Understanding long-term decarbonisation processes for China: insights from recently published energy-emissions scenarios

IDDRI side-event

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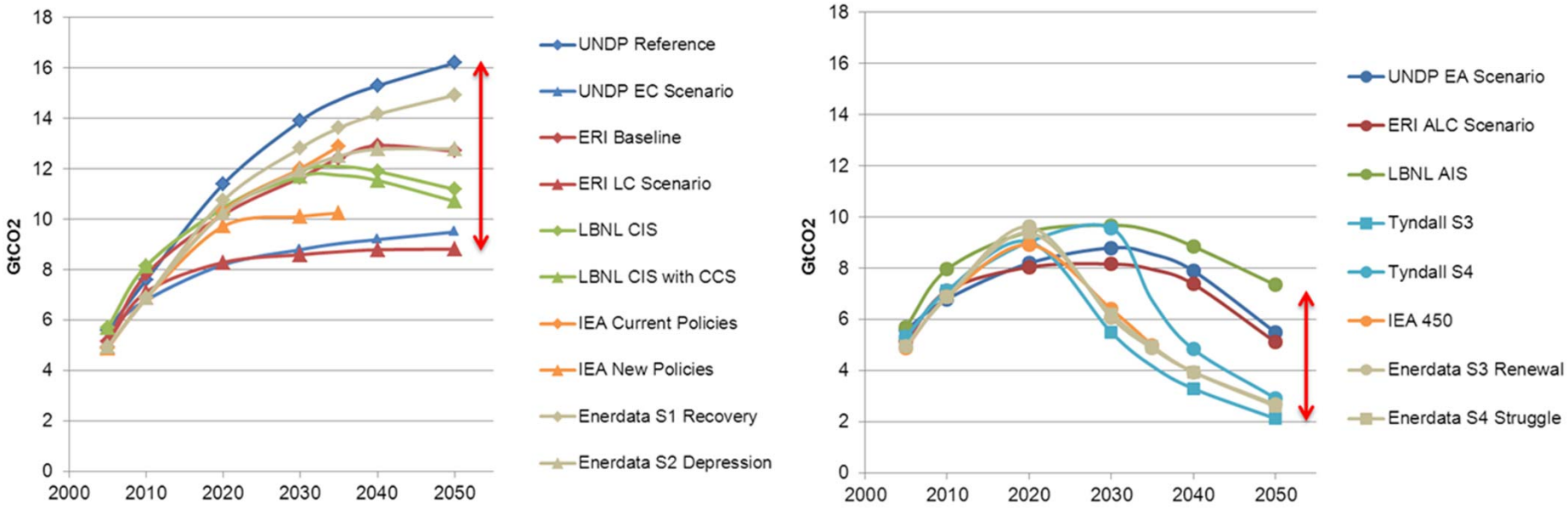
Outline

1. Energy/emissions scenarios to 2050
2. Decomposition method for scenarios comparison
3. Historical emission trends analysis
4. Comparison of existing scenarios at 2050
5. Processes for low-carbon transition in China
6. Key findings for…

Presentation of IDDRI Working Paper:

Bellevrat, E. 2012. Understanding long-term decarbonisation processes for China: insights from recently published energy-emissions scenarios. Working Papers N°XXX/2012, IDDRI. (to be published)

Total emissions projections for China in exisiting "Reference" and "Alternative" scenarios



Uncertainty is wide in existing emissions scenarios for China, and **not easy reading** of them

- What **fundamentals** can explain such different **behaviours**?
- Which lessons can be drawn from an in-depth analysis and comparison?

State of play of existing long-term energy/emissions scenarios for China

Limitations of already published comparison papers (Zheng et al, 2010 and Li and Qi, 2011), which:

- Mainly focus on aggregated figures and results
- Without a clear understanding of the underlying factors

Difficult to draw robust conclusions for policy-making or negotiations purposes from a simple screening of existing scenarios

Difficult to provide comprehensive aspirational visions of where China would/should go in a low-carbon perspective

⇒ Necessity to **develop a post-treatment analysis** to allow comparing the envisioned transition processes for China (from existing scenarios), on an homogenous analytical basis

- **6 forward-looking studies** are analysed
- with **18 scenarios** compared

Original method to compare CO2 emission scenarios on a common and mathematically robust basis

A simple decomposition method for domestic CO2-energy emission variations over time, mixing:

- A **Kaya formula** (represent an aggregated factor) (Kaya, 1989)

$$\mathrm{CO2} = Pop \times \frac{GDP}{Pop} \times \frac{\mathrm{Ene}}{GDP} \times \frac{\mathrm{CO2}}{Ene}$$

- With a **LMDI approach** (logarithmic mean Divisia index byAng et al, 1998)

$$\Delta V_{x_k} = \sum_i \frac{{V_i}^T - {V_i}^0}{\ln {V_i}^T - \ln {V_i}^0} \times \ln\left(\frac{{x_{k,i}}^T}{{x_{k,i}}^0}\right)$$

Resulting in aggregated **decomposition of CO2 emissions** (eliminating any residuals):

$$\Delta CO2 = \sum_k \Delta CO2_{x_k} = \Delta CO2_{Pop} + \Delta CO2_{\frac{GDP}{Pop}} + \Delta CO2_{\frac{Ene}{GDP}} + \Delta CO2_{\frac{CO2}{Ene}}$$

with

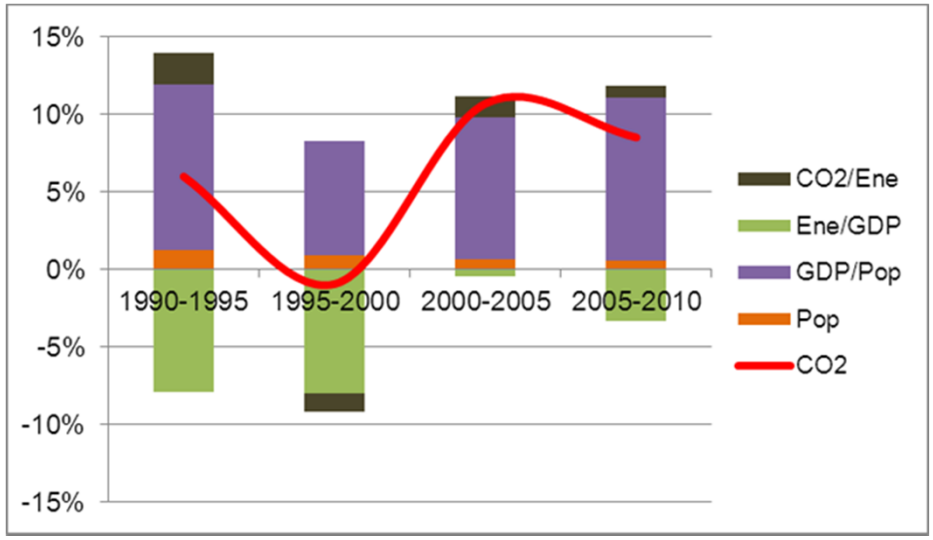
$$\Delta CO2_{x_k} = \frac{CO2^T - CO2^0}{\ln CO2^T - \ln CO2^0} \times \ln\left(\frac{{x_k}^T}{{x_k}^0}\right)$$

A method that could be **further applied with additional dimensions** to assess inter-sectoral/fuel substitutions and add geographical considerations…

Assessment of historical energy-related CO2 emissions for China (validation of the method)

The hectic historical CO2-energy emission variations in China have no trivial explanation!

Averaged annual variations of CO2 emissions and contribution of factors



Pop: Demographic factor
GDP/Pop: Revenue factor
Ene/GDP: Energy intensity factor
CO2/Ene: Carbon content of energies factor

Key factors concomitantly explaining those variations:

- **Economic growth/content**
- **Power sector capacity mix**
- **Energy efficiency P&M**

Issue of statistical data quality…

… even though considered to have improved substantially in recent times

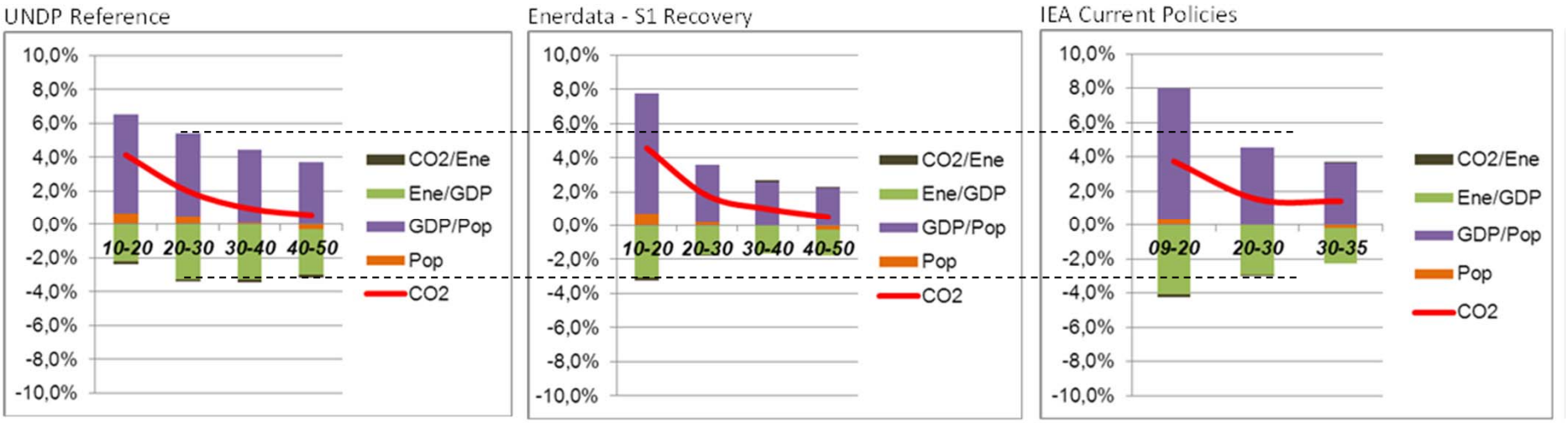
Reference story-lines: the UNDP and Enerdata and IEA "BAU" scenarios

The **most conservative** scenarios could be referred as **BAU**

Similar emission profiles (15-16 GtCO2 in 2050)…

… but **different underlying factors** for CO2 emissions variations

- **Demography** is not (primarily) driving emissions up
- **Energy intensity** improvement is **playing in <u>ALL</u> scenarios**, as historically (i.e. remaining potentials are assumed)



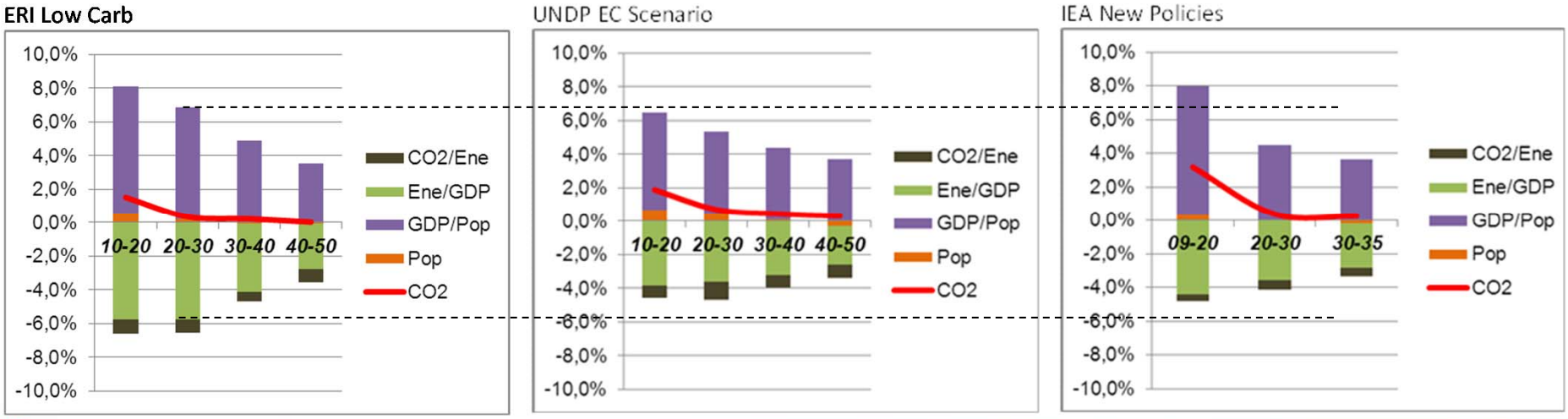
Reference story-lines: the ERI, UNDP and IEA "continuation of current trends" scenarios

The **most optimistic** scenarios, reflecting a **continuation of current efforts**, while not delivering strong signals in the long-term

Similar emission profiles (9 GtCO2 in 2050)… but again **different visions**!

Limited but constant decarbonisation of the Chinese energy mix (<1%/yr)

- **Decreasing returns of energy efficiency** measures in the long-run
- Energy intensity improvement is usually **inversely proportional** to the **economic growth** trends (stock effects)



Common features of decarbonisation processes among scenarios

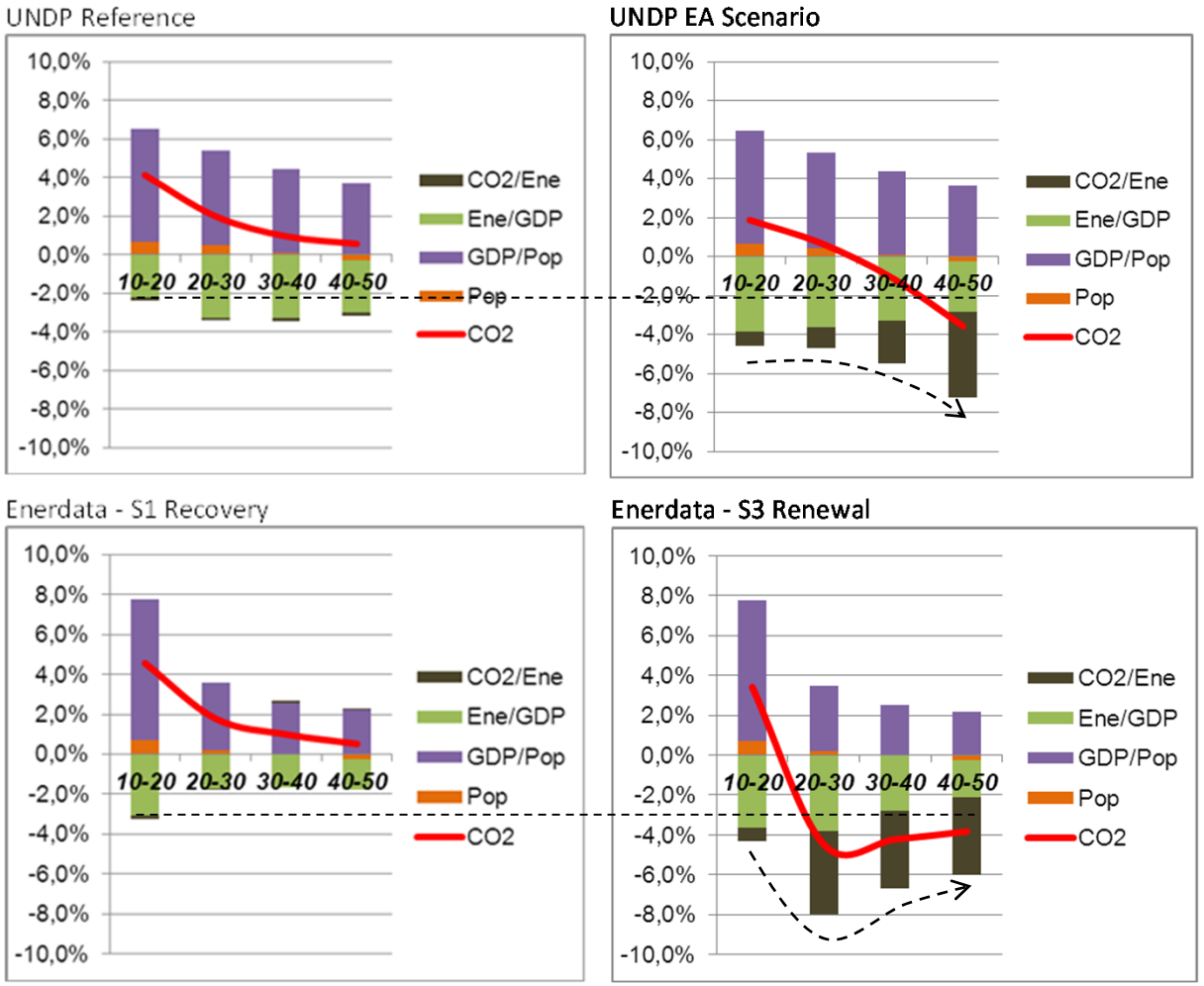
- **Energy efficiency** is an **early mitigation option** in almost all Alternative scenarios

- **Decarbonisation** of the overall energy inputs is a **delayed mitigation option**

… but the **only capable to set the country** on a **low-carbon trajectory** over the long-run

Reference scenarios

Reference scenarios

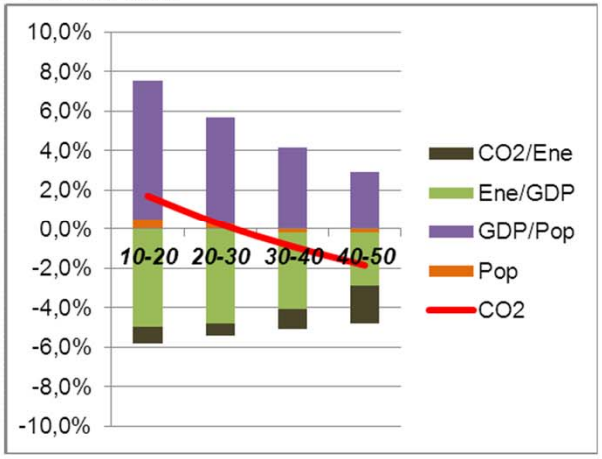


Low-carbon story-lines: the UNDP and ERI "delayed action" scenarios

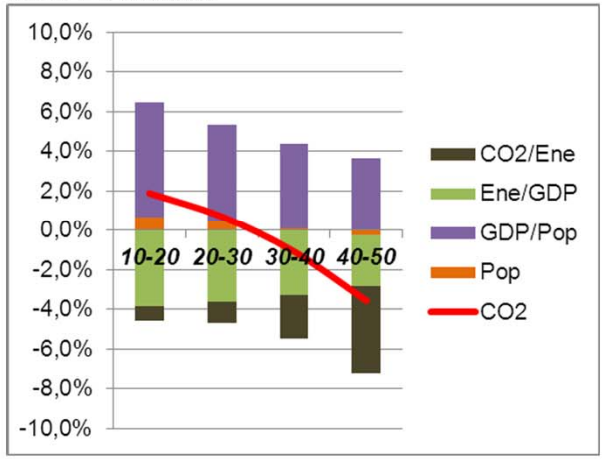
Scenarios reaching around 5 GtCO2 at 2050 (over 7 GtCO2 for LBLN), with **peaking year around 2030**

Delayed action scenarios showing **smooth transition** over time of the decarbonisation factors

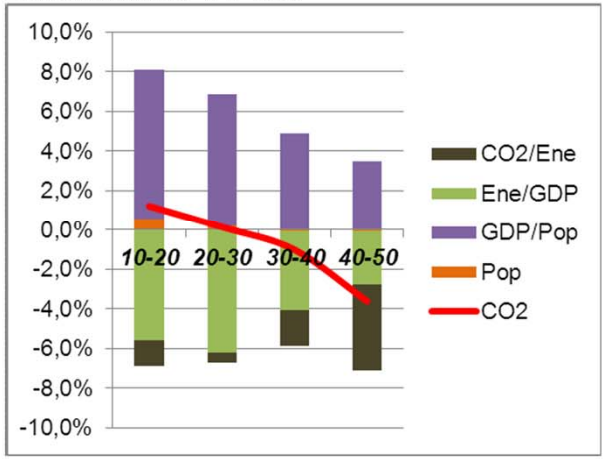
LBLN Low Carb



UNDP EA Scenario



ERI Accelerated Low-carb

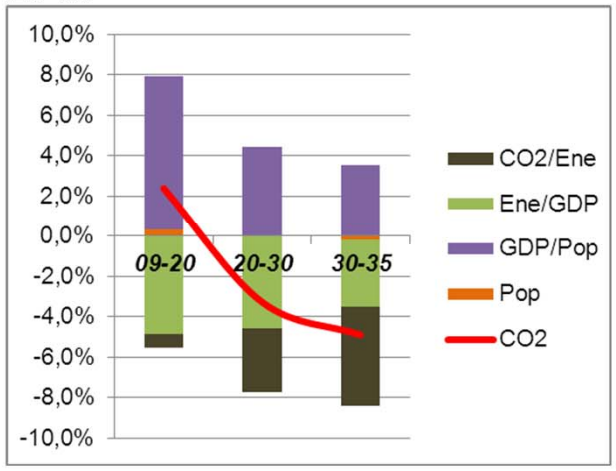


Low-carbon story-lines: the IEA and Enerdata "early action" scenarios

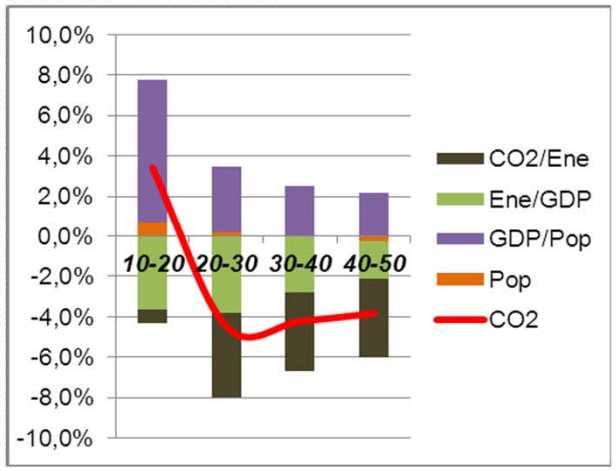
Scenarios reaching around 3 GtCO2 at 2050, with **peaking year around 2020**

Shift in the energy mix supposed to start delivering by 2020, and more or less progressive **decarbonisation** (i.e. different "industrial stories" behind this)

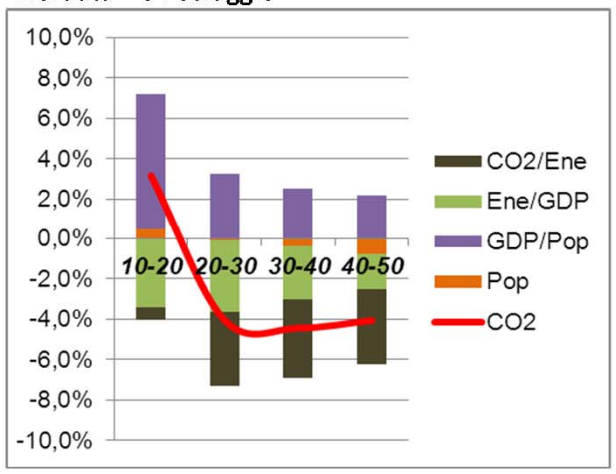
IEA 450



Enerdata - S3 Renewal



Enerdata – S4 Struggle

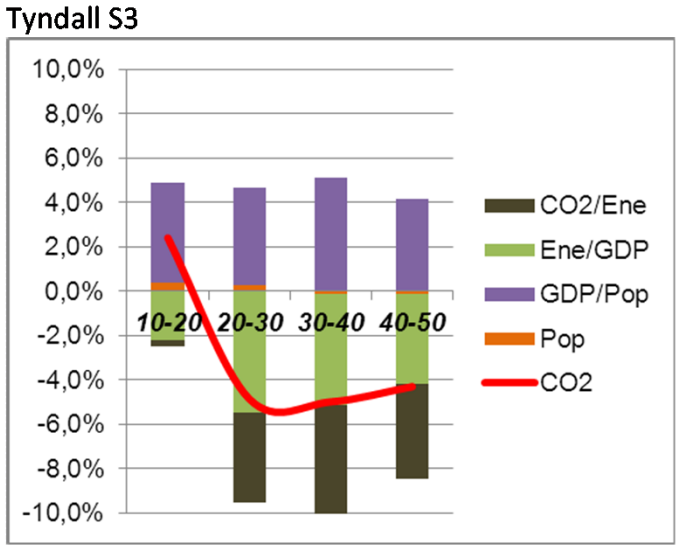


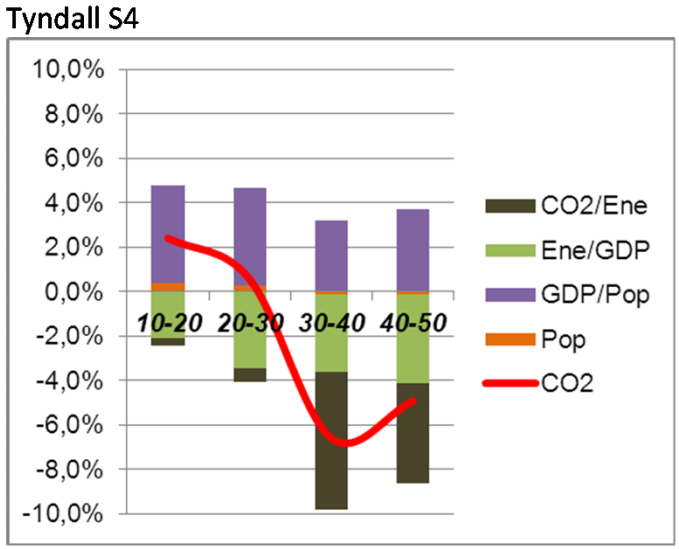
Low-carbon story-lines: the Tyndall "paradigm shift" scenarios

Drastic decarbonisation in both scenarios (2 to 3 GtCO2 at 2050), with **limited but sustained economic growth**

Both describe future **"paradigm shifts"**

- One decade time-lag between the two scenarios: **delayed action requires higher efforts** in the longer-term
- Higher energy intensity potential improvement in S3, due to **different macro-economic backgrounds**





Other lessons: timing of mitigation strategies

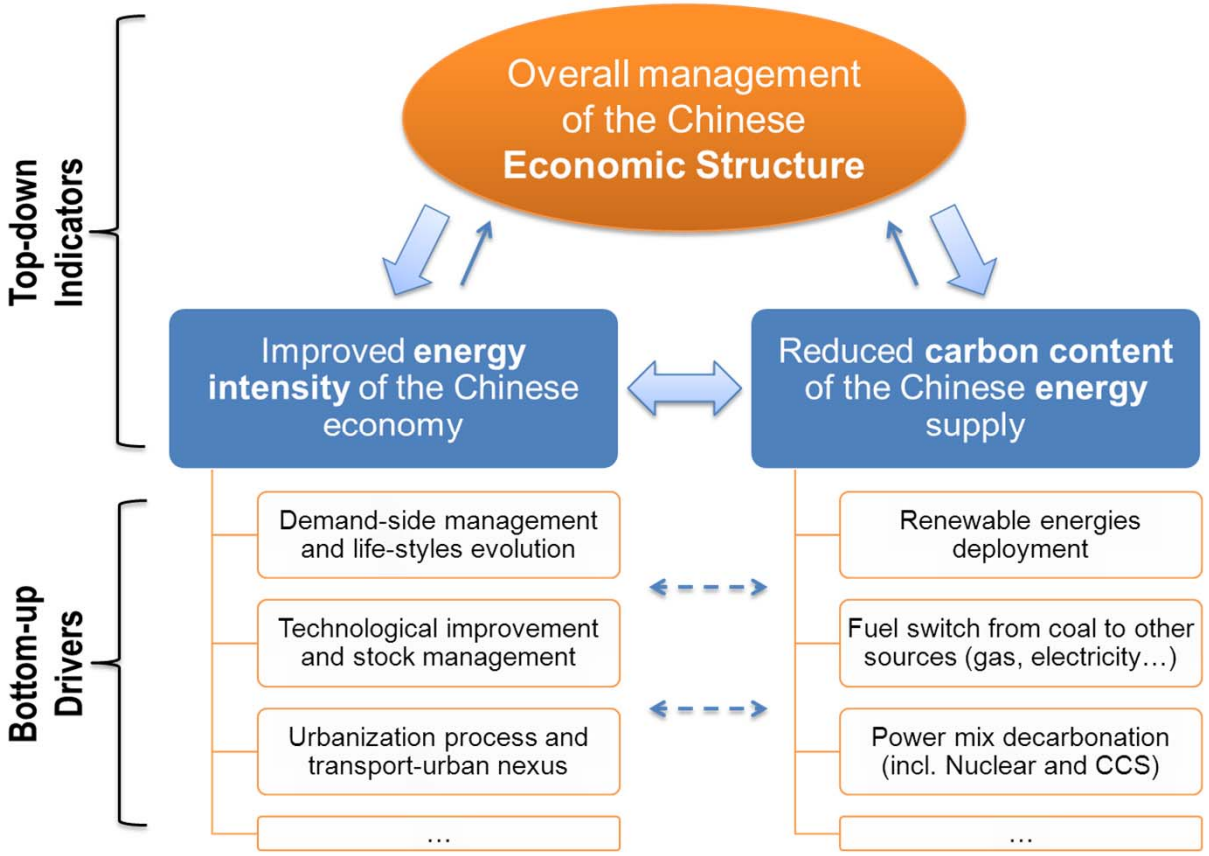
Timing for decarbonisation of the overall energy inputs is key in **the transition process**

- Risks of **lock-in(s) if two delayed action** due to heritage constraints: fixed capital, behaviours etc.
- More **opportunities in a fast growing economy**, but **higher risks for lock-in(s)**
- Higher **path-dependency** in low growth scenarios

A conceptual framework for the transition towards a low-carbon economy in China

- **Structural transformations** of the Chinese economy will act as a **catalyst for the low-carbon** development process

- But still a **lack of macro-economic backgrounds representation** for low-carbon development



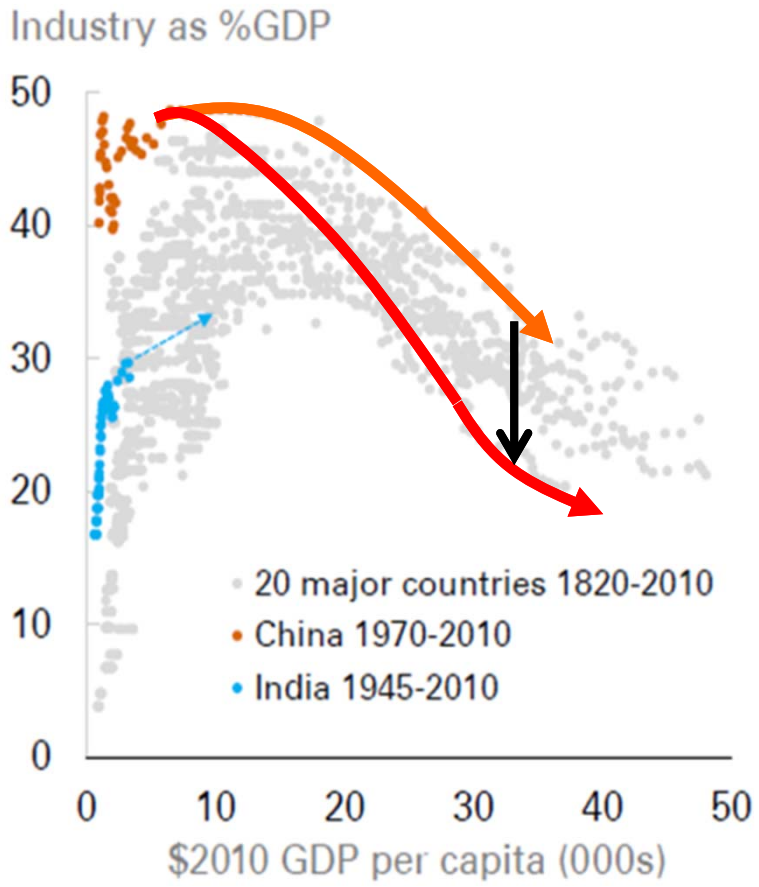
Natural trend vs. accelerated macro-economic transformation for China

- New **economic backgrounds** and models are required for low-carbon development

- Share of industry in GDP in 2050 remains high in most scenarios (33% to 38%)

… except in Tyndall S3 (20%) with an **accelerated macro-economic transformation**

- Factor in the **international context**, to exclude risk of externalizing emissions



Source: BP, 2012

Interlinked levers for the low-carbon transition in China

1. **Enhancing energy efficiency**

   The flagship measure of current and future Chinese policy

   - Incremental technological improvement
   - Energy conservation and "frugal" development

   ⇒ The urbanization process and the urban-transport nexus

2. **Improving the carbon content of energy supply**

   The big shift from the coal paradigm

   - Technical change and radical innovation
   - Fuel switch in final energy consumption

   ⇒ Low-carbon power production mix in the longer-term

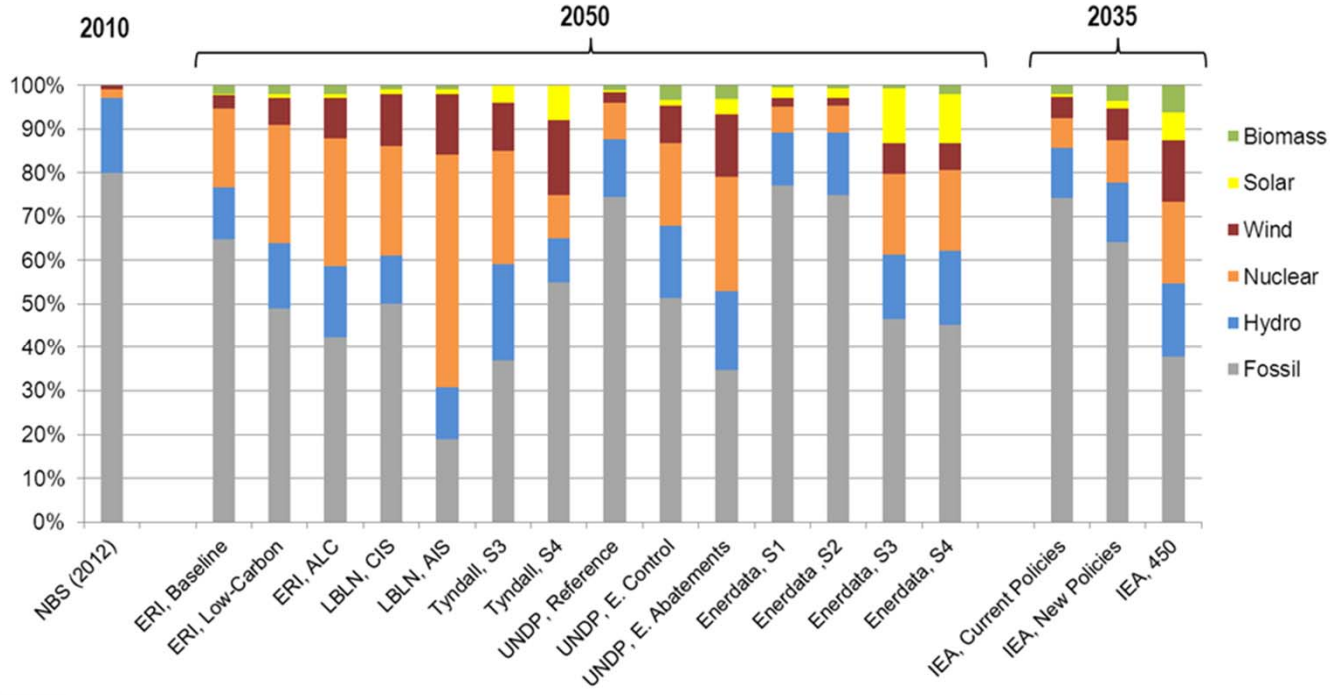
⇒ Interactions between the **"natural" electrification process** observed in most carbon constrained scenarios (i.e. Direct fuel consumption => Second energy carriers) and those two factors for decarbonisation

Key technologies for long-term decarbonisation the Chinese power sector

Renewables may account for 25% to 40% of power generation by 2050, but alone would not allow for a complete post-carbon transition

Most of the studies consider two key technologies: **nuclear and carbon capture and storage (CCS)**, though with much different visions

Power generation outlooks from the compared studies



- Their deployment still relying on the domestic technical potentials
  - industrial capacity
  - geological storage potentials
- These technological routes are not without risks
  (technical, economic, social)

Key findings for… modellers

Further **develop macro-economic narratives** for China, and **reinforce the energy-environment-economy linkage** in a Green Growth perspective

1. Link sectoral forward-looking studies with **consistent macro socio-economic storylines,** compatible with a low-carbon future for China
2. Replace those possible linkages within quantitative approaches, **mixing "bottom-up" and "top-down" assessments**
3. Connect China-focused studies with **international environment storylines**

Key findings for… policy-makers

1. **Know the possibilities** (strengths of the different approaches, complementarity) **and limitations** (domains of validity) of modelling exercises for policy-making purposes
2. **Understand the underlying story-lines**: the main common features and differences among existing scenarios, and their socio-economic implications
3. **Use them** (for what they are) **to establish policy-framework** that would allow setting the country on the desired development trajectory

Key findings for… negotiators

Better understand the **potential of CO2 emissions abatement**, in relation with the Chinese domestic constraints

1. Decipher **already taken commitments** and **existing policies and milestones** with regards to low-carbon development prospects in China
2. Assess the possible **long-term overall emissions trajectory emissions for China** and the related possible **commitments** over the next decades
3. Replace Chinese mitigation potentials **within the global 2°C ambition** and the related "**effort-sharing" among countries**

Learning Platform on Climate Policies

www.learning-platform.org

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