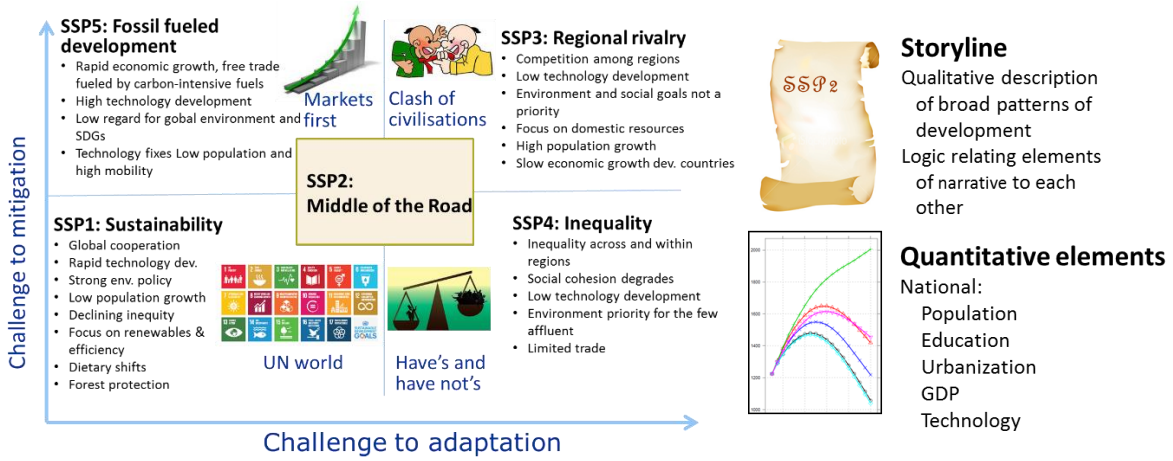
## Shared Socioeconomic Pathways (SSPs)

Global climate change studies rely on numerous assumptions and factors related to policy options and societal developments. Shared Socioeconomic Pathways (SSPs) were developed over the last years as a joint community effort (by an international team of climate scientists, economists and energy systems modelers) to provide a toolkit for the climate change research community to carry out integrated, multi-disciplinary analysis. They describe plausible major global developments that together would lead in the future to different challenges for mitigation and adaptation to climate change. They have also been described as "stories that happened in the future" (Armstrong & Green, 2012), aiming to explore how the future can evolve under a consistent set of assumptions. The SSPs are based on five narratives describing alternative socio-economic developments, including sustainable development, regional rivalry, inequality, fossil-fueled development, and middle-of-the-road development (Riahi et al., 2017).

In the context of the Pathways to Sustainable Energy project, **SSP2** (or else the so-called Middle of the Road scenario) was set as the Reference scenario. The following figure illustrates the drivers under the different SSPs and how the SSP2 stands for the "middle of the road" scenario.




## SSP Storylines

A summary of the SSP2 storyline (quoted from relevant references) is provided here for comprehensiveness. For further details and extended descriptions of SSP storylines, please refer to (O'Neill et al.,2014; 2015), while more focused documentation on SSP2 can be found in (Fricko et al., 2016). You can also find below key assumptions on SSP2 quantitative elements (in terms of Energy, Agriculture & Land Use).

- **SSP 2 - Middle of the Road (or Dynamics as Usual, or Current Trends Continue, or Continuation, or Muddling Through):**

"The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceed unevenly, with some countries making relatively good progress while others fall short of expectations. Most economies are politically stable. Globally connected markets function imperfectly. Global and national institutions work toward but make slow progress in achieving sustainable development goals, including improved living conditions and access to education, safe water, and health care. Technological development proceeds apace, but without fundamental breakthroughs. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Even though fossil fuel dependency decreases slowly, there is no reluctance to use unconventional fossil resources. Global population growth is moderate and levels off in the second half of the century as a consequence

of completion of the demographic transition. However, education investments are not high enough to accelerate the transition to low fertility rates in low-income countries and to rapidly slow population growth. This growth, along with income inequality that persists or improves only slowly, continuing societal stratification, and limited social cohesion, maintain challenges to reducing vulnerability to societal and environmental changes and constrain significant advances in sustainable development. These moderate development trends leave the world, on average, facing moderate challenges to mitigation and adaptation, but with significant heterogeneities across and within countries." (O'Neill et al., 2015)

SSP2 does not imply a simple extrapolation of recent experience, but rather a development pathway that is consistent with typical patterns of historical experience observed over the past century. For example, emerging economies grow relatively quickly and then slow as incomes reach higher levels, the demographic transition occurs at average rates as societies develop, and technological progress continues without major slowdowns or accelerations. Thus, it is a dynamic pathway, yet one in which future changes in various elements of the narrative are consistent with middle of the road expectations, rather than falling near the upper or lower bounds of possible outcomes. There are likely many reasons that trends in SSP elements could end up being moderate, and no specific stance is taken here as to motivating forces.

Population and economic development

"Population and economic developments have strong implications for the anticipated mitigation and adaptation challenges. For example, a larger, poorer population will have more difficulties to adapt to the detrimental effects of climate change. Understanding how population and economic growth develops in the SSPs therefore already gives a first layer of understanding of the multiple challenges. Population growth evolves in response to how the fertility, mortality, migration, and education of various social strata are assumed to change over time. In SSP2, global population steadily grows to 9.4 billion people around 2070, and slowly declines thereafter (KC and Lutz, 2015). Gross Domestic Product (GDP) follows regional historical trends (Dellink et al., 2015). With global average income reaching about 60 (thousand year-2005 USD/capita, purchasing-power-parity – PPP, i.e., GDP/capita) by the end of the century, SSP2 sees an increase of global average income by a factor 6. The SSP2 GDP projection is thus situated in-between the estimates for SSP1 and SSP3, which reach 2100 global average income levels of 82 and 22 (thousand year-2005 USD/capita PPP), respectively. SSP2 depicts a future of global progress where developing countries achieve significant economic growth. Today, average per capita income in the global North is about five times higher than in the global South. In SSP2, developing countries reach today's average income levels of the OECD by around 2060–2090, depending on the region. However, modest improvements of educational attainment levels result in declines in education-specific fertility rates, leading to incomplete economic convergence across different world regions. This is particularly an issue for Africa. Overall, both the population and GDP developments in SSP2 are designed to be situated in the middle of the road between SSP1 and SSP3, see KC and Lutz (2015) and Dellink et al. (2015) for details." (Fricko et al., 2016).

## SSP1, 2 and 3 Assumptions on quantitative elements (Source: Fricko et al., 2016)

| *Energy* | | | |
|---|---|---|---|
| | **SSP1** | **SSP2** | **SSP3** |
| **Energy demand** | Total final energy intensity improvement is approx. 1.7%<br>*(Regional range from 1.3% to 2.45%)* | Total final energy improvement is approx. 1.2%<br>*(Regional range from .9% to 2%)* | Total final energy improvement is approx. 0.3%<br>(*Regional range from .2% to .9%*) |
| **Transport** | High electrification<br>(*max. 75% of total transport possible*) | Medium electrification<br>(*max. 50% of total transport possible*) | Low electrification<br>(*max 10% of total transport possible*) |
| **Residential & Commercial** | High electrification rate: 1.44%<br>*(Regional range from .35% to 4%)* | Medium electrification rate: 1.07%<br>*(Regional range from .23% to 3%)* | Low electrification rate: .87%<br>(*Regional range from .37% to 2%*) |
| **Industry + Feedstocks** | High electrification rate: 0.56%<br>(*Regional range from .2% to 1.2%*)<br><br>High feedstock reduciton rate: -0.33%<br>(*Regional range from -0.51 to 0.59%*) | Medium electrification rate: 0.47%<br>(*Regional range from .07% to 1.08%*)<br><br>Medium feedstock reduction rate: -0.27%<br>(*Regional range from -0.45% to 0.64%*) | Low electrification rate: .12%<br>(*Regional range from -.03% to 0.71%*)<br><br>Low feedstock reduction rate: -0.24%<br>(*Regional range from -0.38% to 0.51%*) |
| **Traditional Fuel Use** | Phase-out by 2040 | Phase-out by 2080 | Continued use of traditional biomass |
| **Fossil Energy Resource** | | | |
| **Coal** | High cost assumptions | Medium cost assumptions | Low cost assumptions |
| **Other Hydrocarbons** | Medium resource availability<br>(*56 ZJ*) | High resource availability<br>(*77 ZJ*) | Low resource availability<br>(*41 ZJ*) |
| **Energy Supply** | | | |
| **Conventional and Unconventional Fossil Fuel Conversion** | Low technology learning rate and slow market penetration<br>*(limited cost reduction (0-30% by 2100; 30% for gas only))* | Medium assumptions<br>*(cost reductions between 10% (coal syn-liquids) and 30% (for other coal and gas))* | High learning rate for coal; medium for others; hydrogen is unavailable<br>(cost reductions from 15-20% (for coal-synthetic liquids gas) and up to 50% for coal) |
| **Commercial Biomass Conversion** | High technology improvements<br>(cost reductions of 30%-50%) | Medium assumptions<br>*(cost reductions of 20%-40%)* | Low technology improvements<br>(cost reductions of 10%-30%) |
| **Non-bio Renewables Conversion** | High technology improvements<br>*(cost reductions between 20%-90%)* | Medium assumptions<br>*(cost reductions between 18%-70%)* | Low technology Improvement<br>*(cost reductions between 10%-30%)* |
| **Nuclear Power** | Low assumption<br>(Cost reductions of 15%) | Medium assumptions<br>*(Cost reductions of 30%)* | No learning |
| **CCS (under climate policy only)** | Low technological development for fossils; High for biomass<br>*(Cost reductions of 0%-50%)* | Medium assumptions<br>*(Cost reductions of 10%-40%)* | Low technological development<br>(*Cost reductions of 10%-27%*) |

* All indicators apply to 2010–2100; Intensity improvements are in FE/GDP annually.

| *Agriculture and land use* | | | |
|---|---|---|---|
| | **SSP1** | **SSP2** | **SSP3** |
| **Net deforestation** | Afforestation (*No net deforestation by 2050, +3% forest area by 2100 compared to 2010*) | Deforestation/Afforestation (Forest loss of 1% by 2050, back to 2010 area by 2100) | Deforestation (*Net forest loss of 3% by 2050 and 6% by 2100 compared to 2010*) |
| **Land productivity growth** | | | |
| **Crops: Yields** | High yield growth (*Annual yield growth from 0.51% p.a. in the North to 0.66% in the South*) | Moderate yield growth (*Annual yield growth from 0.46% p.a. in the North to 0.60% in the South*) | Slow yield growth (*Annual yield growth from 0.35% p.a. in the North to 0.35% in the South*) |
| **Crops: Input intensity** | Low intensity (*Elasticity of variable inputs incl. fertilizer use wrt technological change: 0.75*) | Medium intensity (*Elasticity of variable inputs incl. fertilizer use wrt technological change: 1.00*) | High intensity (*Elasticity of variable inputs incl. fertilizer use wrt technological change: 1.25*) |
| **Livestock: Feed conversion efficiency** | Enhanced efficiency growth (*Annual feed conversion efficiency change from 0.10% in the North to 0.26% in the South*) | Moderate efficiency growth (*Annual feed conversion efficiency change from 0.10% in the North to 0.24% in the South*) | Slow efficiency growth (*Annual feed conversion efficiency change from 0.07% in the North to 0.14% in the South*) |
| **Livestock: Endogenous productivity growth** | High livestock systems transition *(Annually, up to 5% of livestock production systems can be converted to an alternative system or the activity can be abandoned)* | Medium livestock systems transition *(Annually, up to 2.5% of livestock production systems can be converted to an alternative system or the activity can be abandoned)* | Low livestock systems transition *(No adjustment in the ruminant production system structure)* |
| **Environmental impact of food consumption** | | | |
| **Food demand** | Slow consumption growth and more sustainable and healthy diets (*Calorie consumption per capita growing – North : 1%, South: 16%. Livestock product share decreases in North by one third but increases in South, leading to a stable share of 15% globally*) | Moderate consumption growth and increasing share of livestock products in the diet (*Calorie consumption per capita growing by 11% in the North and 22% in the South. Livestock product share in the diet growing from 15% to 18%.*) | Substantial consumption growth but lagging demand for animal proteins in diet in the South (*Calorie consumption per capita growing by 5% in the North and 15% in the South. Livestock product share stays at 15%.*) |
| **Losses & Wastes** | Fast reduction of losses & wastes (L&W) *(L&W in the processing chains reduced from 12% to 7% in the Oilseed and Pulses sector and from 7% to 2.5% in the dairy sector over 2000 and 2050)* | Medium reduction of losses & wastes (L&W) *(L&W in the processing chains reduced from 12% to 7.5% in the Oilseed and Pulses sector and from 7% to 3% in the dairy sector over 2000 and 2050)* | Slow reduction of losses & wastes (L&W) *(L&W in the processing chains reduced from 12% to 9% in the Oilseed and Pulses sector and from 7% to 4.5% in the dairy sector over 2000 and 2050)* |

## References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