WITCH in a nutshell

WITCH: World Induced Technical Change Hybrid model

Key features:

- **Economy:** Dynamic optimal growth
- **Scale:** Global, 14 regions, 5-year time step
- **Energy:** Hard linked Energy Technology
- **Climate:** MAGICC Climate Module
- **Land use:** GLOBIOM coupling
- **Adaptation:** Proactive and reactive
- **Pollutants:** Hard linked to TM5-FASST, impacts on crops and health
- **Tech. change:** Endogenous, both innovation and diffusion
- **Solution:** Game theoretical, all degrees of cooperation
- **Uncertainty:** Deterministic and stochastic programming

Contribution to the modeling community

✓Large contributor of IPCC AR5 scenarios (~ 100)

✓Involved in all recent major model comparison projects (EMF22, EMF27, LIMITS, AMPERE, ROSE, RECIPE, PLANETS, GLOBAL IQ, CPO, AME)

✓SSP contributor

✓Coordinator of FP7 projects (LIMITS, CPO, PLANETS)

✓3 European Research Council (ERC) grants related to the model

✓ Specific tool for the analysis of topics like endogenous technical change, coalition formation, uncertainty, optimal balance of mitigation and adaptation policies

Specific areas of research

Technical change

- ✓ R&D investments, Learning-By-Doing, spillovers
- ✓ Technology policies and international agreements

Coalition formation

- ✓ Stability of international climate agreements
- ✓ Technology transfers agreements
- ✓ Leakage

Uncertainty

- ✓ Hedging strategies
- ✓ Global sensitivity analysis
- ✓ Decision making under uncertainty

Optimal balance of mitigation and adaptation policies

- ✓ Detailed damage functions

New research topics

- ✓ **Climate and air pollution**: coalition formation with local benefits ((endogenous air quality module based on TM5-FASST with costs and benefits of pollution control)
- ✓ **Geo-engineering, adaptation and mitigation**: implications for climate negotiations
- ✓ Accounting for both **state and model uncertainty**: robust decision making in the face of climate risks
- ✓ Climate change **impacts** revisited: **new damage functions** and implications for optimal climate policy
- ✓ **Energy efficiency**: behavioral welfare analysis of public policy instruments
- ✓ **Skill-biased technical change**: implications for green growth
- ✓ **Water** use in the energy sector

The World in 2050

- ✓ **Witch** can be used to evaluate the dynamics of economic, environmental, technological variables in the coming decades and their compatibility with sustainable development.
- ✓ It can also be used to assess the **use of resources** such as energy, land, water,…
- ✓ It provides an economic assessment of both **local and global benefits** of policies. **It takes into account policy interactions both within a country and across countries.**
- ✓ Witch is a macro-optimization model (like DICE, RICE, Remind and many others): therefore it provides a benchmark, trajectories achievable if resources are optimally used and all decisions are rational. **These trajectories are the optimal ones to achieve a given target (set of targets) or to remain within planetary boundaries**
- ✓ **Drivers of sustainable growth are investments** (in education, research and development, energy and water infrastructure, physical capital in all sectors, adaptation, etc), which are optimally, intertemporally and strategically determined.

ICES in a nutshell

ICES: Intertemporal Computable Equilibrium System

Key features:

- **Economy:** Recursive, dynamic CGE model
- **Scale:** Global, multi-sector, multi-region
- **Energy:** Top-Down Description of the Energy System
- **Land use:** Agro Ecological Zoning, REDD, irrigation
- **Adaptation:** Autonomous and planned adaptation
- **Pollutants:** Global (GHGs) and local pollutants
- **Technical change:** Exogenous with international spillovers
- **Climate impacts:** Economy-wide assessment of climate change impacts

ICES a simulation model designed to quantify impacts of climate change, to endogenise adaptation strategies and to project SDGs into the future

Contribution to the modeling community

- ✓ Part of all major FP6 and FP7 projects on climate change impact, adaptation, and mitigation assessment (ENSEMBLE, CIRCE, SESAME, PESETA, ClimateCost, EconAdapt, VECTORS, MEDSEA, GLOBAL IQ)
- ✓ Contributor to the ISI-MIP community
- ✓ Development of a methodology for an indicator-based assessment of sustainable development policies and green growth

Specific areas of research

Climate change Impacts

- ✓ **Cross-sectoral assessment**: agriculture, energy demand, energy supply, human health, sea-level rise, tourism, ecosystems, river floods
- ✓ Soft-link **coupling** with bottom-up models: land use, crop, sea-level rise, energy
- ✓ Estimation of damage functions with autonomous adaptation
- ✓ Quantification of the role of autonomous adaptation and its limits

Mitigation

- ✓ Climate policies
- ✓ International technology spillovers
- ✓ Renewable energy
- ✓ Deforestation and afforestation

Sustainability impacts and green growth potential of different growth paths and policies

New research topics

- ✓ Implication of climate change impacts and adaptation expenditure for **public budget sustainability**. Analysis of different funding options for adaptation
- ✓ Explicit representation of effects of changes in **ecosystem services** and of their non-market non-use value in agents consumption patterns and CGE economic assessment
- ✓ **Regionalization** of the CGE structure at the sub-national level for a high resolution representation of climate change impacts and adaptation and better coupling with spatially resolved impact models
- ✓ **Integration of SDGs** into the modeling structure

More on Sustainability

Research agenda:

- ✓ Model-based ex-ante sustainability assessment rooted on sustainable development indicators (41) and development of composite sustainability index
- ✓ Aggregation avoiding overlapping of indicators
- ✓ Country sustainability ranking
- ✓ Co-benefits of climate policy on sustainability
- ✓ Analysis of goal-specific policies

Ex-ante assessment of SDGs

Methodology: model-based simulation of future trends of selected SDGs in different scenarios

Purpose, define:

- ✓ sustainability over time (future)
- ✓ sustainability across countries (ranking)
- ✓ sustainability through states of the world (scenario analysis)

In order to:

- ✓ verify fulfillment of targets
- ✓ assess distance-to-target
- ✓ compute investments effort and define instruments to match targets
- ✓ highlight trade-offs / synergies among SDGs

Ex-ante assessment of SDGs

IDENTIFICATION OF CRITICALITIES/GOALS

DEFINITION OF TARGETS

CHOICE OF INDICATORS

ASSESSMENT OF INDICATORS' PERFORMANCE

IF BELOW THE TARGET, POLICY IMPLEMENTATION

POLICY EVALUATION

- SPECIFIC INDICATOR
- OTHER INDICATORS
- FINANCIAL MECHANISM

Representation of key drivers

TW2050 DRIVERS	ICES	WITCH
HUMAN CAPITAL	Education expenditure	Education expenditure
ICT	Index on ICT maturity	No
INVESTMENT & GDP GROWTH	Recursive, exogenous saving rate	Optimization, Endogenous saving rate
DEVELOPMENT	Public debt, Gross domestic expenditure on R&D as share of GDP	Clean energy endogenous technological change
FOOD	Proportion of population below minimum level of dietary energy consumption	
ENERGY	Share of the population with access to reliable electricity, Rate of primary energy intensity Primary energy by type	Per capita electricity, Rate of primary energy intensity Primary energy by type
AIR QUALITY	Mean urban air pollution of particulate matter (PM10 and PM2.5)	Mean urban air pollution of particulate matter (PM10 and PM2.5)
WATER and SANITATION	Proportion of total water resources used (MDG Indicator)	Water needs in the energy sector
BIODIVERSITY and ECOSYSTEMS	Yes	

BACK-UP SLIDES

SDGs Coverage

N.	SDGs	# INDICATORS
1	POVERTY	3
2	HUNGER and SUSTAINABLE AGRICULTURE	2
3	HEALTH and WELL-BEING	3
4	EDUCATION	1
5	GENDER EQUALITY	1
6	WATER and SANITATION	1
7	ENERGY	3
8	SUSTAINABLE GROWTH and EMPLOYMENT	5
9	INFRASTUCTURE and INDUSTRIALIZATION	3
10	INEQUALITY WITHIN and AMONG COUNTRIES	4
11	SUSTAINABLE CITIES	2
12	SUSTAINABLE PRODUCTION and CONSUMPTION	3
13	CLIMATE CHANGE	2
14	OCEANS, SEAS, MARINE RESOURCES	1
15	TERRESTRIAL ECOSYSTEMS and BIODIVERSITY	2
16	PEACE, JUSTICE and INCLUSIVE INSTITUTIONS	2
17	MEANS of IMPLEMENTATION	3

SDGs Coverage: Some examples

N.	SDGs	INDICATOR
1	POVERTY	
2	HUNGER and SUSTAINABLE AGRICULTURE	7. Proportion of population below minimum level of dietary energy consumption (MDG Indicator)
3	HEALTH and WELL-BEING	32. Healthy life expectancy at birth
4	EDUCATION	
5	GENDER EQUALITY	
6	WATER and SANITATION	52. Proportion of total water resources used (MDG Indicator)
7	ENERGY	54. Share of the population with access to reliable electricity,
8	SUSTAINABLE GROWTH and EMPLOYMENT	8.5. Employment to population ratio (EPR)
9	INFRASTUCTURE and INDUSTRIALIZATION	63. [Index on ICT maturity] - to be developed
10	INEQUALITY WITHIN and AMONG COUNTRIES	
11	SUSTAINABLE CITIES	33. Mean urban air pollution of particulate matter (PM10 and PM2.5)
12	SUSTAINABLE PRODUCTION and CONSUMPTION	*Material Productivity
13	CLIMATE CHANGE	
14	OCEANS, SEAS, MARINE RESOURCES	
15	TERRESTRIAL ECOSYSTEMS and BIODIVERSITY	85. Red List Index
16	PEACE, JUSTICE and INCLUSIVE INSTITUTIONS	94. Perception of public sector corruption
17	MEANS of IMPLEMENTATION	17.3. Gross domestic expenditure on R&D as share of GDP [CNI]

Examples of interactions with key sectors

TW2050 SECTOR	INDICATOR
ICT	63. [Index on ICT maturity]
INVESTMENT & GDP GROWTH	17.3. Gross domestic expenditure on R&D as share of GDP [CNI]
FOOD	7. Proportion of population below minimum level of dietary energy consumption (MDG Indicator)
ENERGY	54. Share of the population with access to reliable electricity, 56. Rate of primary energy intensity 7.1. Primary energy by type [CNI]
PLANETARY BOUNDARIES	85. Red List Index *Material Productivity
AIR QUALITY	33. Mean urban air pollution of particulate matter (PM10 and PM2.5)
WATER and SANITATION	52. Proportion of total water resources used (MDG Indicator)

UN SDSN GOAL	*INDICATORS*
1. End poverty in all its forms everywhere	1 Proportion of population below $1.25 (PPP) per day (MDG Indicator)
	2. Proportion of population living below national poverty line, differentiated by urban and rural (modified MDG indicator)
	3. Multidimensional Poverty Index
2. End hunger, achieve food security and improve nutrition, and promote sustainable agriculture	7. Proportion of population below minimum level of dietary energy consumption (MDG Indicator)
	Agriculture value added per worker
3. Ensure healthy lives and promote well-being for all at all ages	29. [Percentage of population without effective financial protection for health care] - to be developed
	32. Healthy life expectancy at birth
	33. Mean urban air pollution of particulate matter (PM10 and PM2.5)
4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all	SHARE OF EDUCATION EXPENDITURE OVER GDP
5. Achieve gender equality and empower all women and girls	42. Percentage of referred cases of sexual and gender-based violence against women and children that are investigated and sentenced
6. Ensure availability and sustainable management of water and sanitation for all	52. Proportion of total water resources used (MDG Indicator)
7. Ensure access to affordable, reliable, sustainable, and modern energy for all	54. Share of the population with access to reliable electricity, by urban/rural
	56. Rate of primary energy intensity improvement
	7.1. Primary energy by type ***[CNI]***
8. Promote Sustained, Inclusive and Sustainable Economic Growth, Full and Productive Employment and Decent Work for All	57. GNI per capita (PPP, current US$ Atlas method)
	8.1. Growth rate of GDP per person employed (MDG indicator) ***[CNI]***
	8.5. Employment to population ratio (EPR) by gender and age group (15–64) ***[CNI]***
	17.3. Gross domestic expenditure on R&D as share of GDP ***[CNI]***
	17.2. [Indicator on debt sustainability] - to be developed ***[CNI]***
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	63. [Index on ICT maturity] - to be developed
	64. [Labour and Capital] Manufacturing value added (MVA) as percent of GDP
	66. Total energy and industry-related GHG emissions by gas and sector, expressed as production and demand-based emissions (tCO_2e)
10. Reduce inequality within and among countries	67. [Indicator on inequality at top end of income distribution: GNI share of richest 10% or Palma Ratio]
	68. Percentage of households with incomes below 50% of median income ("relative poverty")
	10.1. Gini Coefficient ***[CNI]***
	GINI among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable	*11.5. [Percentage of urban solid waste regularly collected and well managed] – to be developed* ***[CNI]***
	12.4. [CO2 intensity of the building sector and of new buildings (KgCO2/m2/year)] ***[CNI]***
12. Ensure sustainable consumption and production patterns	Enlighting and Emergy
	Material Productivity
	Adjusted Net Savings
13. Take urgent action to combat climate change and its impacts	79. CO_2 intensity of new power generation capacity installed (gCO_2 per kWh), and of new cars (gCO_2/pkm) and trucks (gCO_2/tkm)
	80. Net GHG emissions in the Agriculture, Forest and other Land Use (AFOLU) sector (tCO_2e)
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	83. Proportion of fish stocks within safe biological limits (MDG Indicator)
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat	84. Annual change in forest area and land under cultivation (modified MDG Indicator)
	85. Red List Index
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build	94. Perception of public sector corruption
	100. Evaluative Wellbeing and Positive Mood Affect
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development	96. Official development assistance (ODA) and net private grants as percent of high-income country's GNI
	97. Domestic revenues allocated to sustainable development as percent of GNI
	17.6. Average tariffs imposed by developed countries on agricultural products and textiles and clothing from developing countries (MDG Indicator) ***[CNI]***

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Thanks!