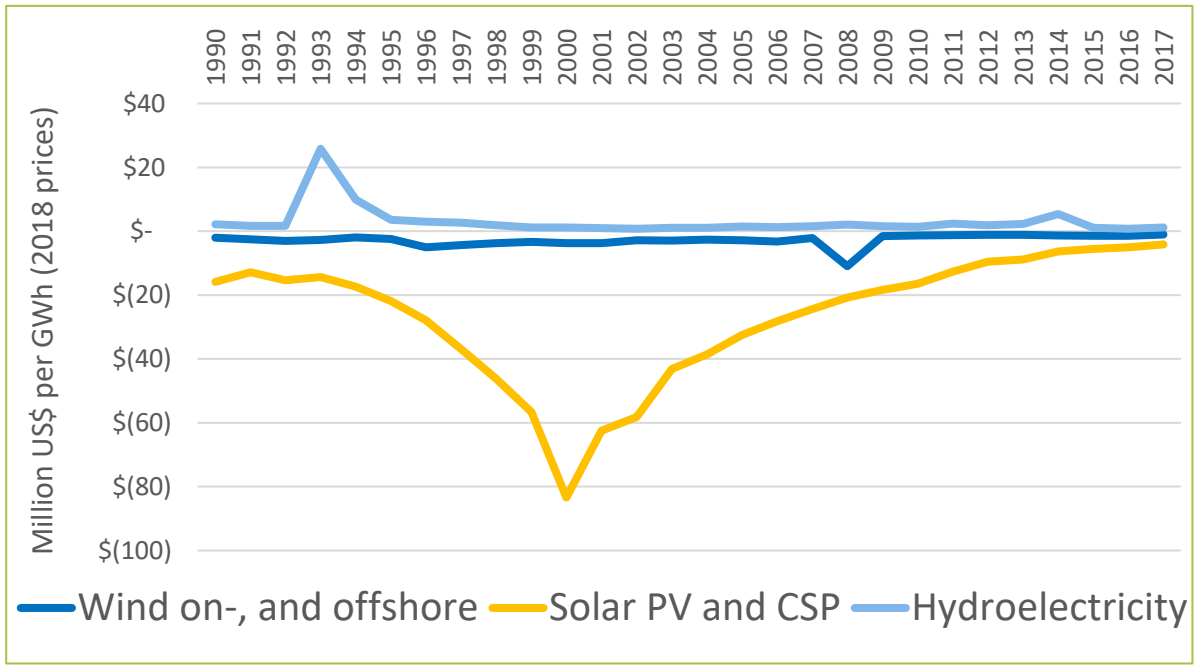
Renewable energy assets are already valuable and will increase in value with market evolution and climate policies

Total renewable energy wealth in 15 countries 1990-2017



Average unit solar & wind wealth (per GWh) in 15 countries



- Hydro assets have mostly positive, though volatile, values
- Solar and wind assets still have mostly negative values as nascent, subsidized but fast-growing industries with rapidly decreasing technology costs
- Unit solar and wind rents are approaching positive values

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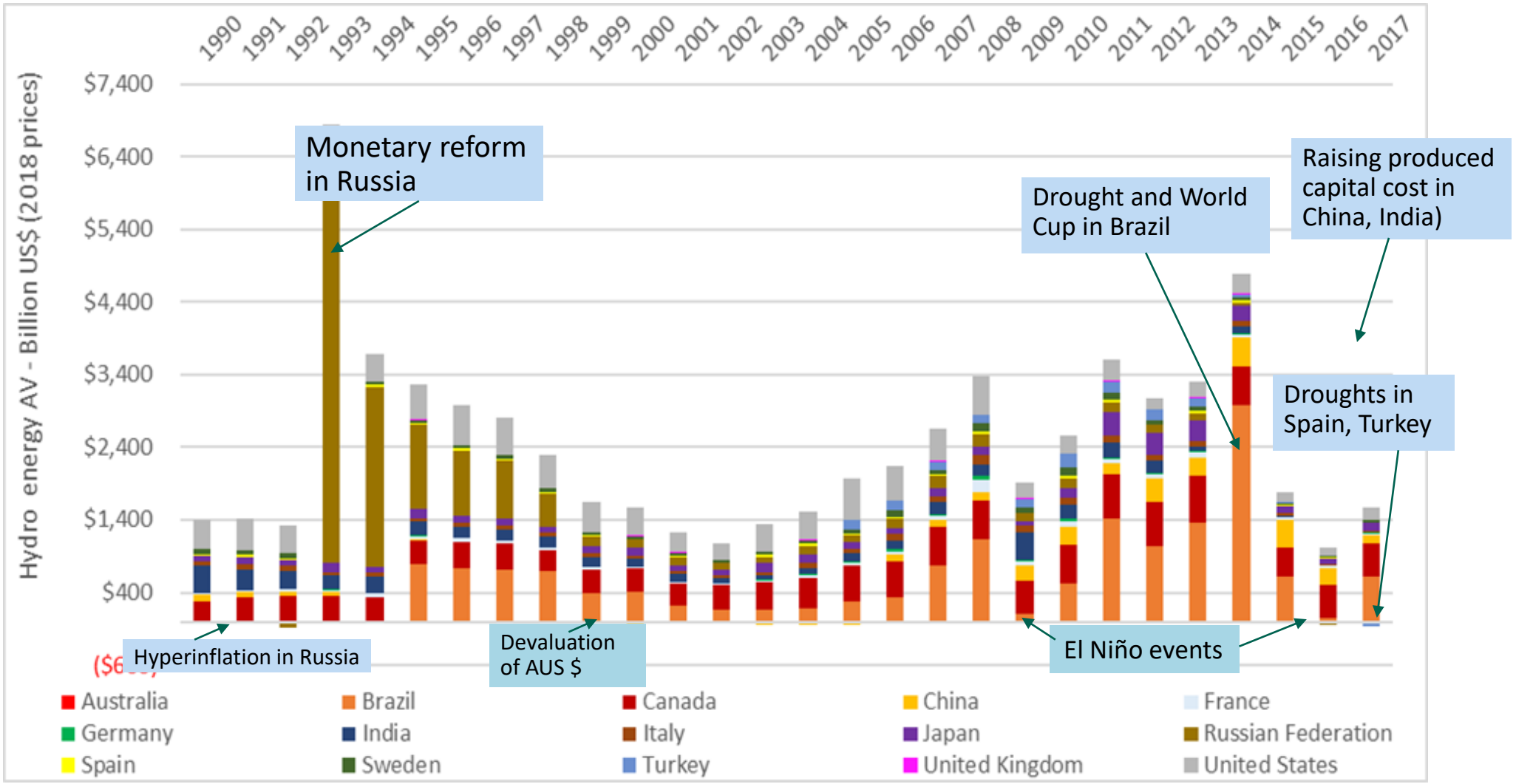
Historical hydro values fit well to the observed variations in electricity prices, generation levels and other market drivers



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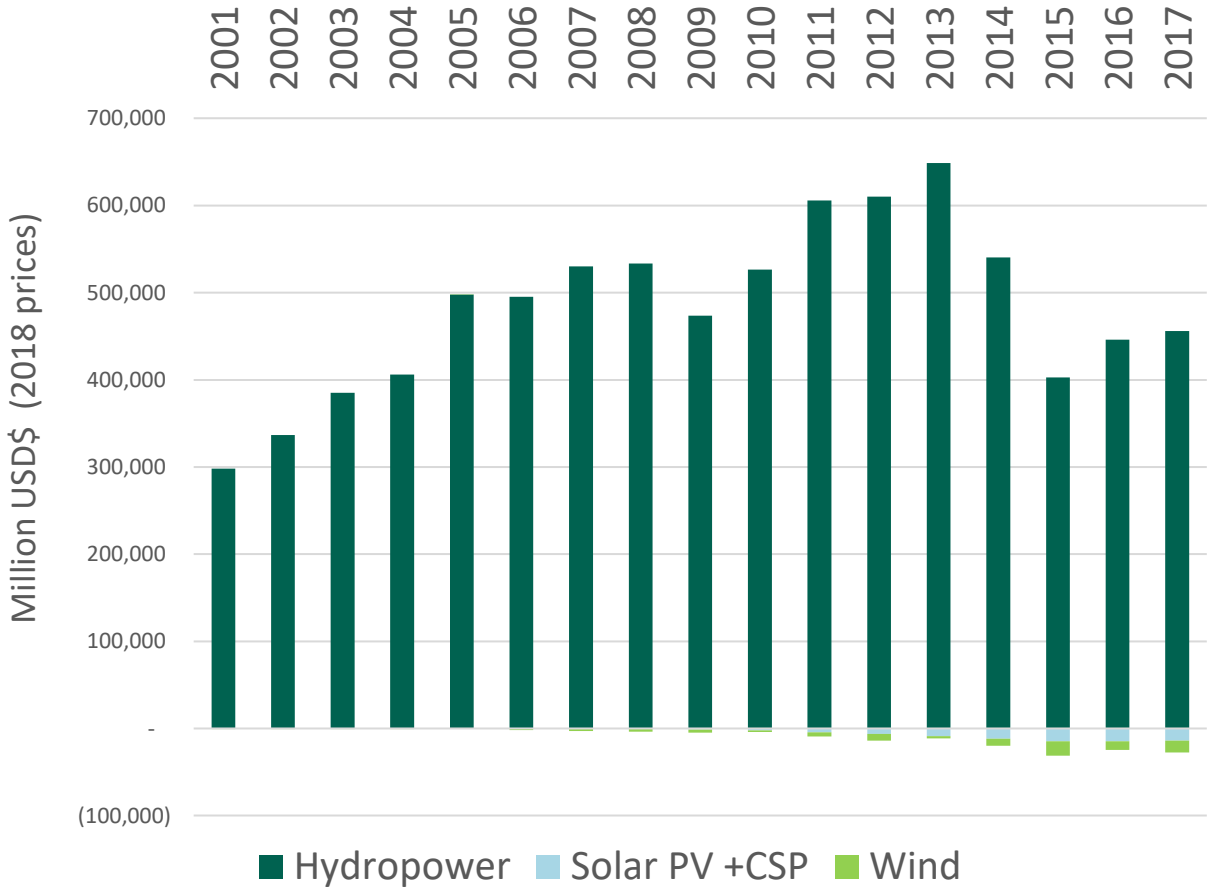
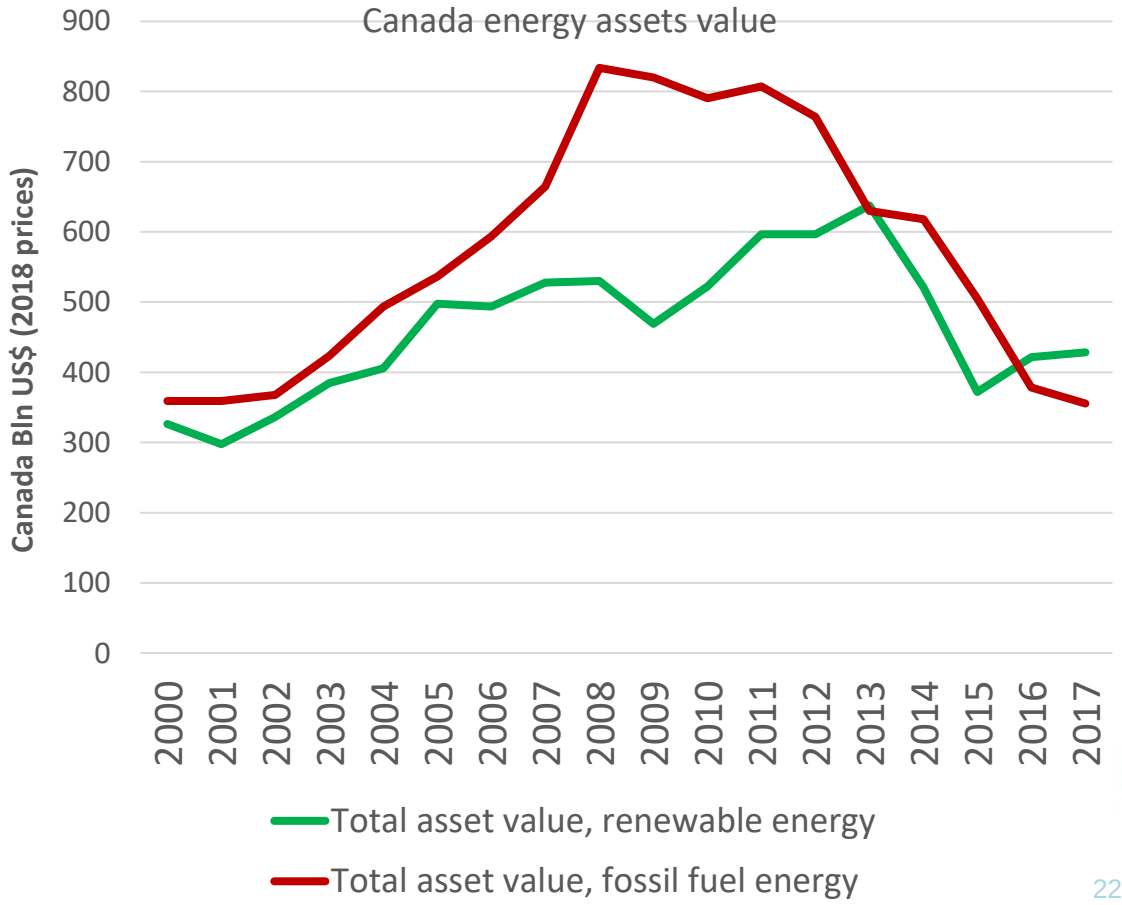
Renewable Energy – still unaccounted wealth of nations with value increasing under low carbon transition

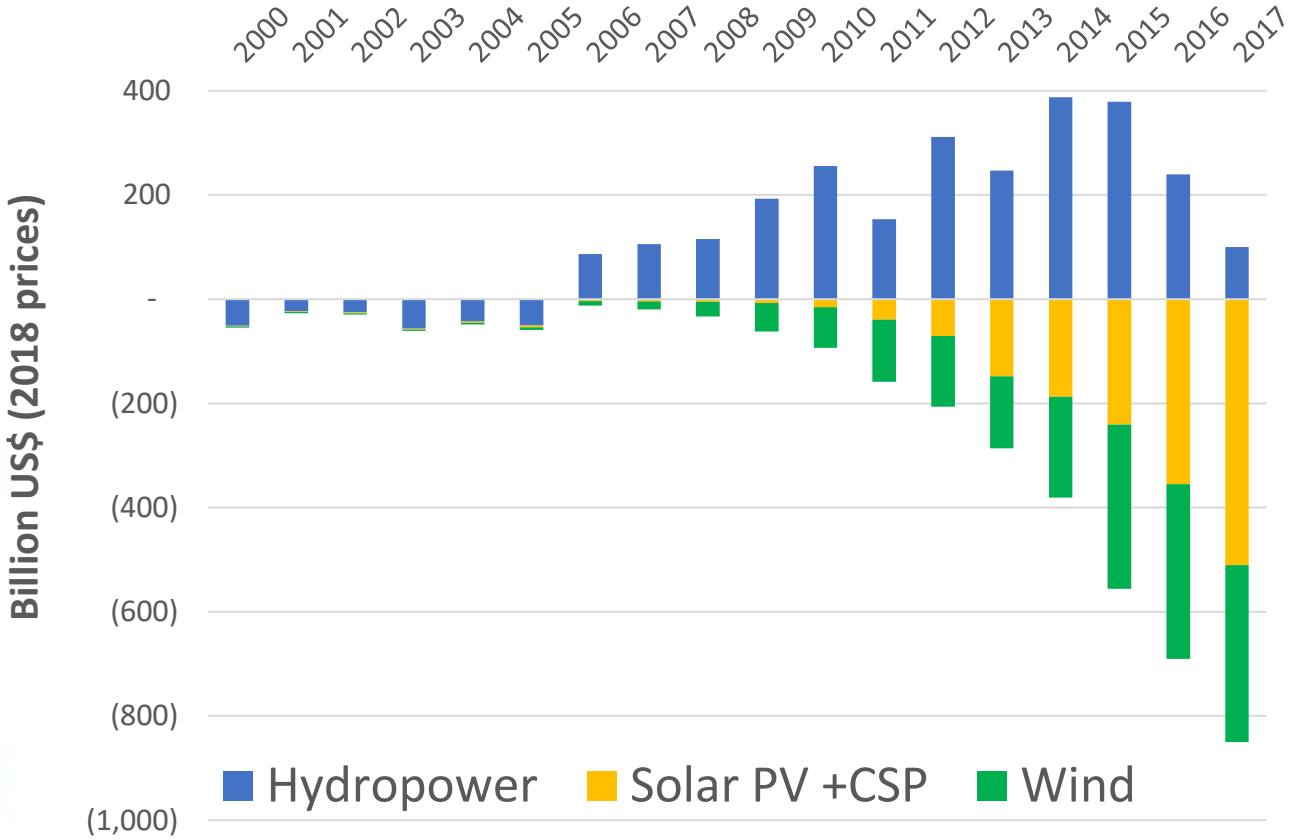
The value of renewable energy assets in Canada 2000-2017

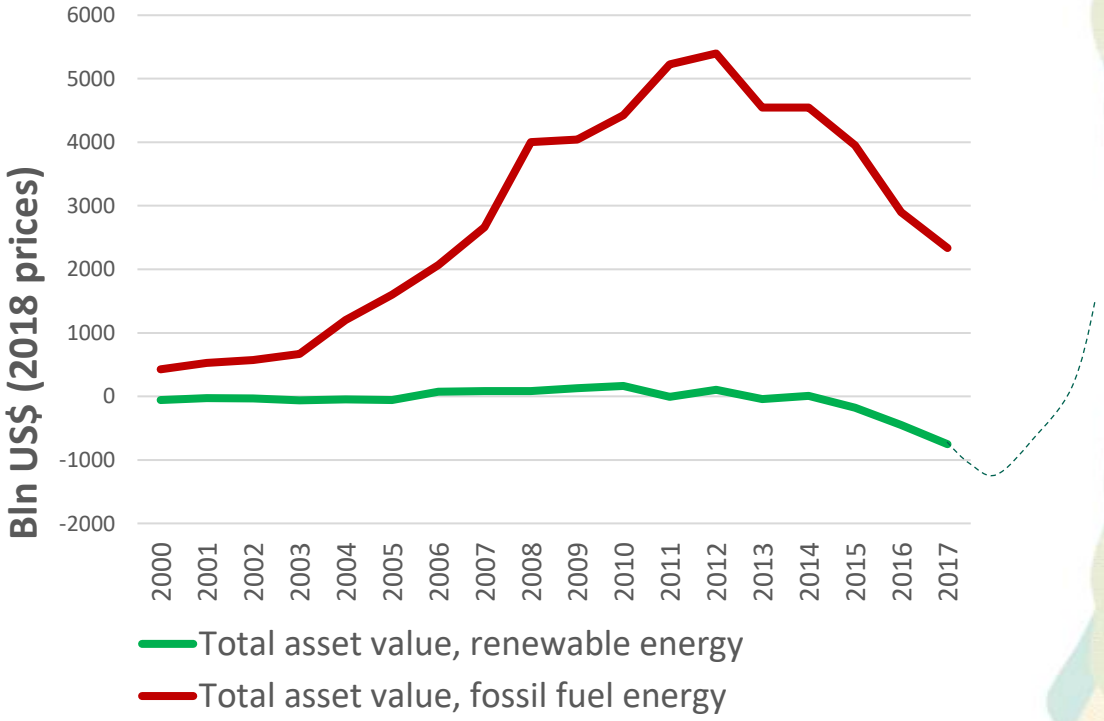




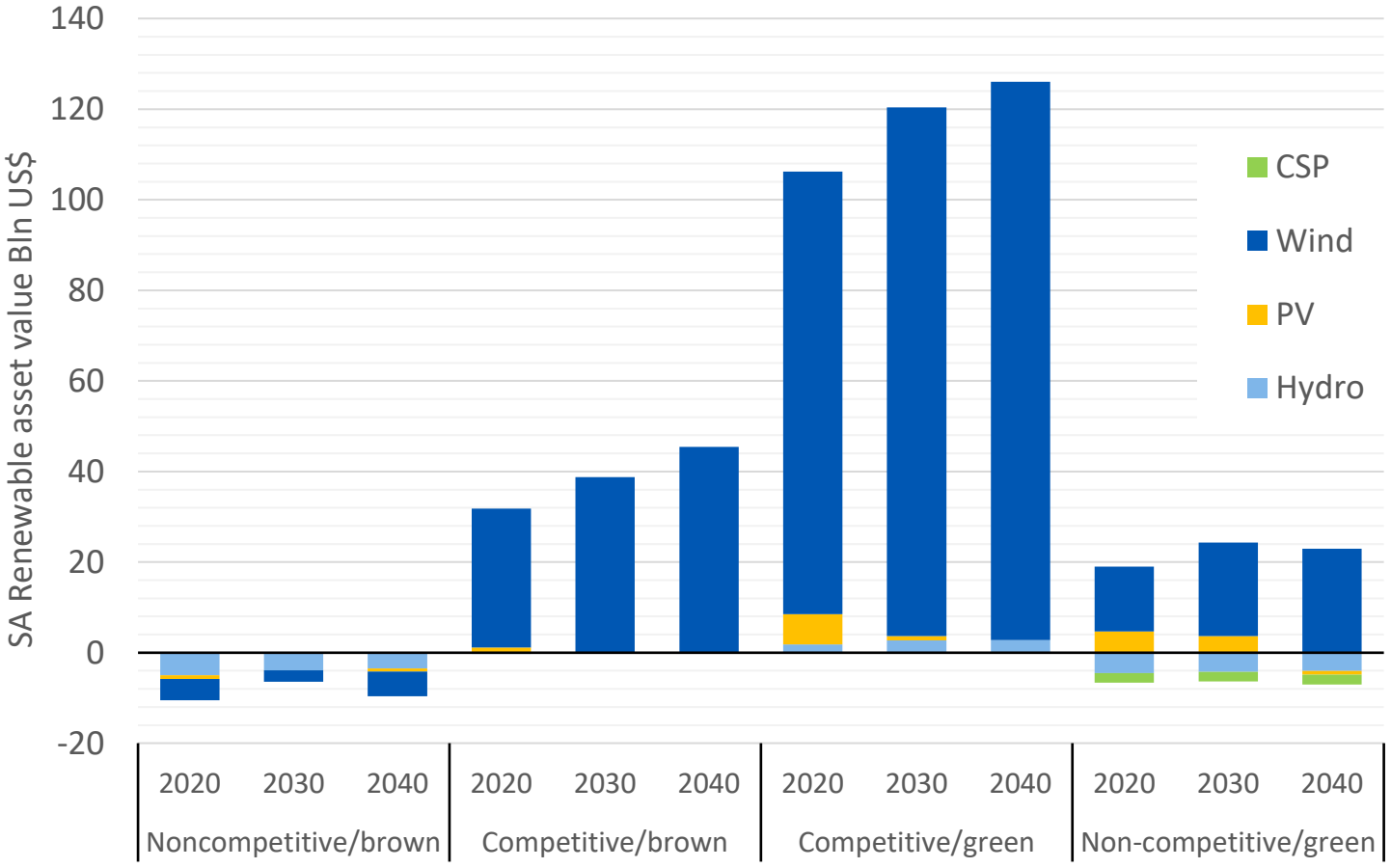
Renewable Energy – still unaccounted wealth of nations with value increasing under low carbon transition

The value of renewable energy assets in China 2000-2017

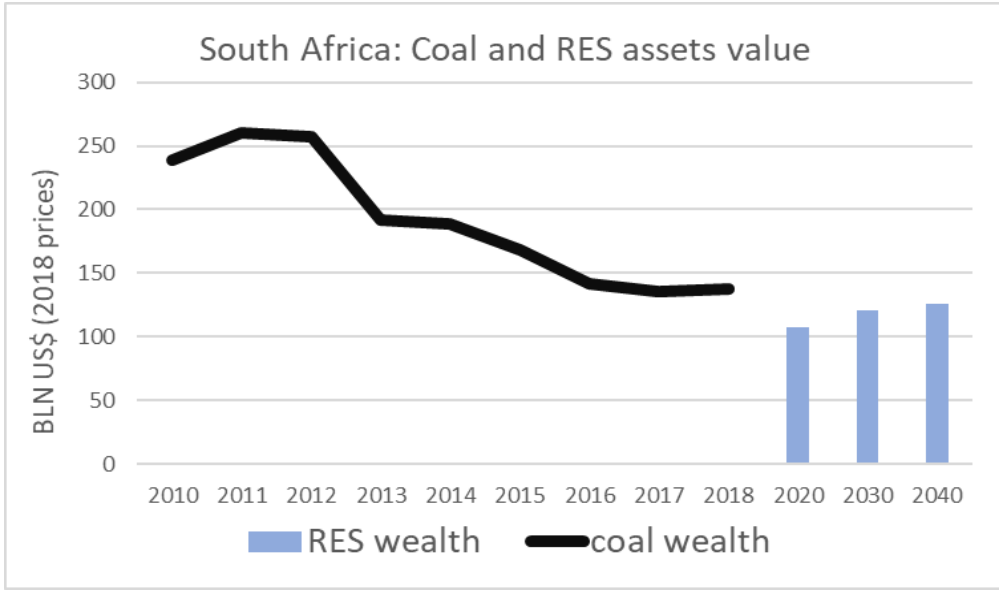




Value of renewable energy assets can increase with efficient market and climate policies: Simulation of future renewable energy asset value in South Africa



Fossil fuel vs. renewable electricity asset values under alternative policy reform scenarios



Competitive scenarios: allow premature retirement of non-competitive thermal power plants
Green scenarios: Carbon pricing

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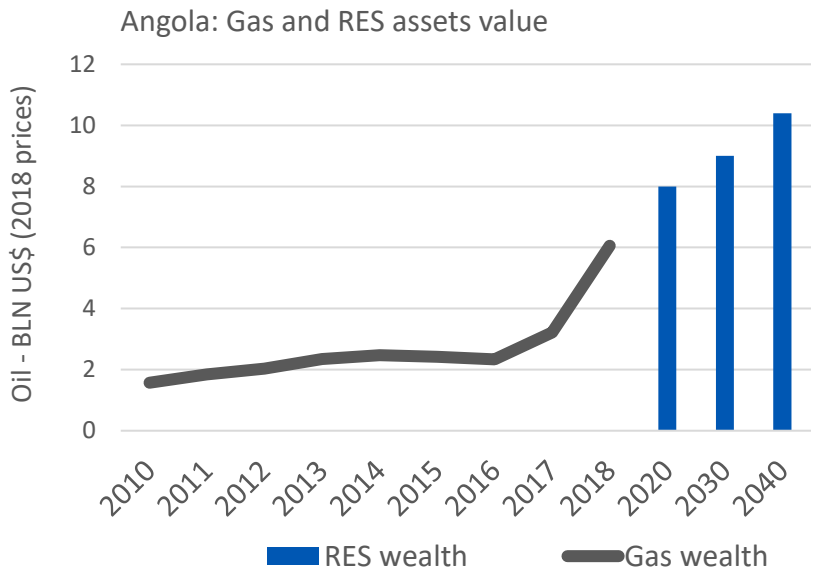
From accounting to policies: Simulations of future renewable energy asset value

Angola

Fossil fuel vs. renewable electricity asset values under alternative policy reform scenarios



Competitive scenarios: allow premature retirement of non-competitive thermal power plants
Green scenarios: Carbon pricing

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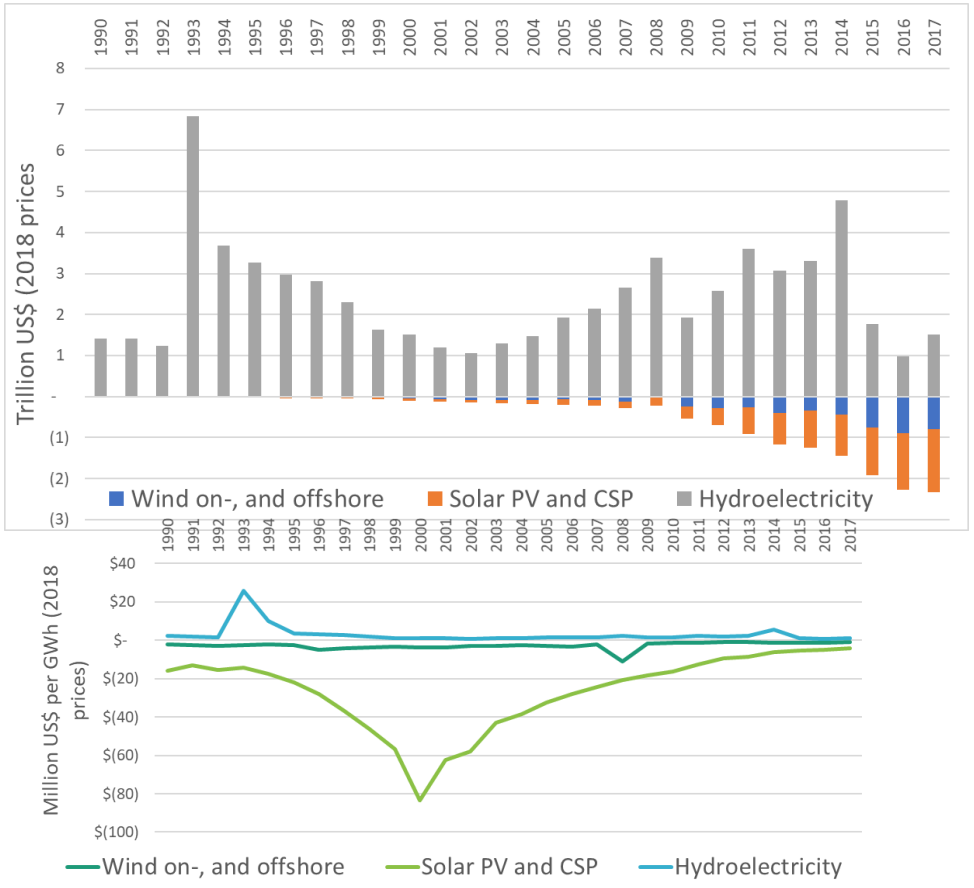
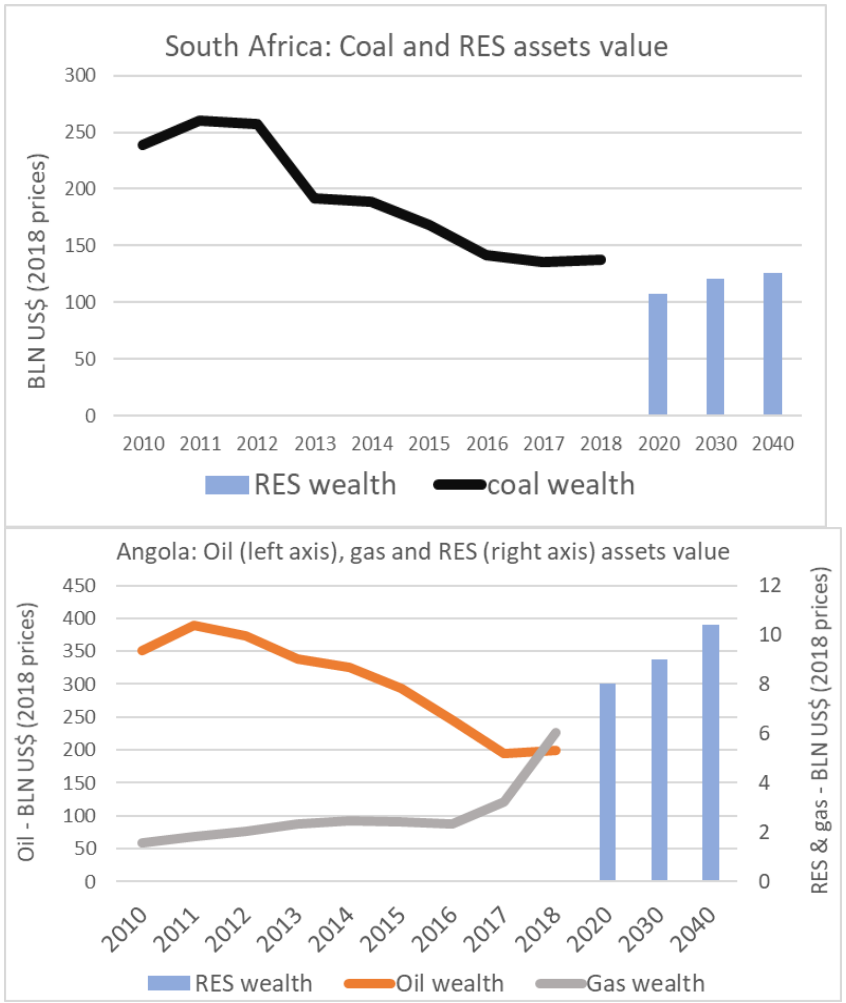
Pillar 1: Example of Renewable energy – from accounting to policies

1.4. Balance sheet



Comparison of fossil fuel with simulated renewable electricity asset values under alternative policy reforms

1.3 Policy



Operations

Informing portfolio of WB SCDs, CPFs, DPOs, EEX projects

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Going forward

- SNA guidance note on accounting for renewable energy resources in the national balance sheets approved as 2025 SNA standard.

- Use this new SNA methodology to extend the pilot accounts from 15 countries (in CWON 2021) to all 145 CWON countries and integrate into core renewable natural capital accounts.

- Enhance the policy use of renewable energy asset accounts, by further analysis how energy, climate and fiscal policies can enhance rent creation from RE assets to match fossil fuel rents (building upon previous collaboration between ENB and EEX EPM modeling team)

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Thank you

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