The FORWAST model

An IO-based model for mass flow analysis, waste flow analysis, and life cycle assessment

Jannick H Schmidt

Presentation to the Final workshop of the FORWAST project
Copenhagen, 25th November 2009

2.-0 LCA consultants

www.lca-net.com

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- Definitions
- Calculation of waste generation
- Modelling of waste treatment in the IO-model
- Life cycle emissions
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Model outputs

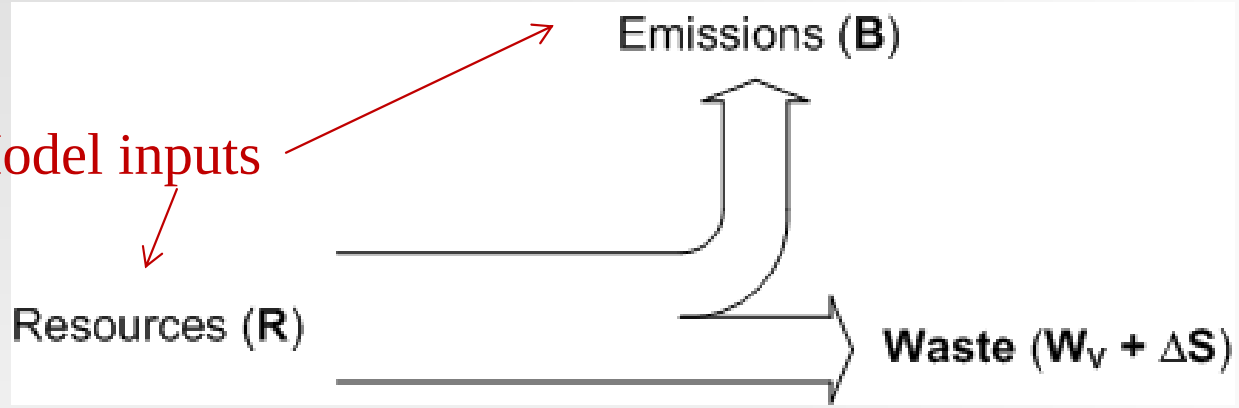
- Waste generation in years 2003-2035
- Accumulated stocks in years 2003-2035
- Environmental impact of EU27 production and consumption

Definitions

- **Definition of waste:**
  - Output of a human activity that remains in the technosphere and cannot directly (i.e. without further processing or emissions) displace another product
  - After processing in a waste treatment (recycling) activity, the recovered waste may displace other products.
- **Definition of stock:**
  - Product that has not yet become waste or emissions
- **Definition of environmental impact:**
  - Included emissions: CO_2, CO, N_2O, CH_4, NO_x, NMVOC, SO_2
  - CO_2-equivalants calculated using IPCC 100 year GWP
  - Resouce input (fibre/food) 1 kg C = -3.67 kg CO_2

Mass balance approach

- Total material flow in economy

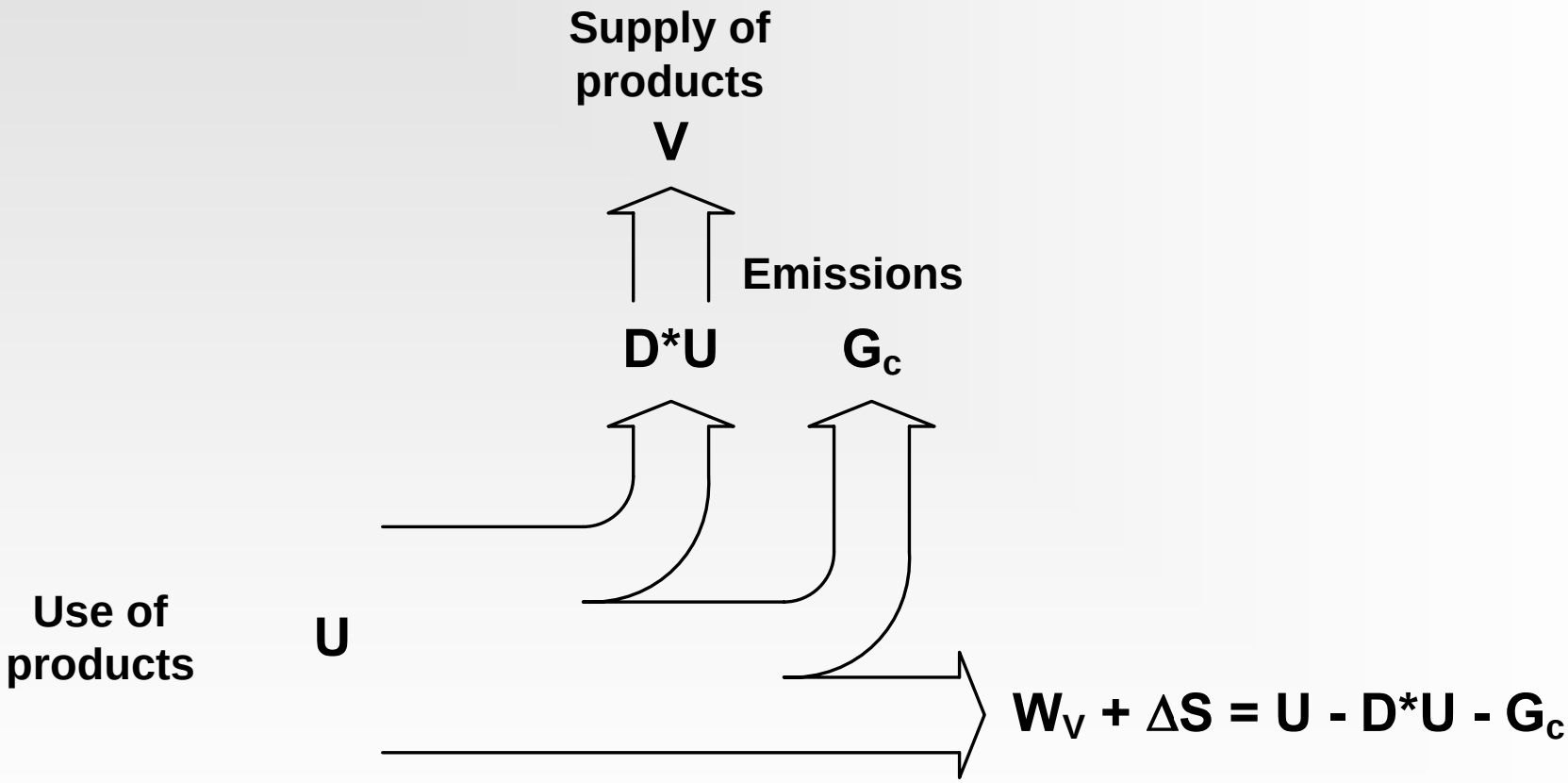


- Detailed material flows in economy (which products and activities)

Input flows	Intermediate flows	Output flows
Resources	Monetary transactions in the economy (supply-use tables) 	Emissions
		Waste ($\mathbf{W_V}$ + $\Delta\mathbf{S}$)
	Price information on products	

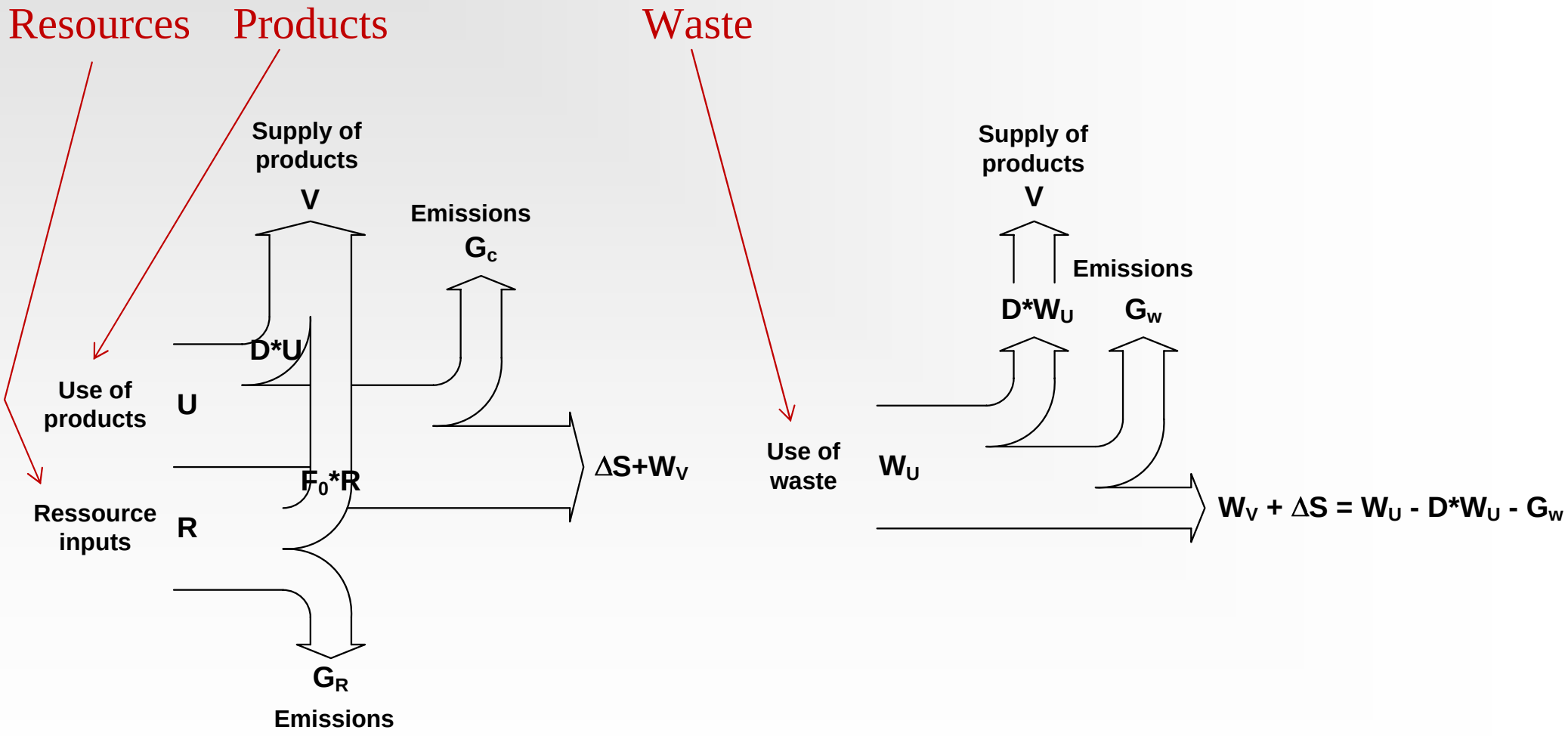
Calculation of waste generation

- Inputs of products become products, emissions and waste



Calculation of waste generation

- Three types of inputs



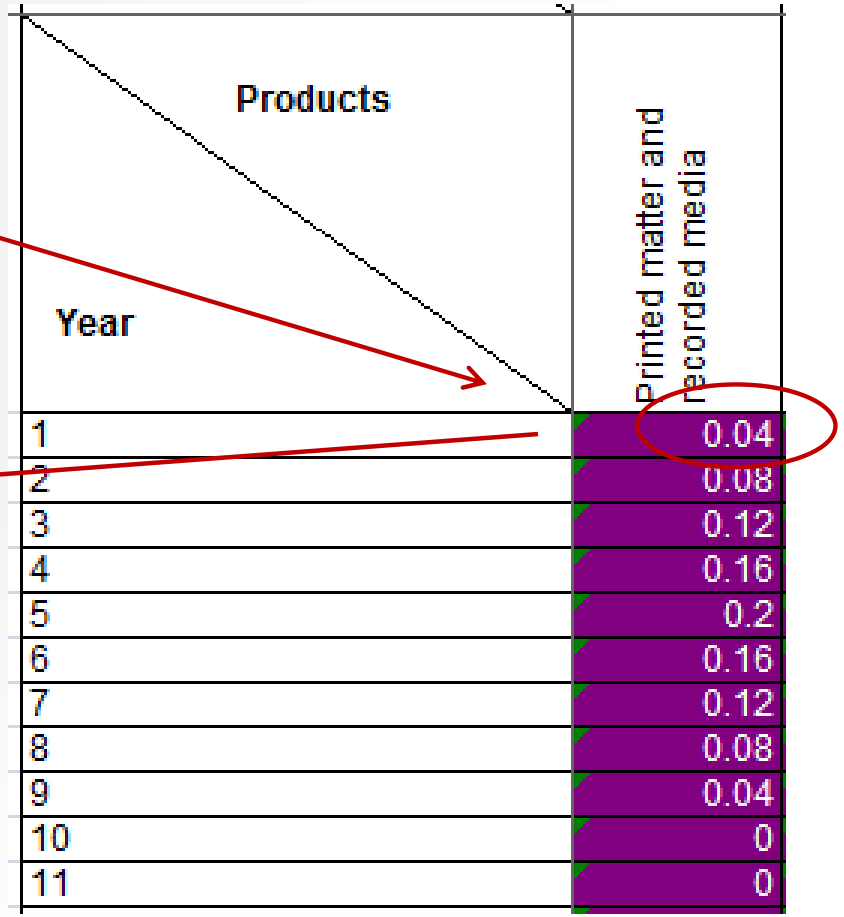
Physical activity

Waste treatment activity

Distiction between waste and stock addition

1 kg waste ($\mathbf{W_V}$) + stock addition ($\Delta\mathbf{S}$)

Stock degradation



0.04 kg waste ($\mathbf{W_V}$) +

0.96 kg stock addition ($\Delta\mathbf{S}$)

Modelling of waste treatment in the IO-model

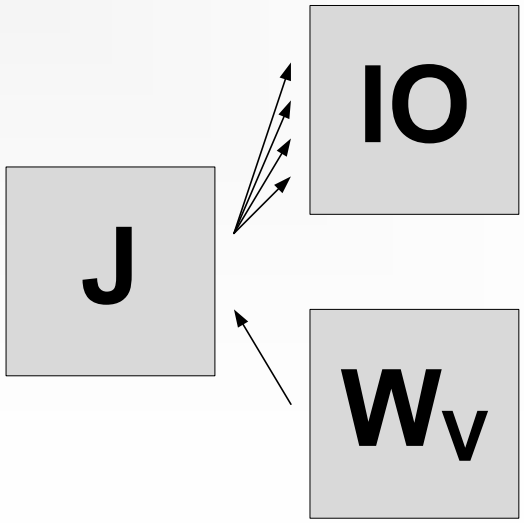
Specification of treatment for each waste type (**J**)

Calculated waste output from activity ($\mathbf{W_v}$)

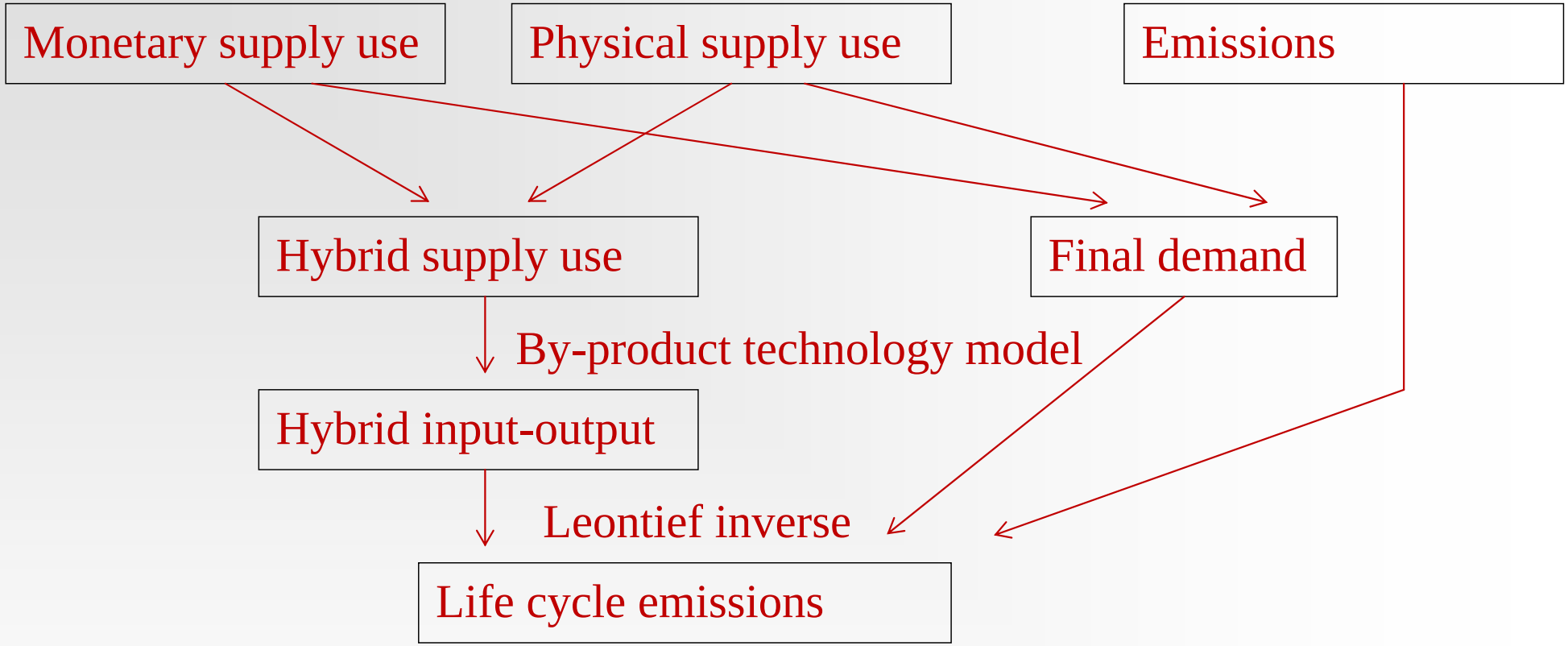
102 waste types → **34 waste types**

- waste from 58 physical produts in SUT
- waste from 44 waste treatment activities

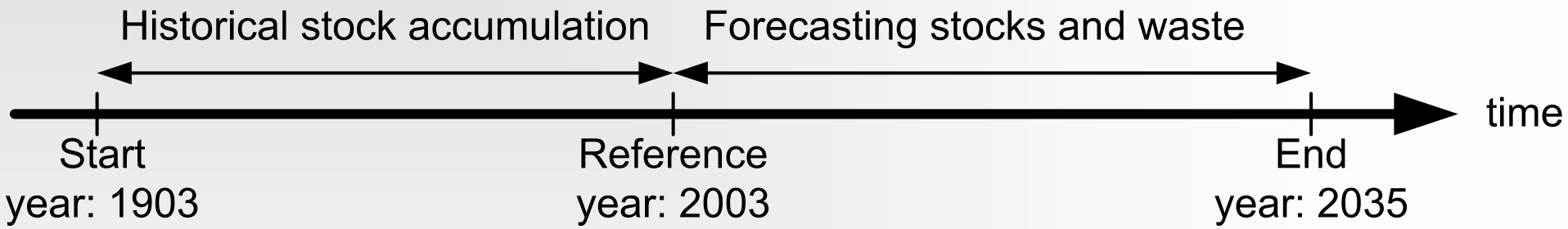
Hybrid units in IO-table:
Waste treatment services are measured in kg treated waste



Model output: Environmental impact

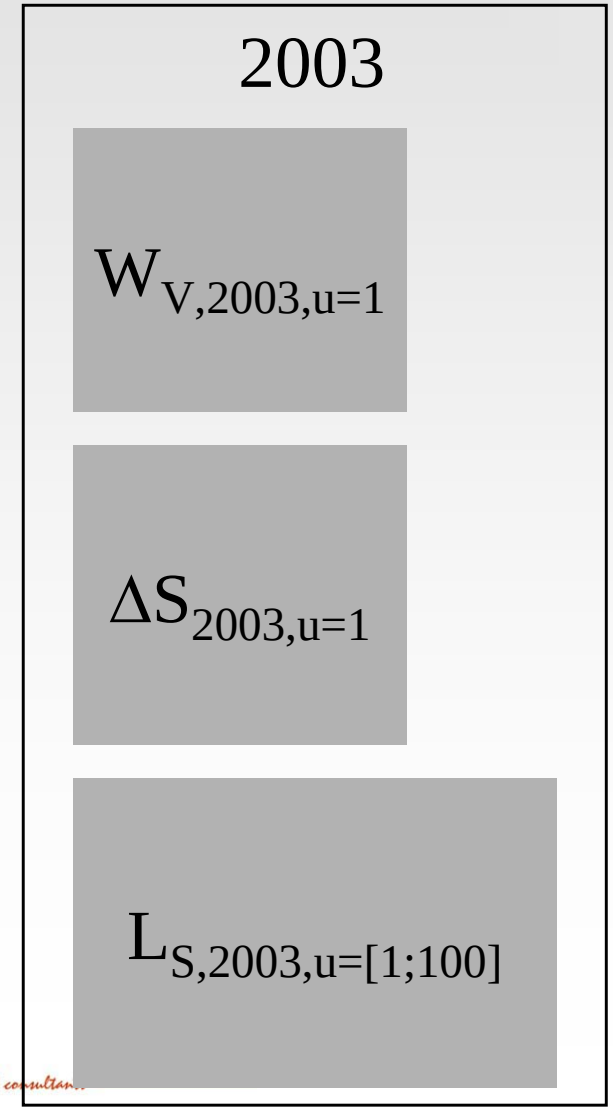


Time series: calculation of waste and stocks



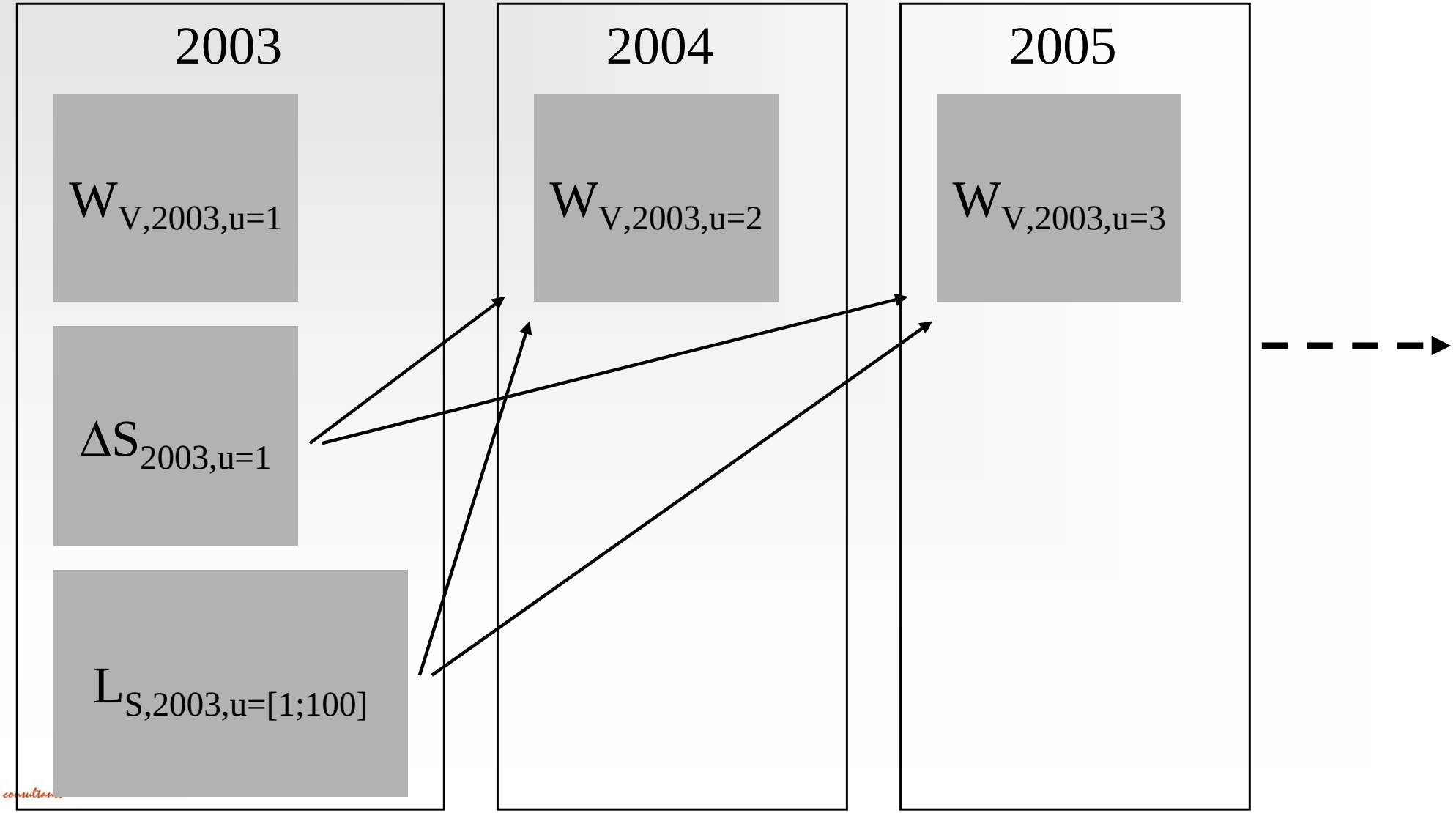
Model output: Accumulated waste generation

- For each year, e.g. 2003, we have:



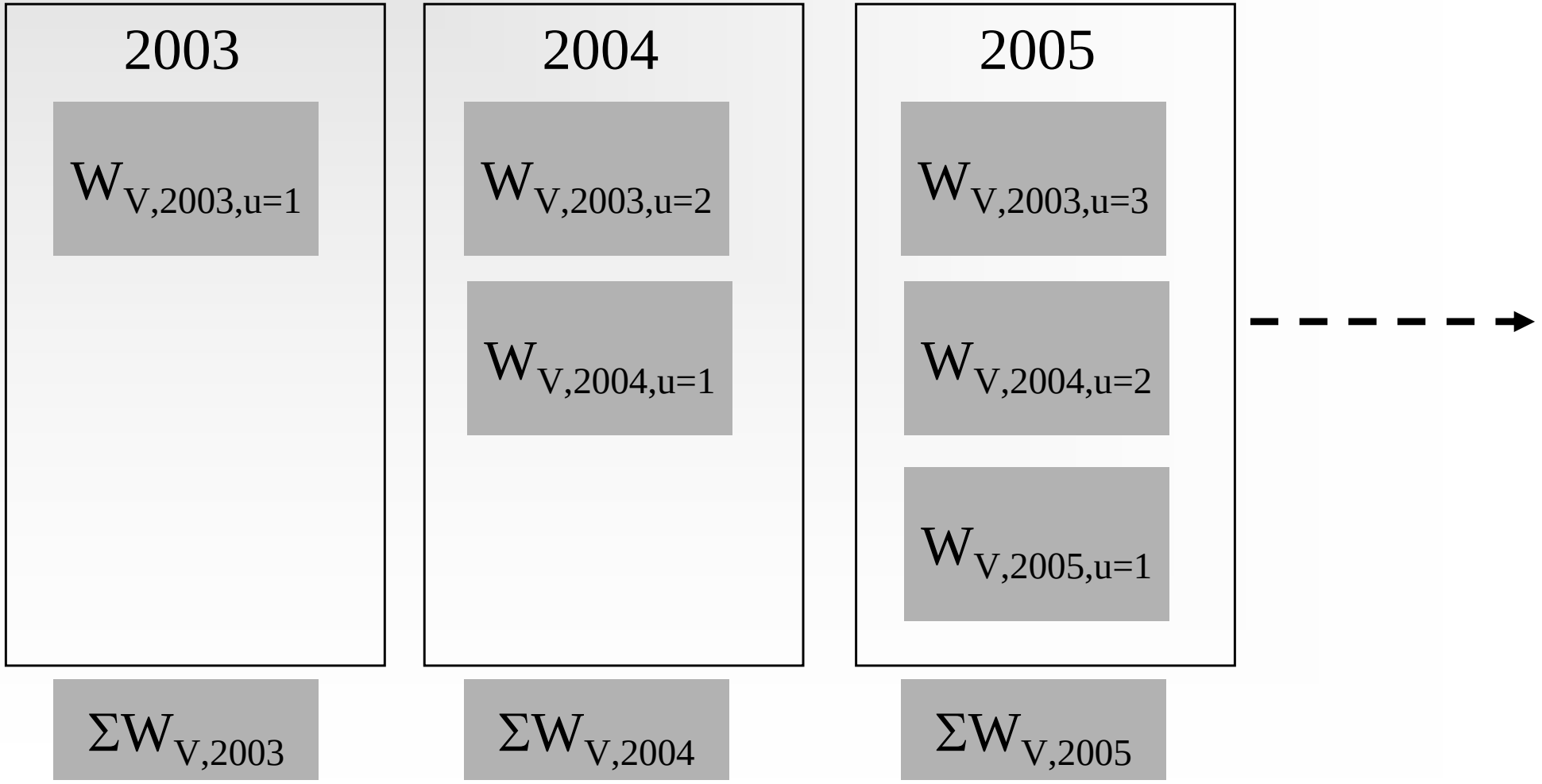
Model output: Accumulated waste generation

- We can calculate waste from $\Delta S_{2003,u=1}$ for the subsequent years:



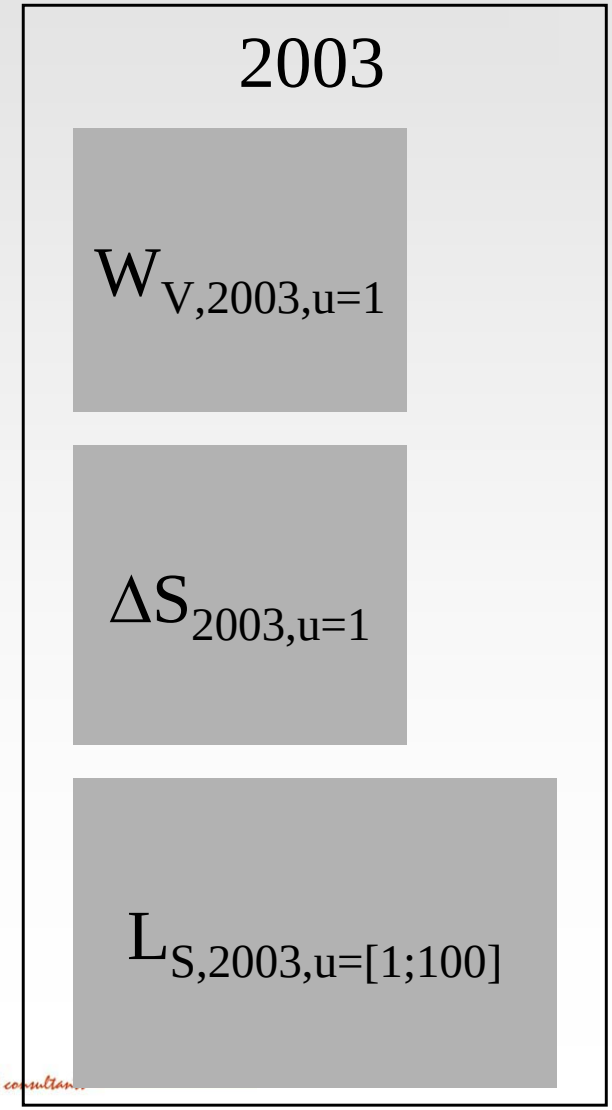
Model output: Accumulated waste generation

- We can do the same for all years, and then sum up the waste for each year originating from several years:



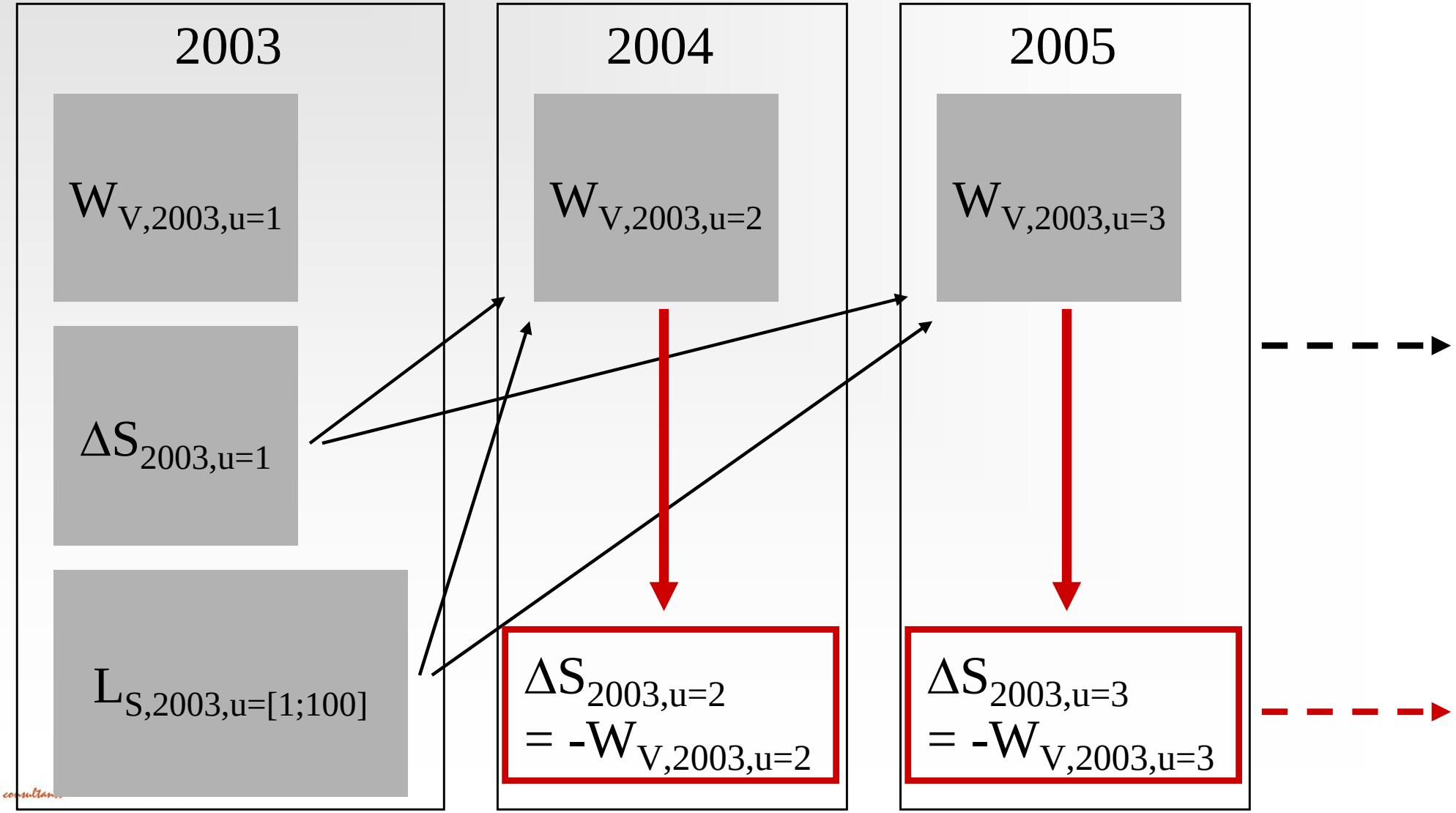
Model output: Accumulated stocks (S)

- For each year, e.g. 2003, we have:



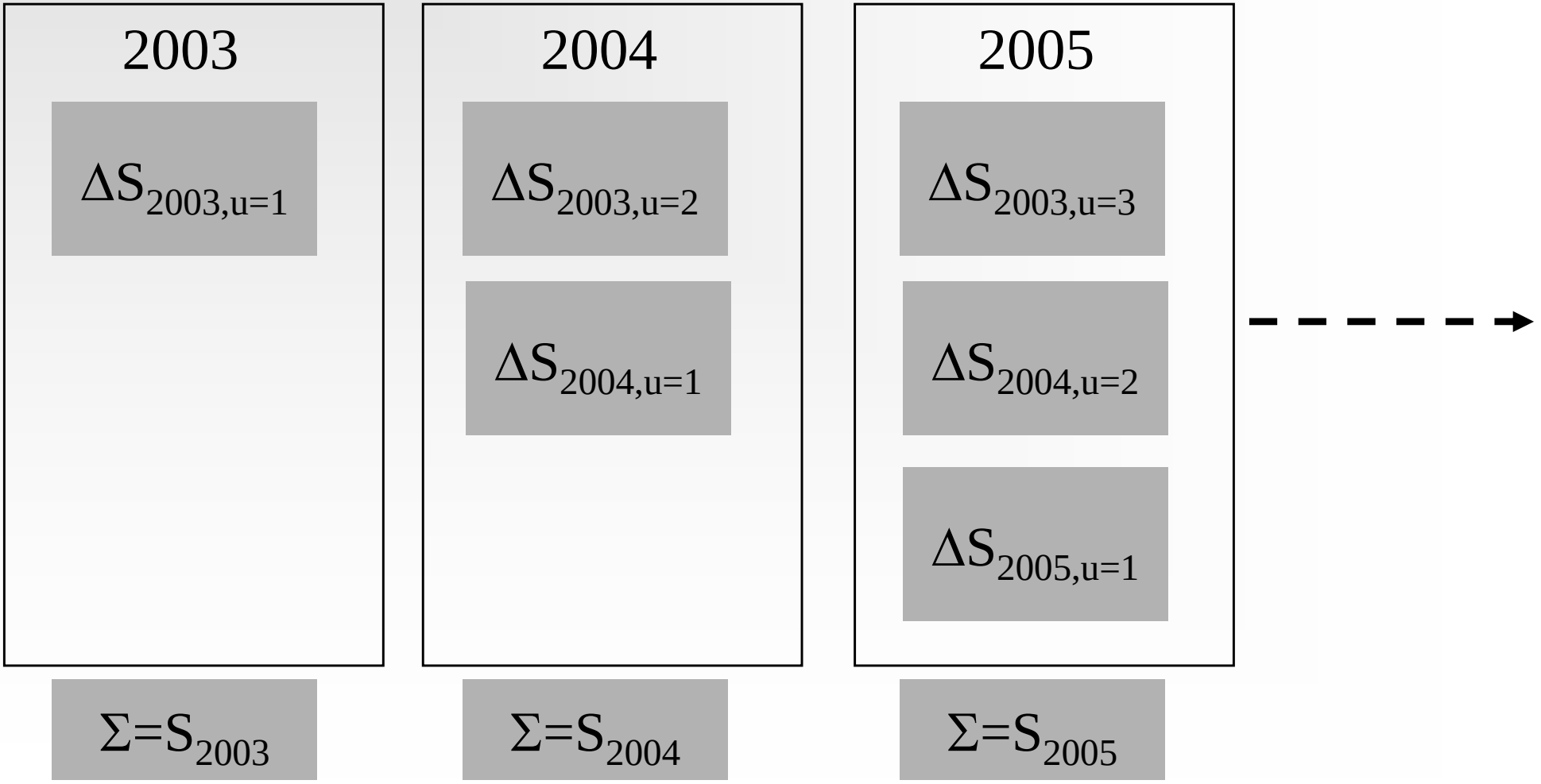
Model output: Accumulated stocks (S)

- We can calculate $\Delta S_{2003,u=2...endyear}$ for the subsequent years:



Model output: Accumulated stocks (S)

- We can do the same for all years, and then sum up the stock changes for each year originating from several years:



The model

- Self-validating; Mass balance checks (activities and products)
- Overall model outputs (wastes and stocks) are:
  - only affected by uncertainties in resource and emission data
  - all other uncertainties are allocation uncertainties
- State-of-art IO-model
  - Hybrid unit model (easy to use for hybrid LCA)
  - Waste is correctly modelled: Virgin/recycled, and several treatments