CO_2 emission pathways and socio-economic implications

Drawing from SR15 and our research

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Key concept: Global carbon budget

- Limiting global warming requires limiting the total cumulative global anthropogenic emissions of CO_2 since the preindustrial period, that is, staying within a total carbon budget
- Cumulative emissions from pre-industrial to end 2017: 2200 ± 320 $GtCO_2$
- Remaining budget for 1.5°: ???

Key concept: Global carbon budget

- Large uncertainties all over the place!

SR15, chap.2, table 2.2 (part)

Additional Warming since 2006–2015 [°C]*(1)	Approximate Warming since 1850–1900 [°C]*(1)	Remaining Carbon Budget (Excluding Additional Earth System Feedbacks*(5)) [$GtCO_2$ from 1.1.2018]*(2)			Key Uncertainties and Variations*(4)					
		Percentiles of TCRE *(3)			Earth System Feedbacks *(5)	Non-CO_2 scenario variation *(6)	Non-CO_2 forcing and response uncertainty	TCRE distribution uncertainty *(7)	Historical temperature uncertainty *(1)	Recent emissions uncertainty *(8)
		33rd	*50th*	*67th*	*[$GtCO_2$]*	*[$GtCO_2$]*	*[$GtCO_2$]*	*[$GtCO_2$]*	*[$GtCO_2$]*	*[$GtCO_2$]*
0.3		290	160	80						
0.4		530	350	230						
0.5		770	530	380						
0.53	**~1.5°C**	**840**	**580**	**420**	Budgets on the left are reduced by about –100 on centennial time scales	±250	–400 to +200	+100 to +200	±250	±20
0.6		1010	710	530						
0.63		1080	770	570						

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Key concept: Global carbon budget

- Let us assume: remaining carbon budget for 1.5° = 420 $GtCO_2$
- Current emissions are approx. 42 ± 3 $GtCO_2$ (incl. LULUCF)
- **So 10 years left!**

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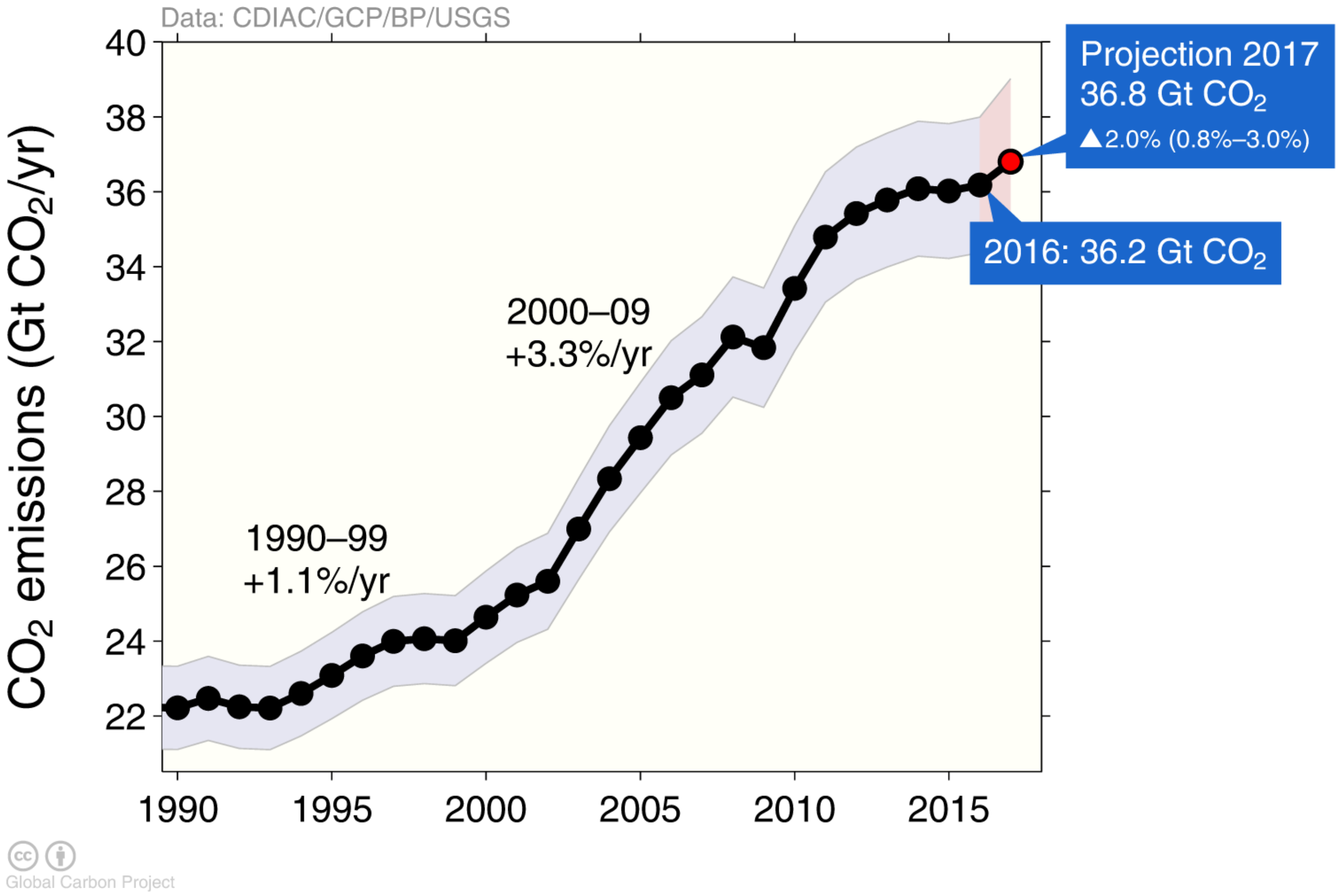
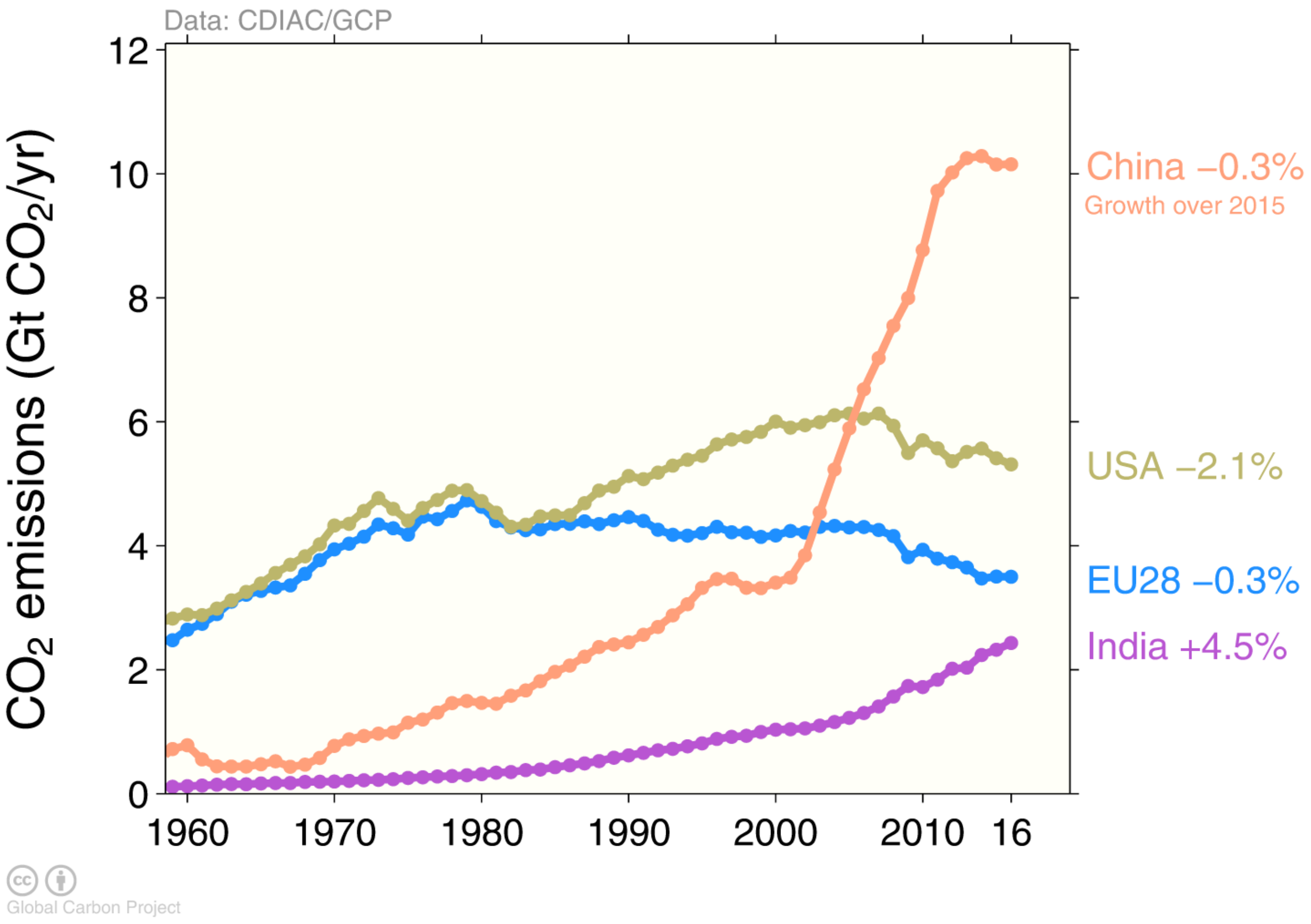
How many years to deplete the budget?

- 10 years left!
- More, if emissions decrease gradually
- Less, if emissions keep rising
- More, if 'negative emissions' are possible



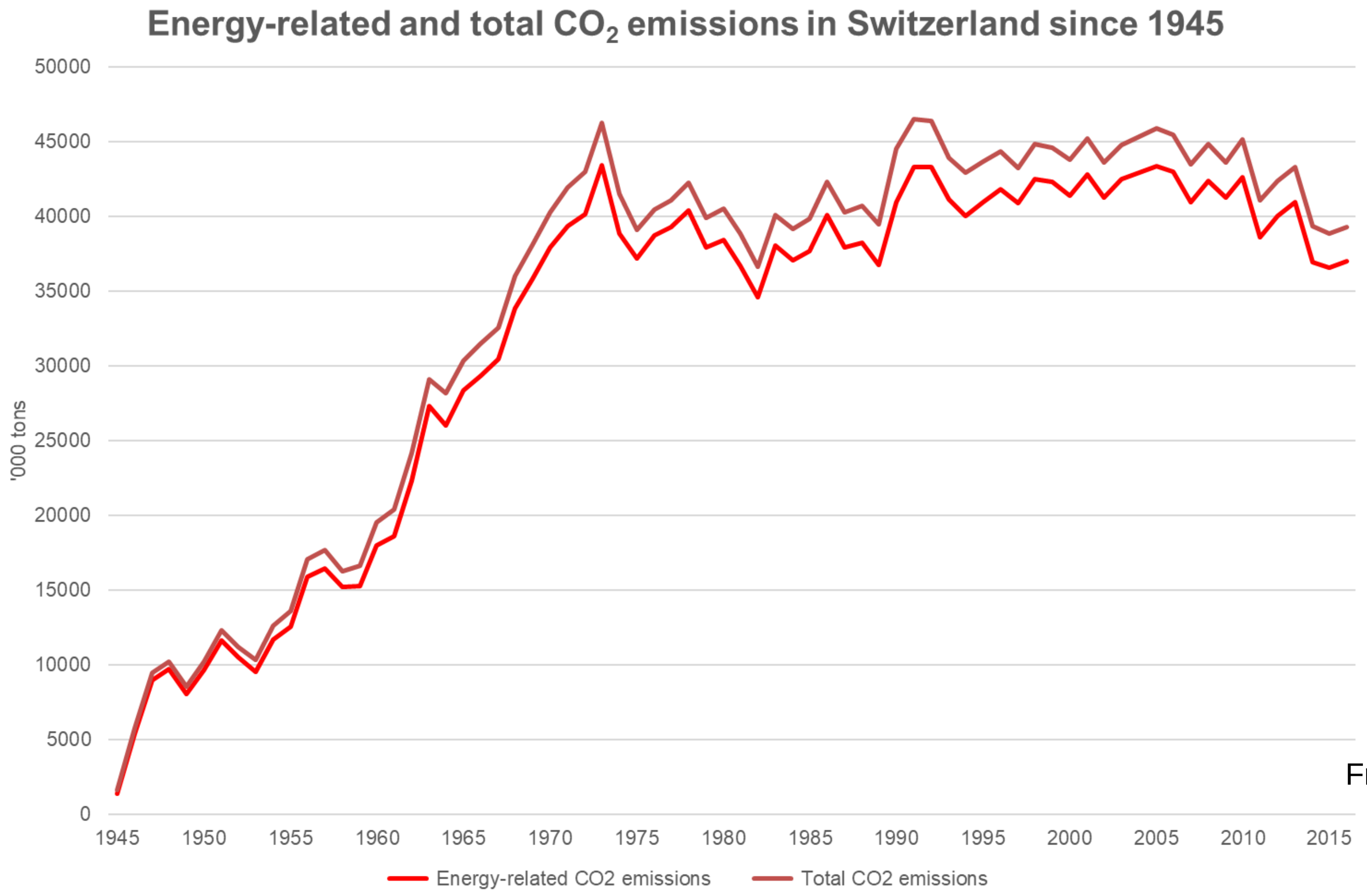
Global Carbon Project. (2017). Supplemental data of Global Carbon Budget 2017 (Version 1.0) [Data set]. Global Carbon Project. https://doi.org/10.18160/gcp-2017

Emissions are declining in some regions



Global Carbon Project. (2017). Supplemental data of Global Carbon Budget 2017 (Version 1.0) [Data set]. Global Carbon Project. https://doi.org/10.18160/gcp-2017

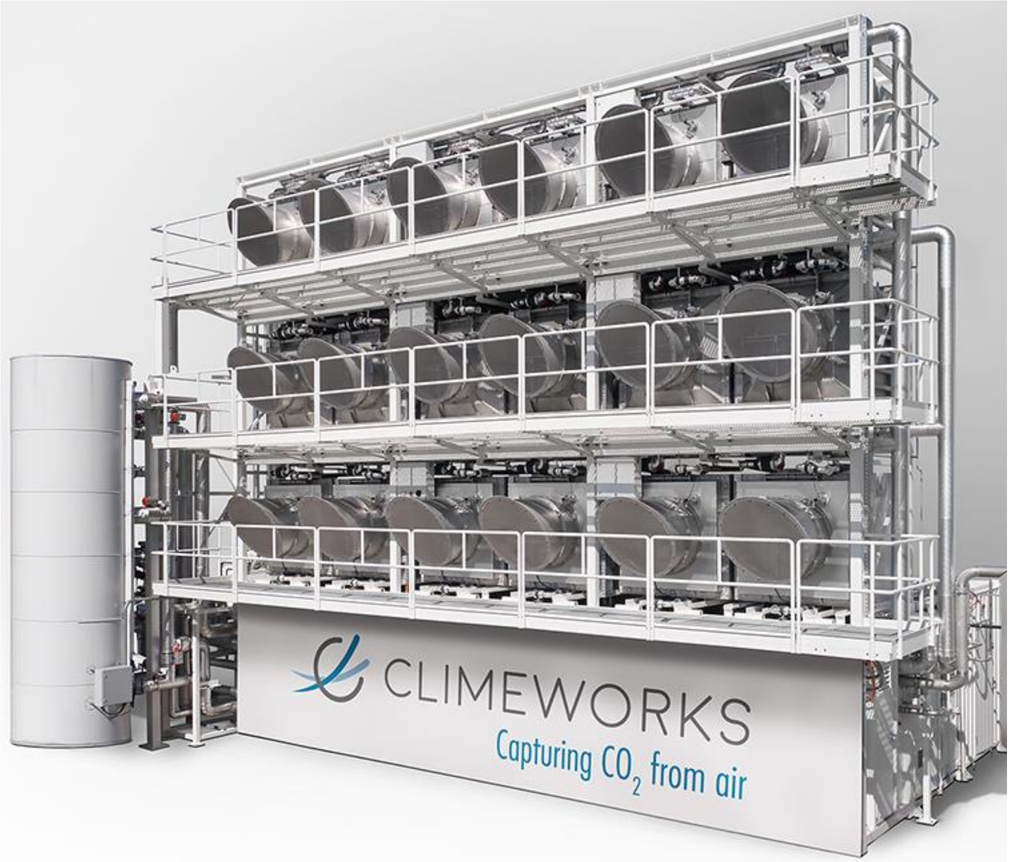
Emissions are declining in Switzerland but very slowly



From Fed. off. env. data

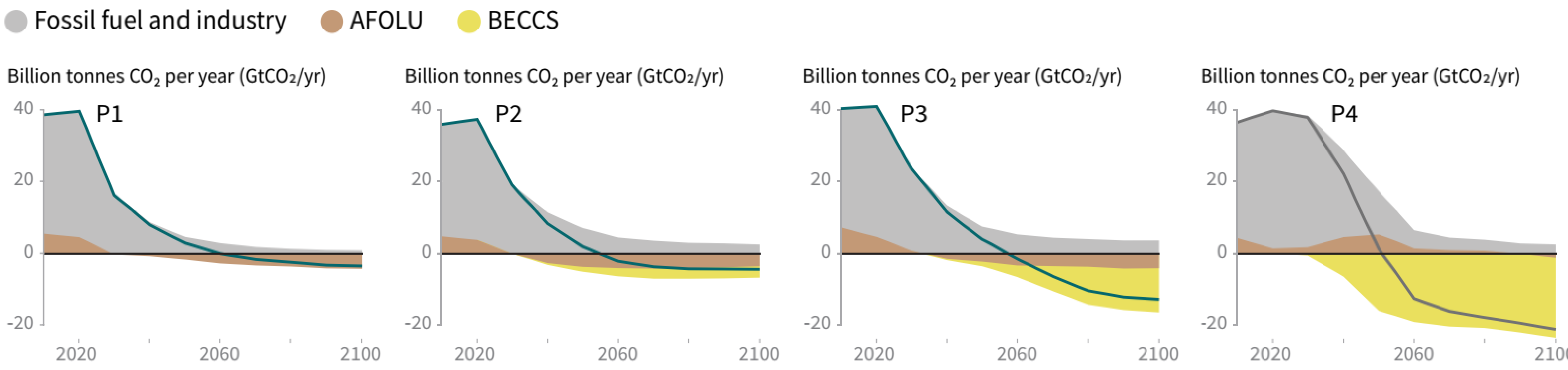
Pathways compatible with global budget

- Delaying peak emissions reduction will require steeper reduction to zero (budget is quickly depleted)
- The possibility of withdrawing CO_2 from the atmosphere would help ('negative emissions'):
  - BECC: biomass use for energy production with carbon capture and storage
  - Afforestation
  - Direct air withdrawal



Pathways compatible with global budget

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

SR15, SPM fig. 3b

All pathways require rapid and profound transformations

- Net CO_2 emissions = 0 around 2050
- Transformation of energy use: deep electrification and energy efficiency improvements in buildings, mobility, industry
- Transformation of electricity generation: mostly renewables (70-85% in 2050), no more coal
- Profound changes in land use, depending on scenario
- Nothing unheard of, even a speed of transformation that is known, but the scale is new

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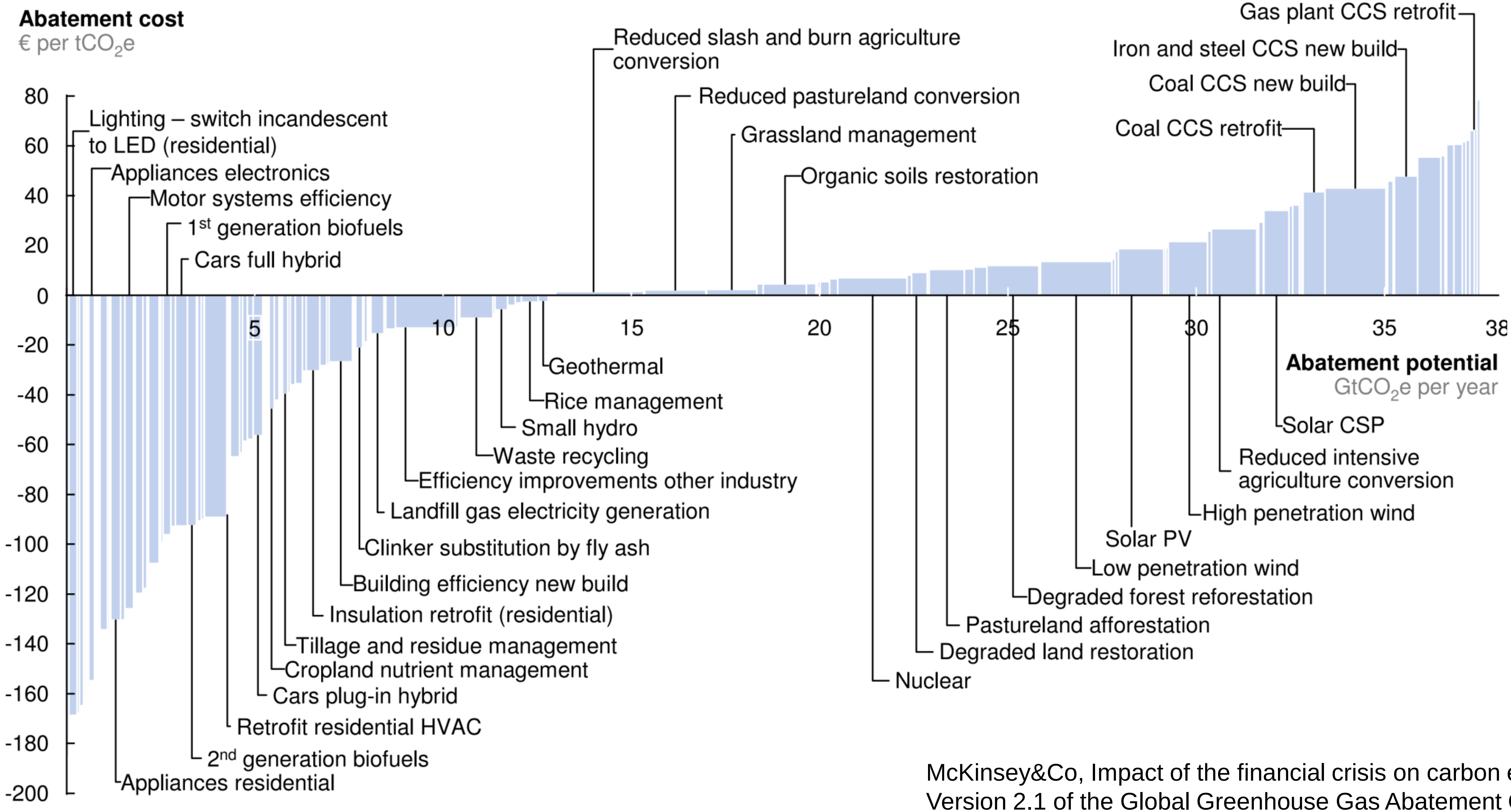
What would it cost?

- No estimates of total costs in SR15, only marginal costs
- These are very high, 3-4× higher than for +2°
- Marginal costs do not mean much when the cost curve gets very steep
- A lot of measures are costless or generate greater external benefits than private costs (clean air, clean water, clean soils)

What would it cost?



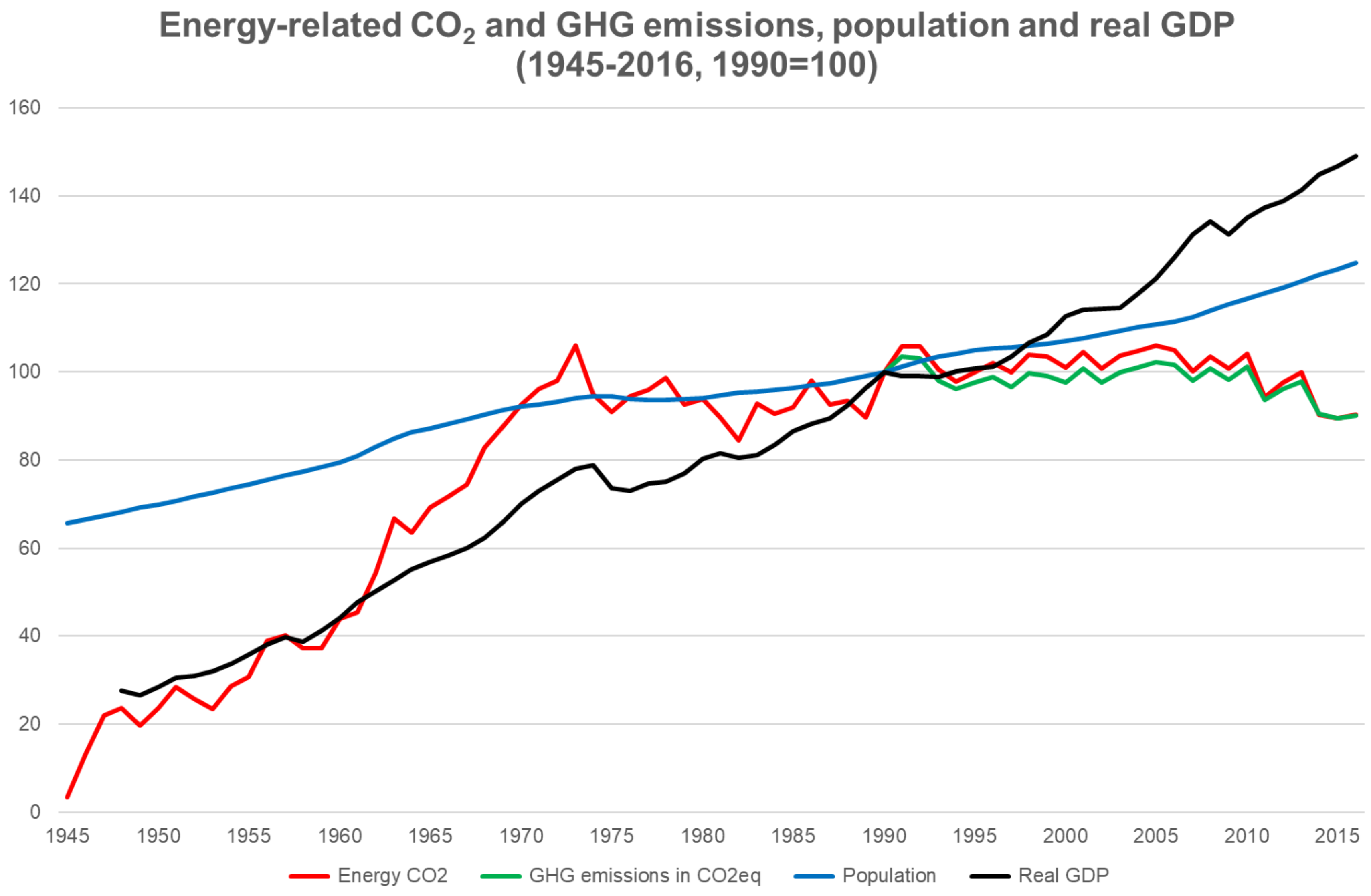
McKinsey&Co, Impact of the financial crisis on carbon economics. Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve, 2010

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: Global GHG Abatement Cost Curve v2.1

What was achieved in Switzerland?

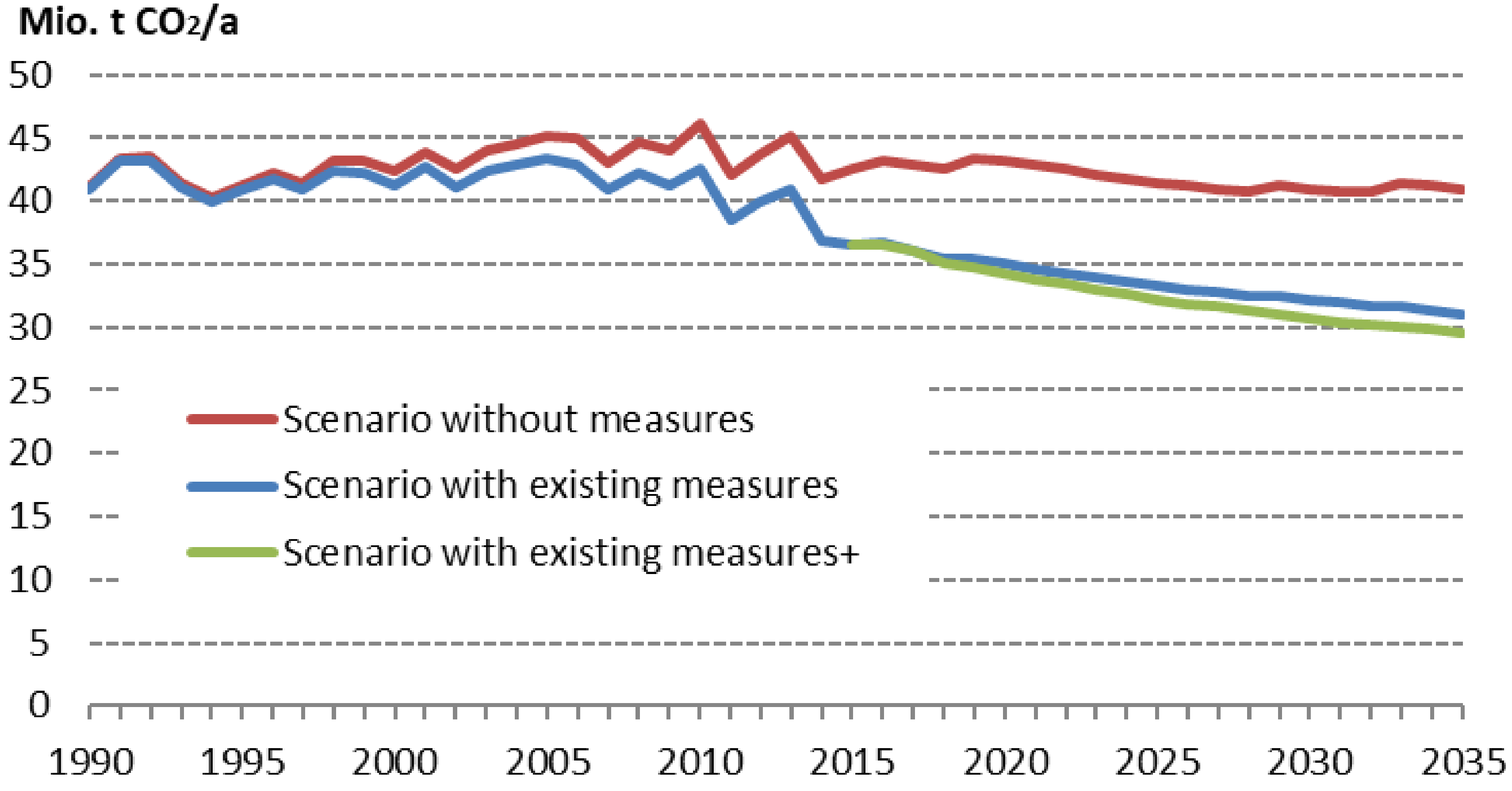
Decoupling after first oil-price shock (1973)
Many causes, among which the shift from domestic production to imports of industrial goods



From Fed. off. env. and Fed. off. of statistics data

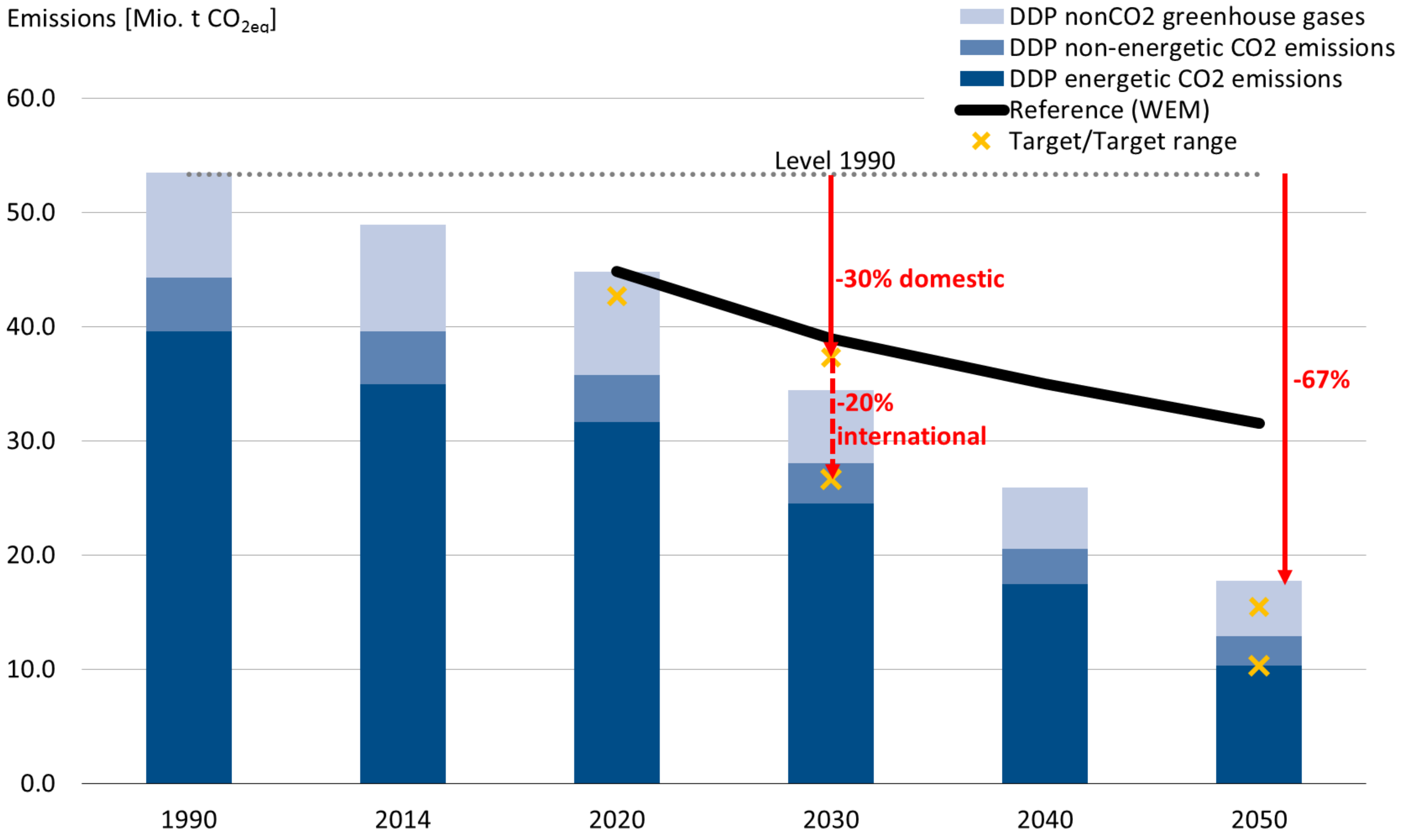
How much is attributable to policy?

Energy-related CO_2 emissions in a scenario without measures and two scenarios with existing and announced measures (1990-2035)



Vielle, Marc, and Philippe Thalmann, "Updated emissions scenarios without measures, 1990-2035", Report for Federal Office for the Environment, Lausanne, 12 October 2017

Deep decarbonisation pathways



Schäppi, Bettina, Alexander Wunderlich, Jürg Füssler (INFRAS), Marc Vielle, Philippe Thalmann (EPFL), "Pathways to deep decarbonisation – Results of a modelling exercise", Report for Federal Office for the Environment (FOEN), Zürich and Lausanne, 20.12.2016

How to get there

	2020	2030	2040	2050
CO_2 tax (CHF_{2013}/tCO_2)	177			
Price of CO_2 certificats (CHF_{2013}/tCO_2)	82			
Tax on gasoline and diesel (CHF_{2013}/l)	0.05			
Same CO_2 tax on all fossils (CHF_{2013}/tCO_2)		88	189	511
Social cost (% household consumption, relative to reference scenario)		0.11	0.42	0.78

Vielle, M., B. Schäppi, P. Thalmann, J. Füssler, "Simulations of proposed deep decarbonisation pathways – Phase 2: A contribution to Switzerland decarbonisation pathways", Report for Federal Office for the Environment (FOEN), Lausanne and Zürich, 20.12.2016, Scenario with induced technical progress (CCS is allowed but hardly used)

511 CHF/tCO_2 with emissions of 1 tCO_2 on average per inhabitant in 2050 is comparable to 128 CHF/tCO_2 for current emissions of 4 tons per inhabitant

511 CHF/tCO_2 amount to 1.35 CHF/litre heating oil, which are added to the expected pre-CO_2-tax price of 1.40 CHF/litre in 2050

For instance in house heating

Mean annual rate of change per decade

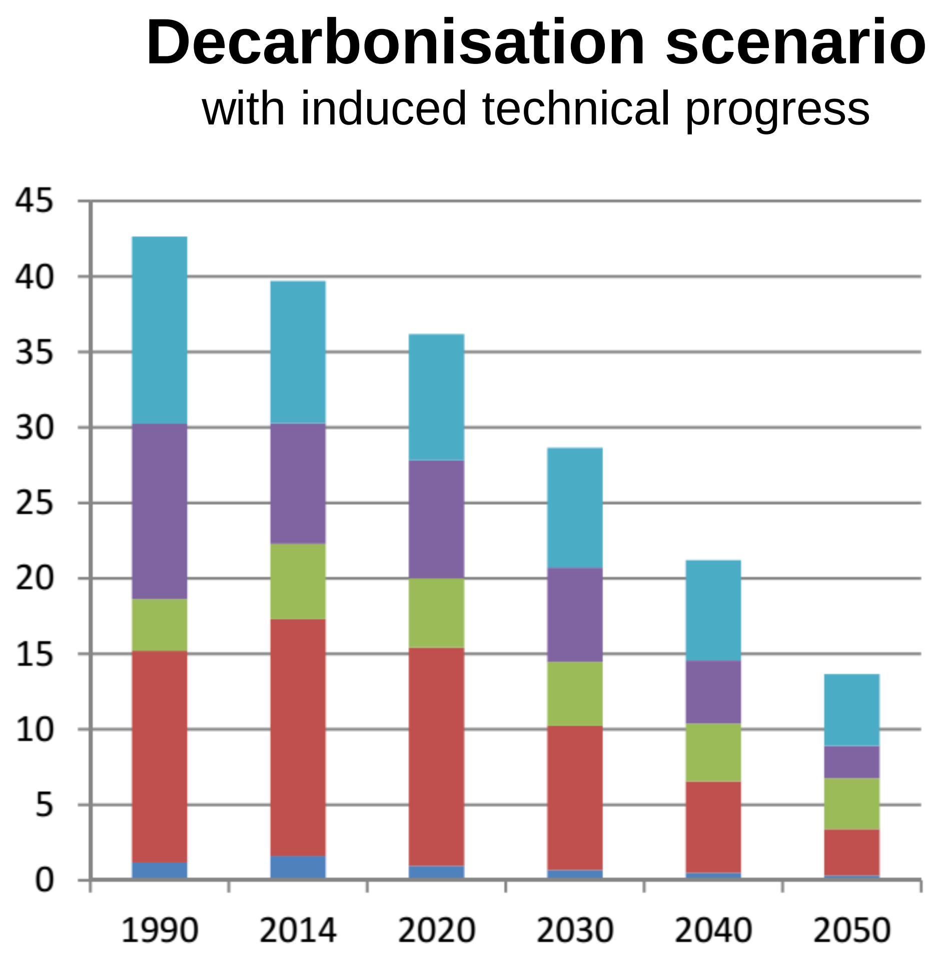
Decarbonisation scenario with induced technical change

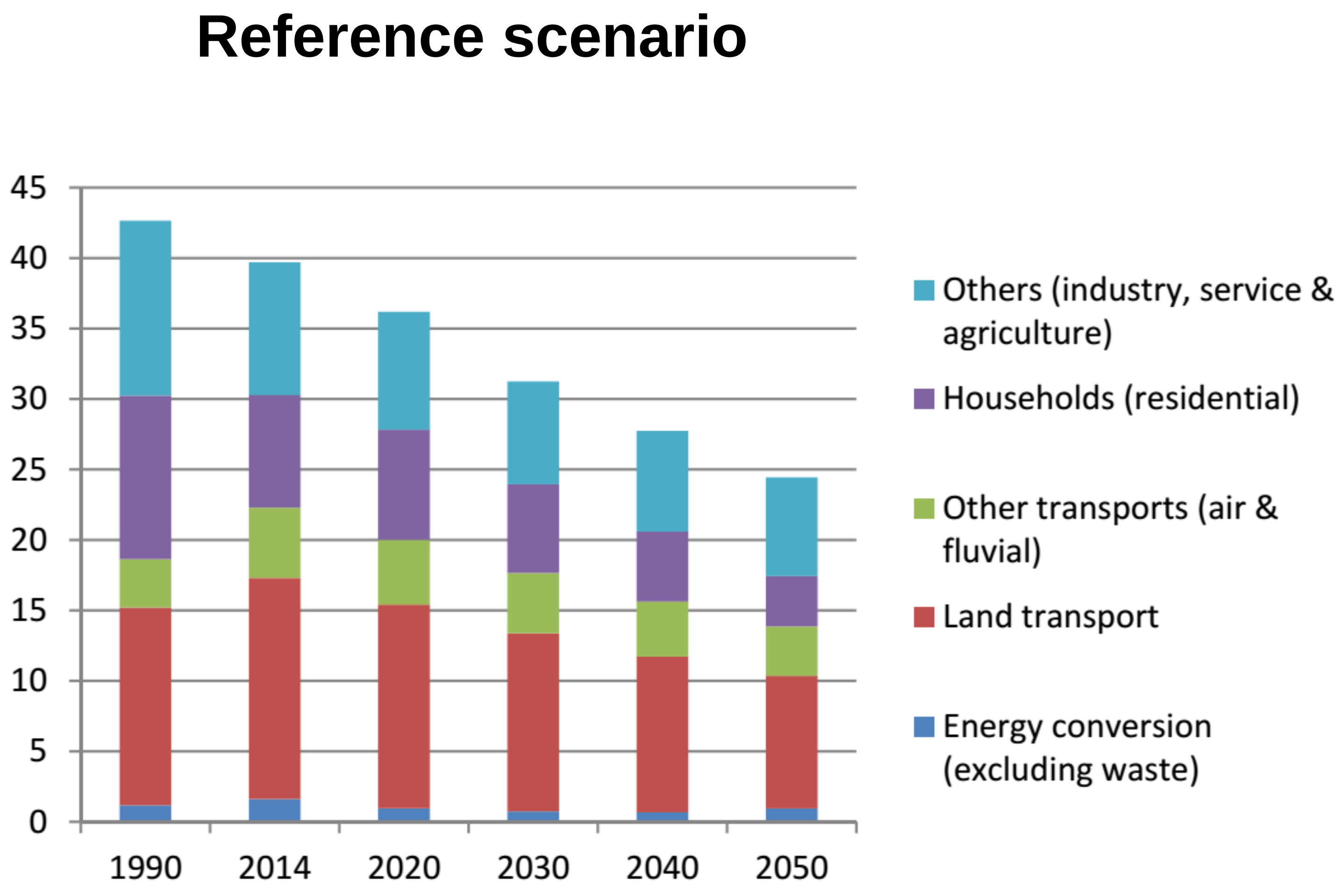
	2010-2020	2020-2030	2030-2040	2040-2050
Heated surface	+1.5%	+1.1%	+0.7%	+0.6%
Energy intensity	-3.7%	-2.7%	-3.3%	-3.5%
Carbon intensity	-0.0%	-0.6%	-1.3%	-3.7%
CO_2 emissions	**-2.3%**	**-2.2%**	**-3.9%**	**-6.5%**

Vielle et al. (2016, unpublished table)

All sectors must contribute

CO_2 emissions (Mt)





Vielle et al. (2016, Fig. 2 + 15)

Incomes of 4 billion CHF are at stake

	Billion CHF, 2017
Spending for final energy use	26.5
./. Electricity	- 10.0
Spending for final use of fossil energy	16.5
./. Petroleum tax	- 4.6
./. CO_2 tax	- 1.1
./. Value-added tax	- 1.2*
Spending for final use of fossil energy without taxes	9.6
./. Imports of fossil energy	- 5.7
Net domestic incomes form sale of fossil energy	3.9*

Data sources: Fed. off. of energy (Gesamtenergiestatistik), Fed. finance admin. and Federal customs admin. / * = Estimates

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Conclusions

- Our economies must get free of fossil fuels
- The longer we wait, the higher the decarbonisation rate
- High-income, high-tech countries should pave the way
- Pushing firms and households to decarbonize through price signals will call for high taxes … hardly acceptable, hardly doable (even if actual welfare cost is small)
- A 'New Climate Deal' is needed
- Example: decarbonisation of Swiss railway transportation between 1918 and 1950!