# Worldwide Resource Efficient Steel Production

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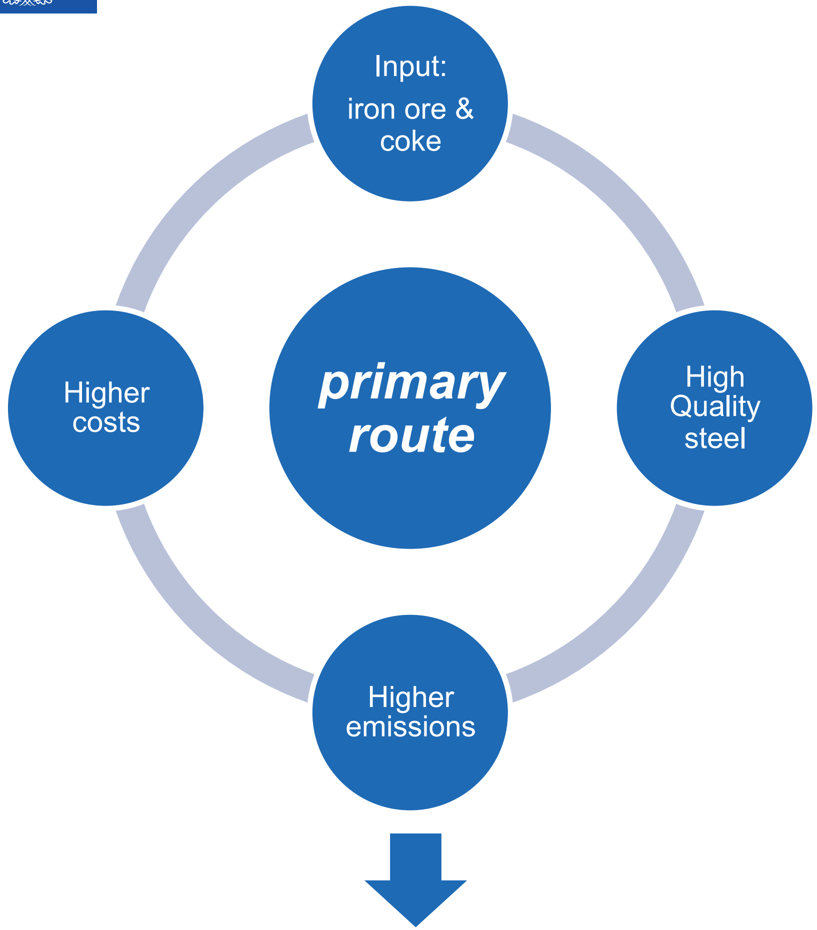
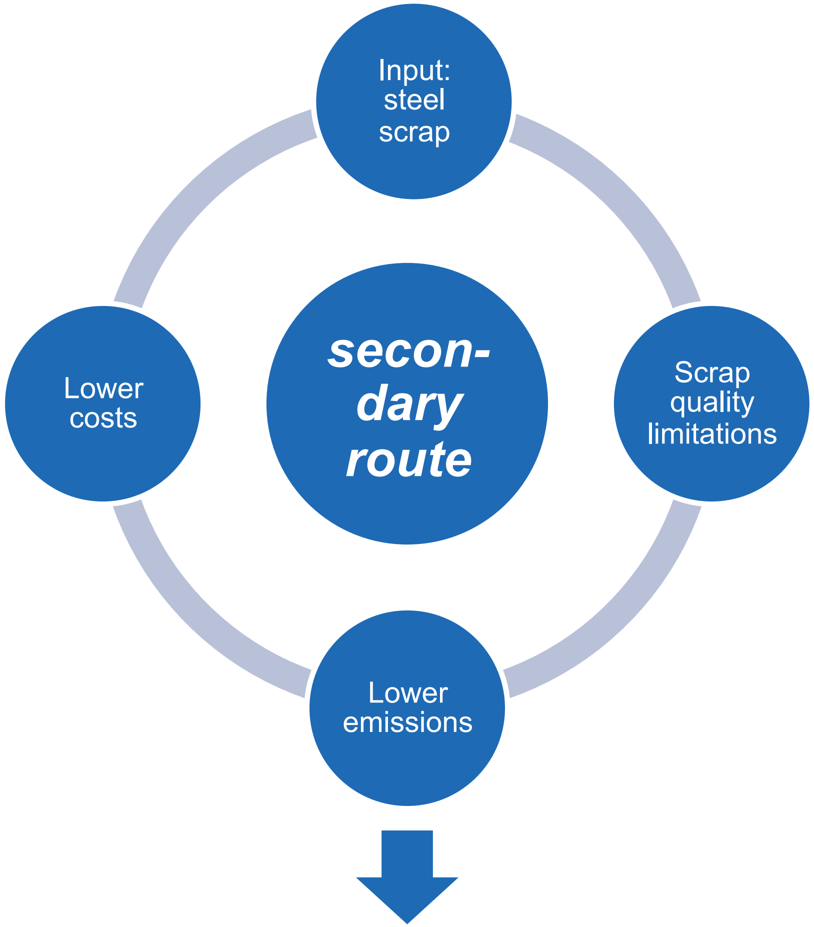
# Steel production technologies




*mainly **flat steel** products and*
***Blast Oxygen Furnace (BOF)***

*mainly **long steel** products and*
***Electric Arc Furnace technology (EAF)***

# Hypothesis and objectives

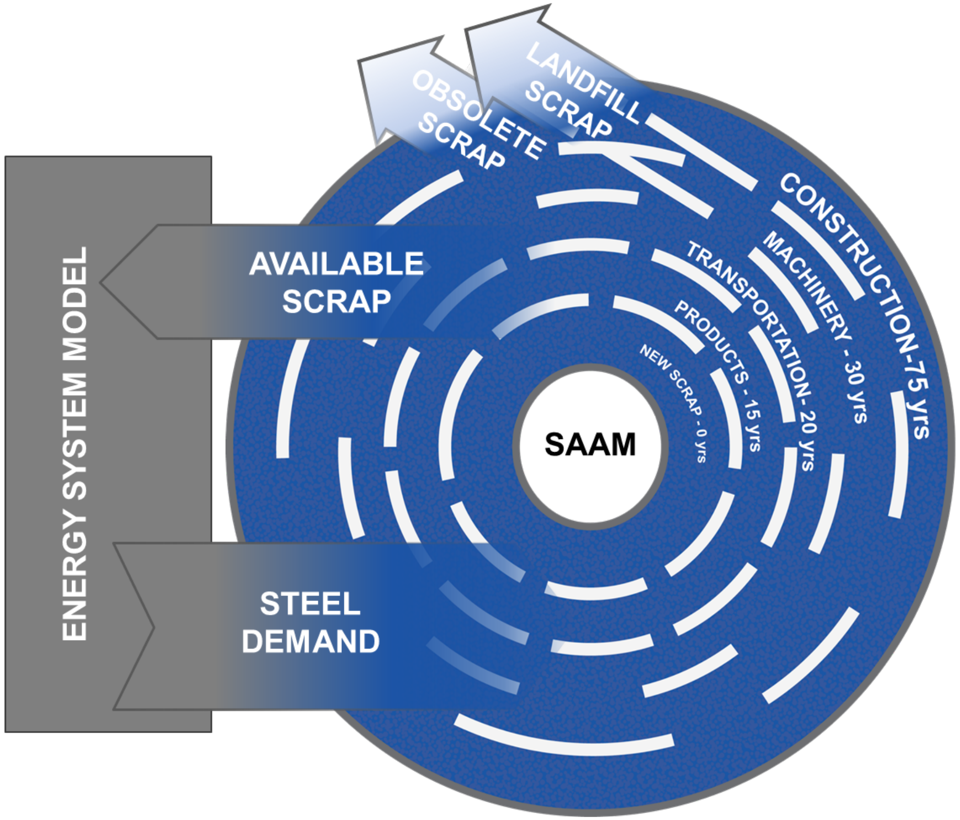
**Assumption:** tendency towards Electric Arc Furnace (EAF) technology supported by increased scrap availability

**Objective:** provide **new insights** for future long term developments in the steel sector using modelling tools

**How much scrap will be available for steel production and where? How will scrap availability affect investments?**

***Emerging technologies:***
-top gas recycling in blast furnace
-JET Blast Oxygen Furnace (BOF)
-scrap purification technology

# SAAM – Scrap Availability Assessment Model




$$S_t = \sum_{i=0}^{n} \eta_i \cdot \rho_i \cdot (1 - \gamma_i) \cdot P_i,$$

where,
$S_t$ = scrap made available during the time period t;
$n_i$ = share of steel use that each product group, i, has in the total in-use steel stock;
$\rho_i$= recycling rate;
$\gamma_i$ = fraction of the in-use steel forming obsolete stocks; and
$P_i$ = total steel produced for the time period equal to t minus the average life-time, T, of the product group i

# Steel production cost optimisation model

**Input**

-**flat and long steel demand** (steel optimization model)
-**scrap availability** (SAAM)
-**steel production technologies** (literature and consulatation with industry experts)

**Optimization**

**minimization** of global system costs (16 regions):
**-CAPEX** (capital expenditure)
**-OPEX** (operational expenditure)
**-Fuel**
**-Raw materials**

**Output**

-steel **quantities** (long and flat products) **per production technology**
-investments in new production capacities
-**interregional trade** scrap and finished products
-**policy impacts**

*TIMES-based model*
*modelling horizon: 2013 to 2100 (milestone: 2050)*

# Modelling scenarios

### *Scrap availability*

**less low quality scrap (Scenario 1)**

- Recycling rate from 60% to 80% in 2050

**baseline (Scenario 2)**

- Recycling rate from 60% to 85% in 2030

**less high quality scrap (Scenario 3)**

- 25% less high quality scrap by 2030

### *Carbon pricing*

**baseline**

- No carbon price placed (0€)

**T15 - EU**

- carbon price 15€ after 2020

**T15 - WORLD**

- carbon price 15€ after 2020

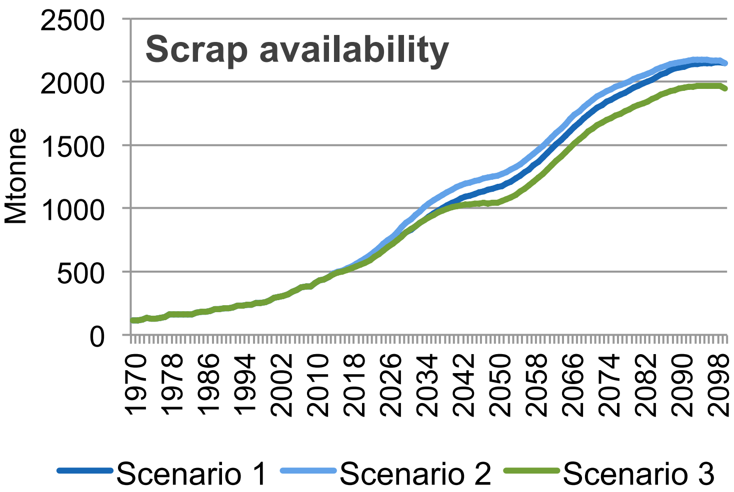
**T50 - EU**

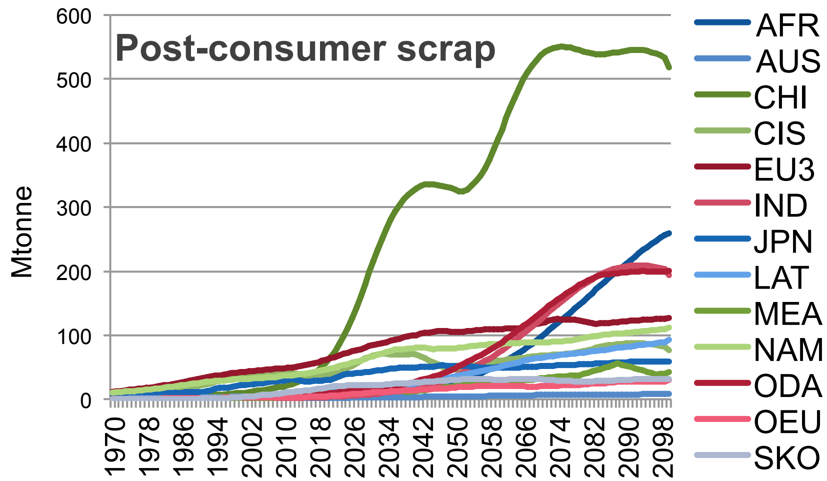
- carbon price up to 50€ by 2050

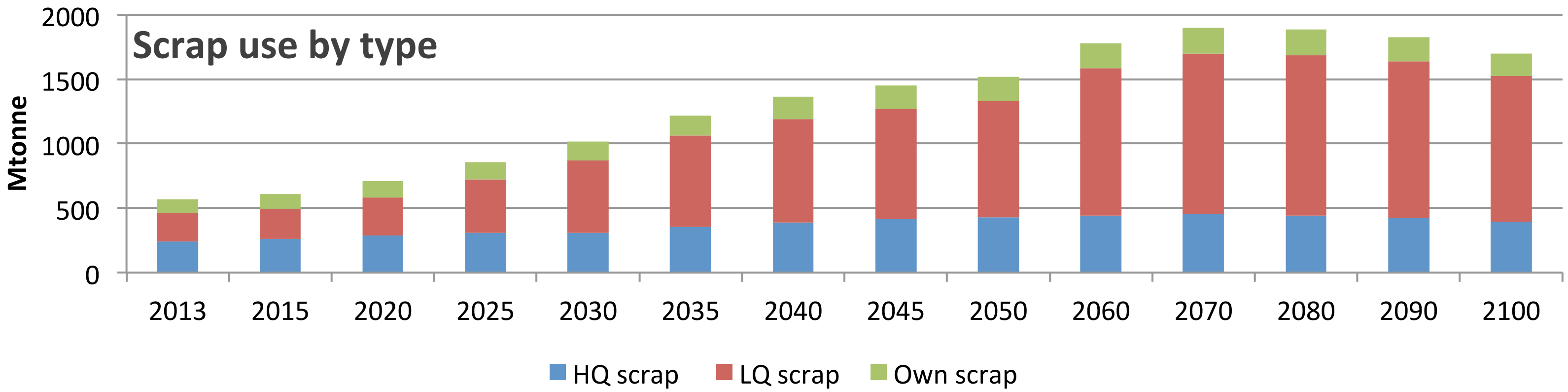
**T50 - WORLD**

- carbon price up to 50€ by 2050

# Results – scrap availability and use

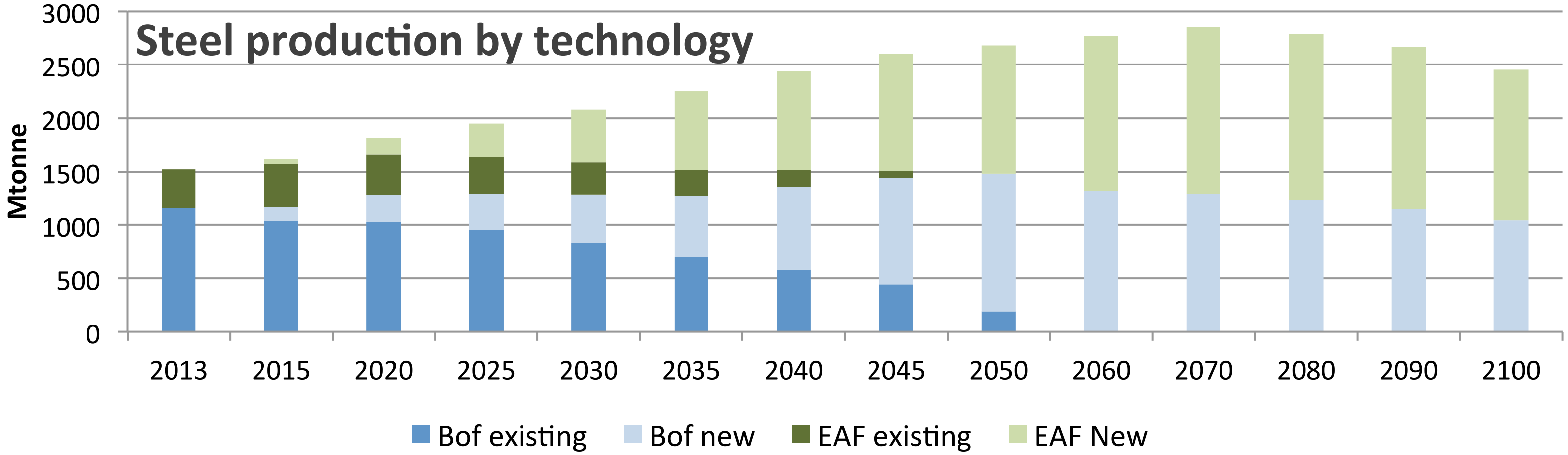


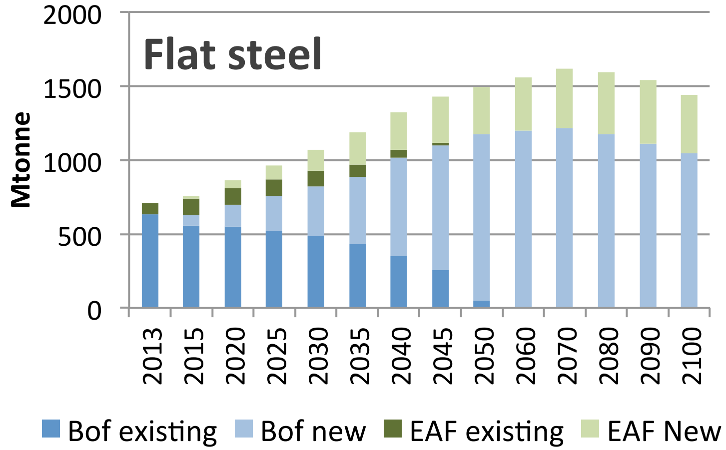



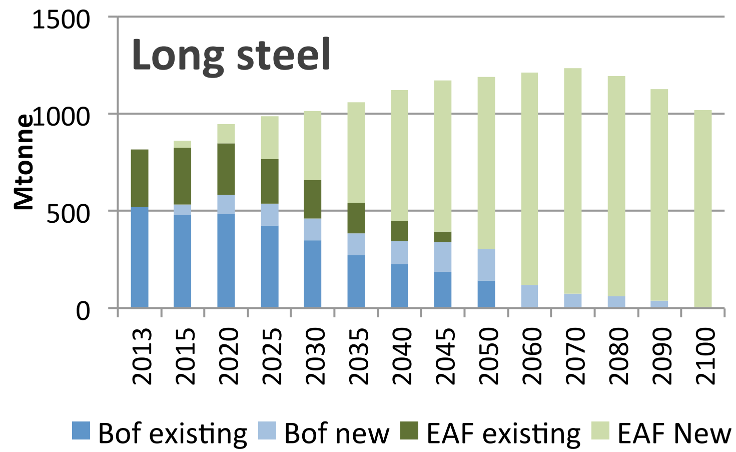




*high model accuracy for global historical values, uncertainties for regional values*

# Results – steel production technologies

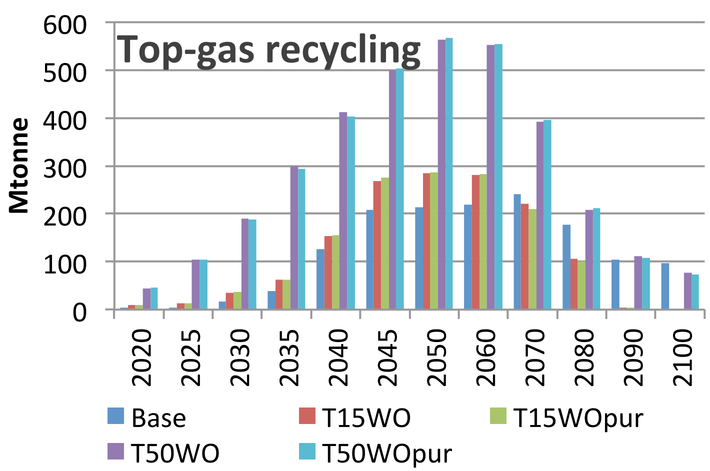


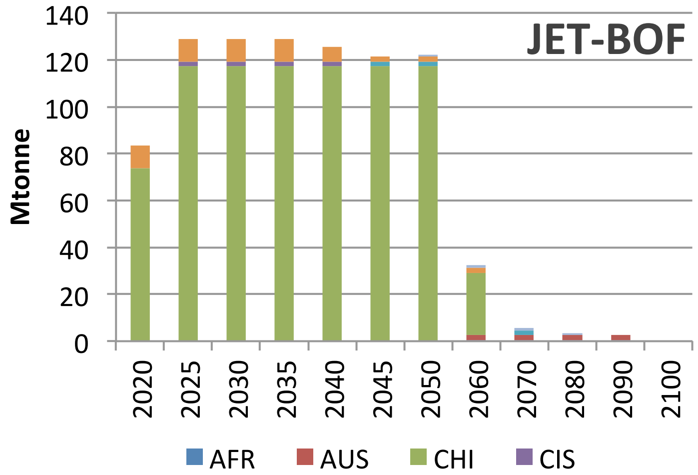



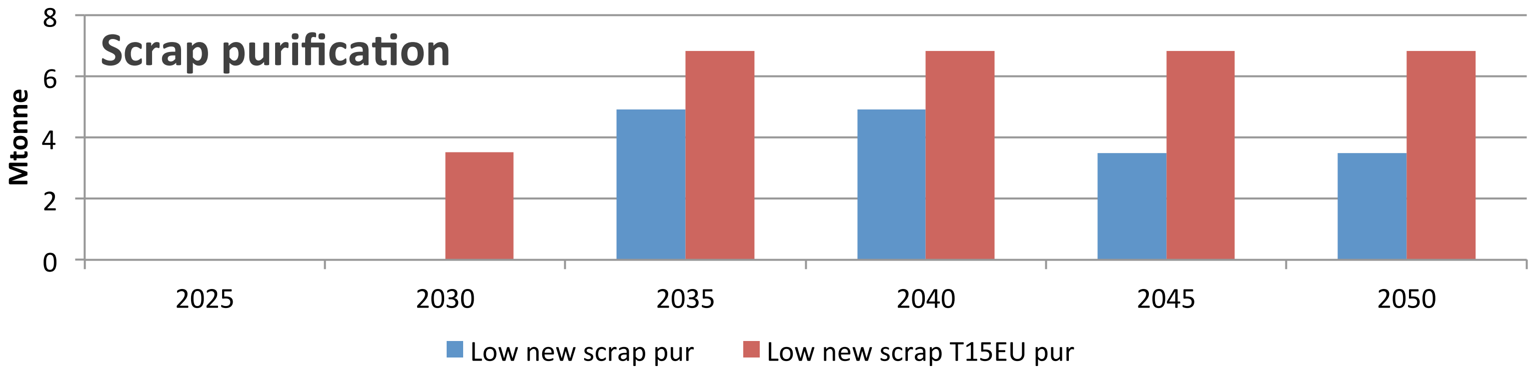

*primary & secondary route balance is stable for flat steel, changes for long steel*

# Results – emerging technology adoption



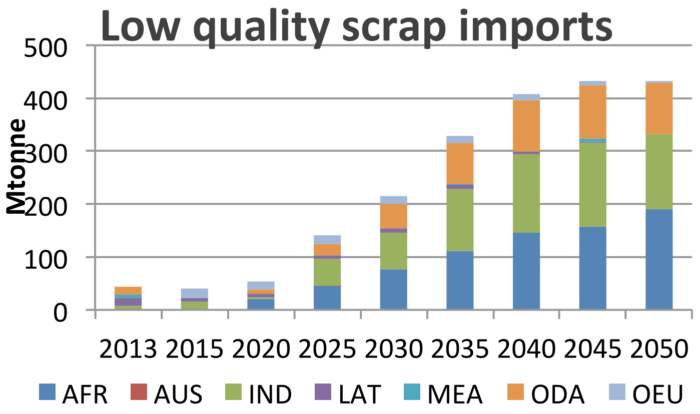



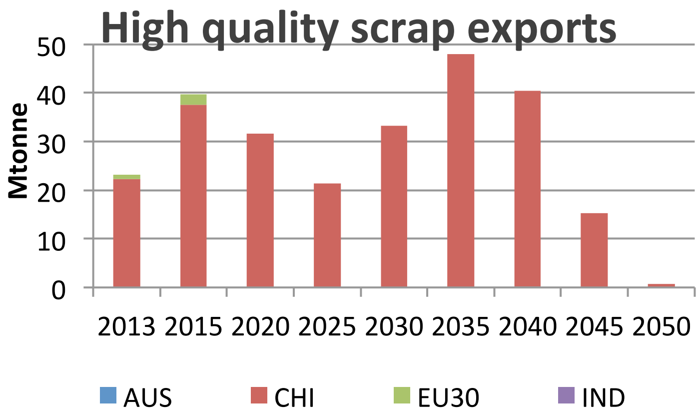

*adoption of new technologies depends on rising CO2 prices and excess capacity*

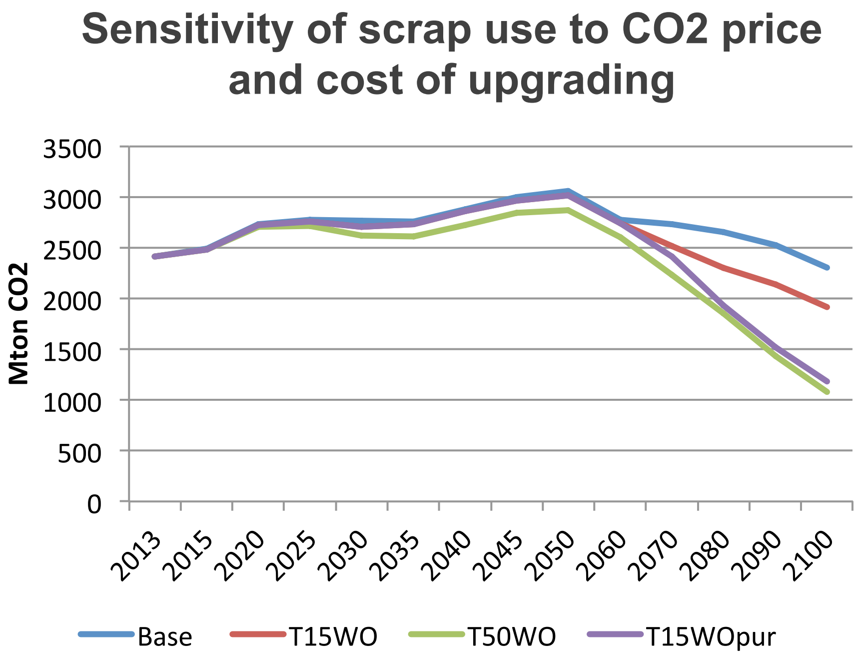



*scrap purification becomes more attractive when less high quality scrap is available*

# Results – trade and policy impacts




*increasing scrap use and adoption of new technologies contribute to emission decrease only after 2050 in all scenarios and as production peaks*

# Conclusions

-global **steel production** increases, **peaking in 2070**

-**primary and secondary route** split evolves from **1:2.5** in 2015 to an **almost 1:1 split in 2050** – secondary route **exceeds** primary in 2060

-**secondary route** will be **favored regardless of policy instruments** due to **lower costs** and **higher energy efficiency**

-**secondary route** very important for **developing countries** (long steel demand for **growing infrastructure needs**)

-introduction of **emerging technologies** may require **more stringent policies** (e.g. increased global carbon price)