MinFuture

Design Principles

Models and uncertainty analysis

TU Wien, 07.06.2018

MinFuture is funded by the Horizon 2020 Framework Programme of the European Union under Grant Agreement no. 730330. The contents of this document are the sole responsibility of MinFuture and can in no way be taken to reflect the views of the European Union.

Design Principles

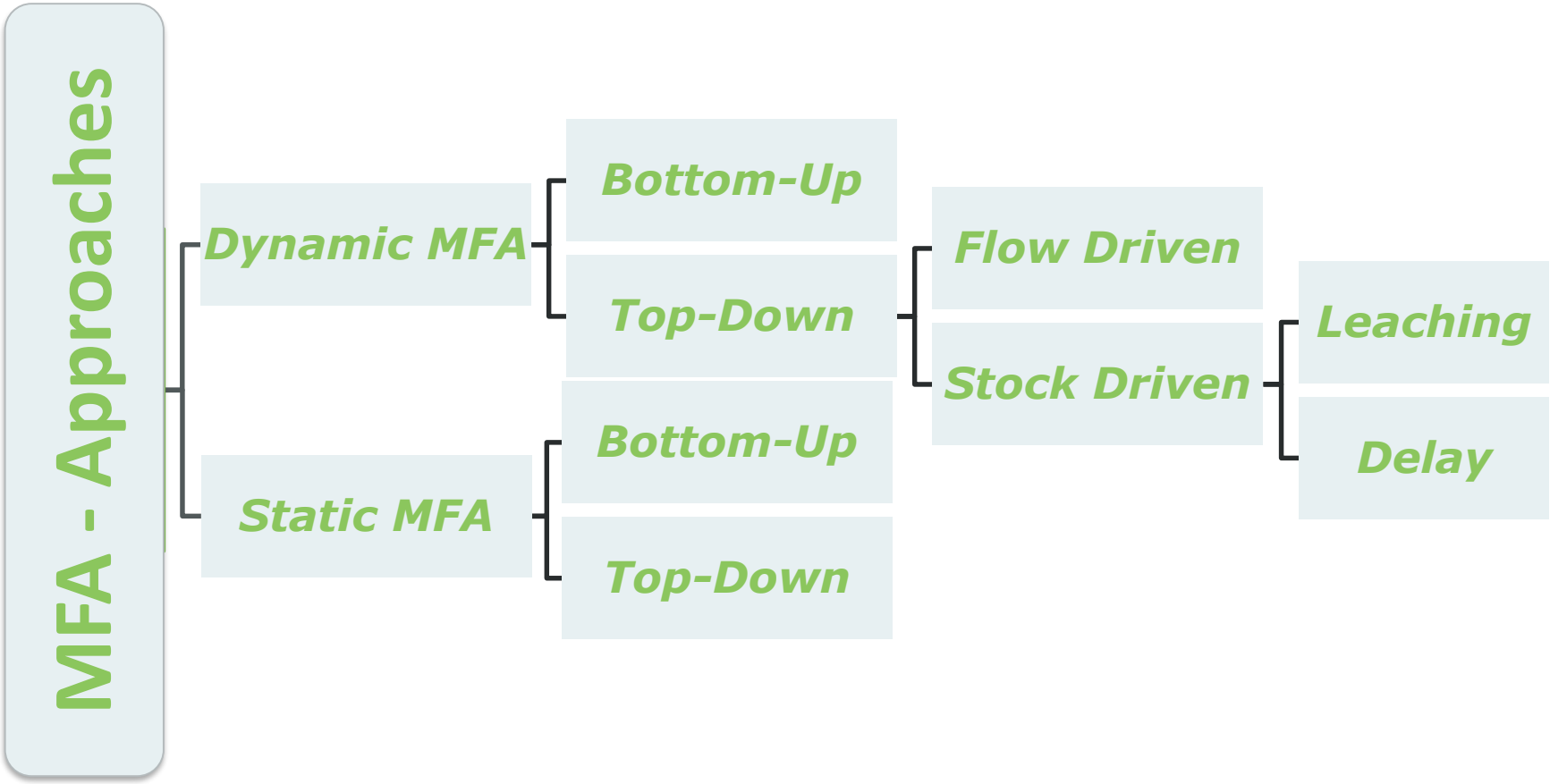
- → Models and Scenarios
- → Drivers
- → Model Uncertainty

Models and Scenarios

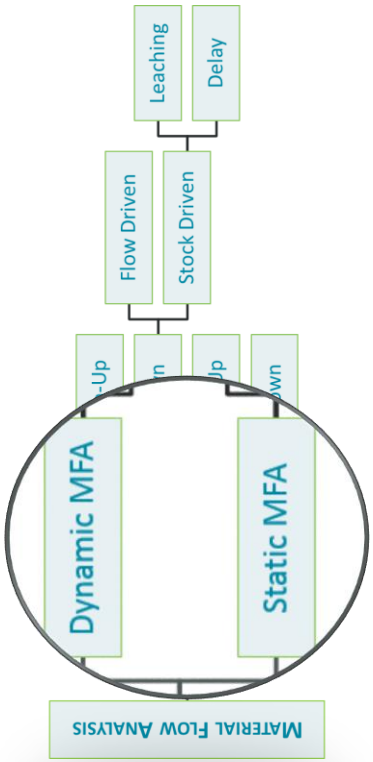
MFA Approaches

- **Material Flow Analysis**
  - generates a quantitative understanding of flows in a system
  - provides a basis for system optimization.
- **Estimation of future flows**
  - is an important information for environmental policy.
  - for demand and/or supply of raw materials are made based on scenarios.
  - is based on certain assumptions, which are transformed into mathematical functions.

Models and Scenarios



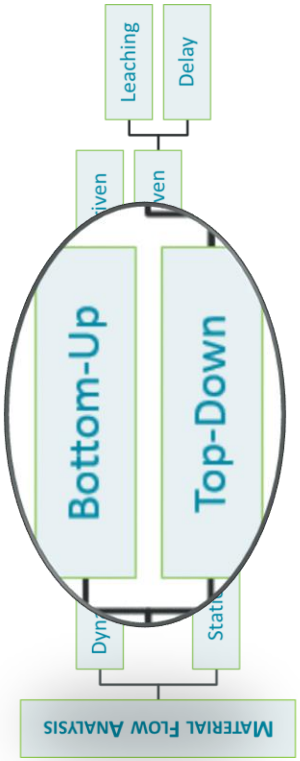
Models and Scenarios



- **Dynamic MFA**
  - describes the behavior of a system over several time increments.
  - provides information about material usage over time and consequent changes in stocks and flows within the system.

- **Static MFA**
  - investigates the patterns of material use and material losses in the system.
  - balances a certain period in time and provide a snapshot of a system.
  - is typically used to generate a quantitative understanding of material systems.

Models and Scenarios

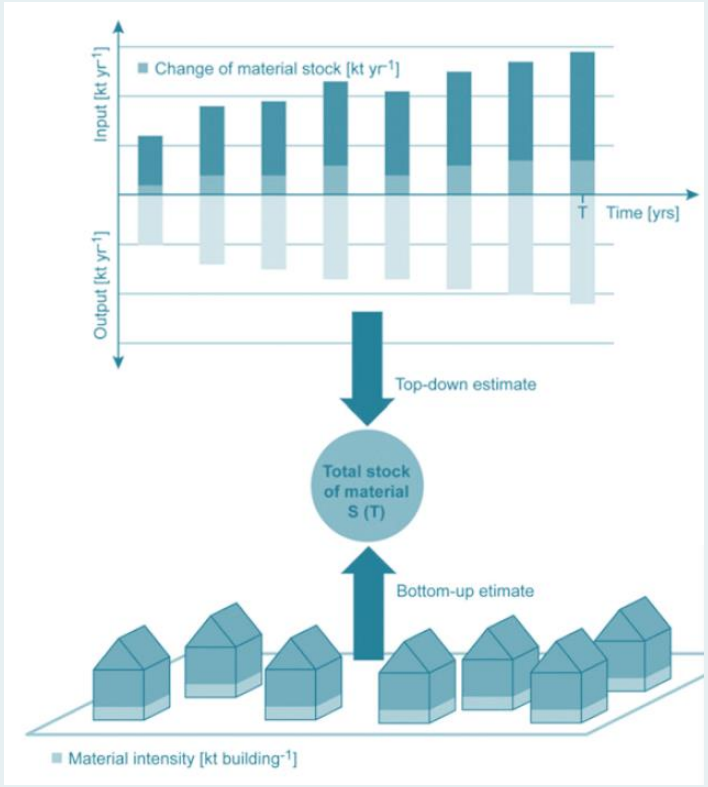


- **Top-Down**
  - A time series of input-output balances is used to calculate the total stock.

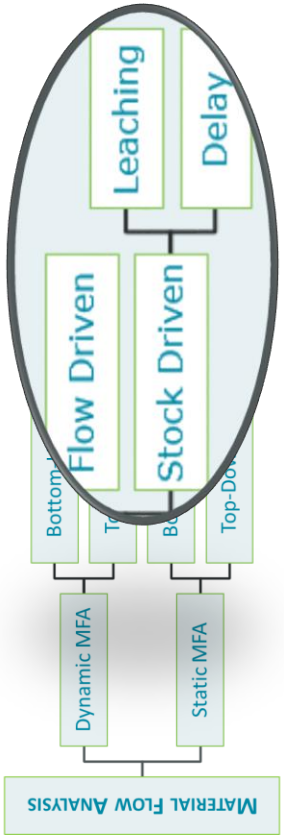
    → Derives the stock from the net flow (the difference between inflows and outflows)

- **Bottom-Up**
  - Directly estimates the stock by summing up the material in question

    → Estimates on deriving the total stock from the material intensities



Models and Scenarios



- **Flow Driven** *"Driven by the inflow"*

  Given: the inflow and a lifetime distribution

  → the outflow and stock are calculated

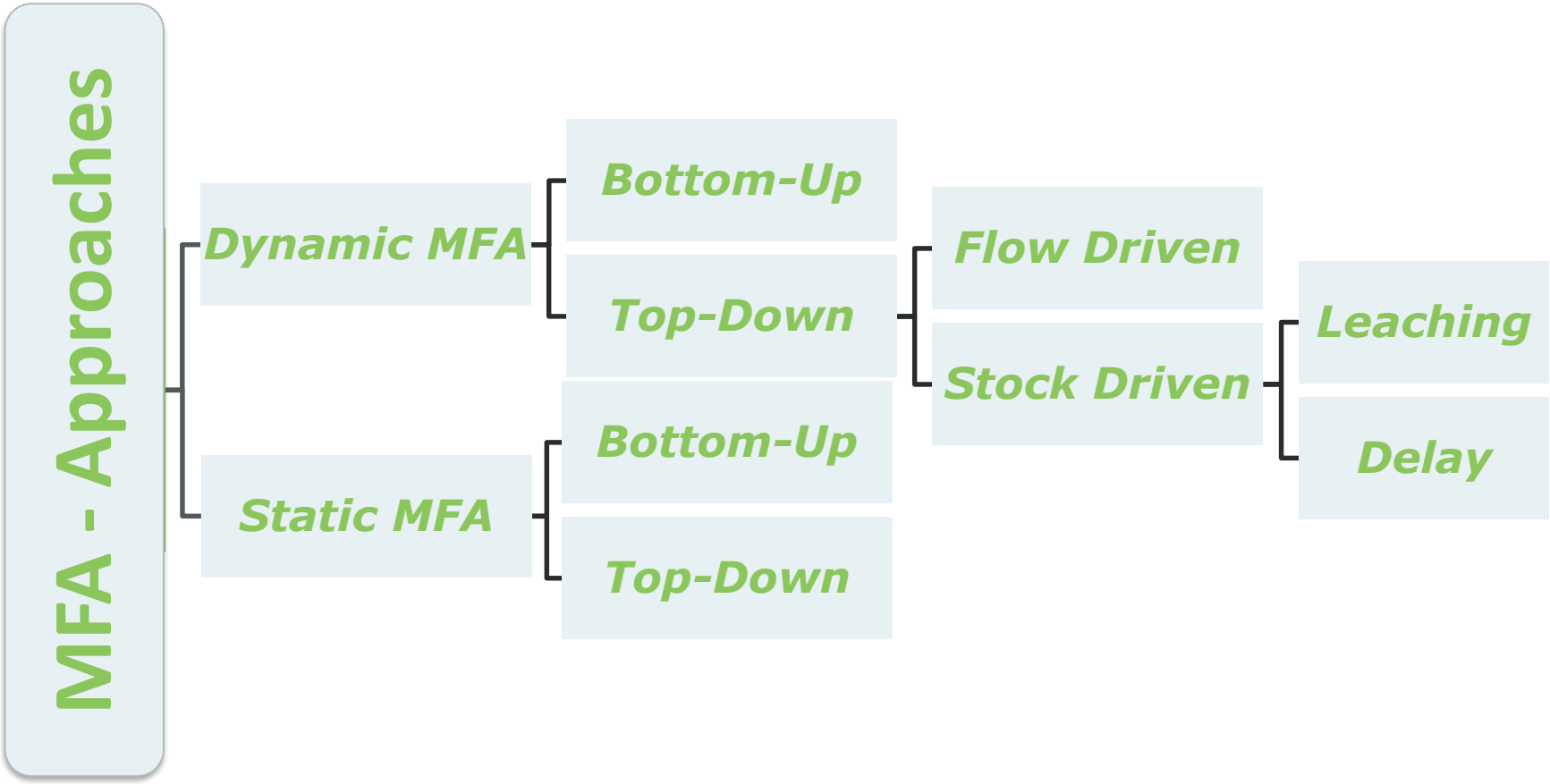
- **Stock Driven** *"Driven by the stock"*

  Given: the stock and a lifetime distribution

  → the outflow and inflow are calculated

Leaching	**Delay**
○ The stock as a size buffer - every stock is classified into age categories. ○ The output is calculated as a leaching part of the stock for each year t.	○ The outflow is a delayed inflow: the stock as a time buffer. ○ The life span of the products determines the delay.

Models and Scenarios



Models and Scenarios

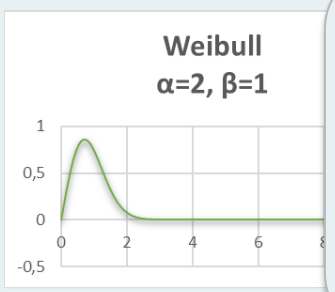
Drivers

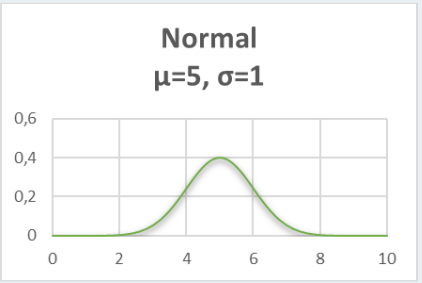
- Driver is any factor that directly or indirectly causes a change in a system
- With increasing mobilization, transformation and use of materials, the influence of anthropogenic activities as drivers of material flow systems increases
- Resource policies can only successfully contribute to efficiency, consistency and sufficiency when they tackle key underlying drivers

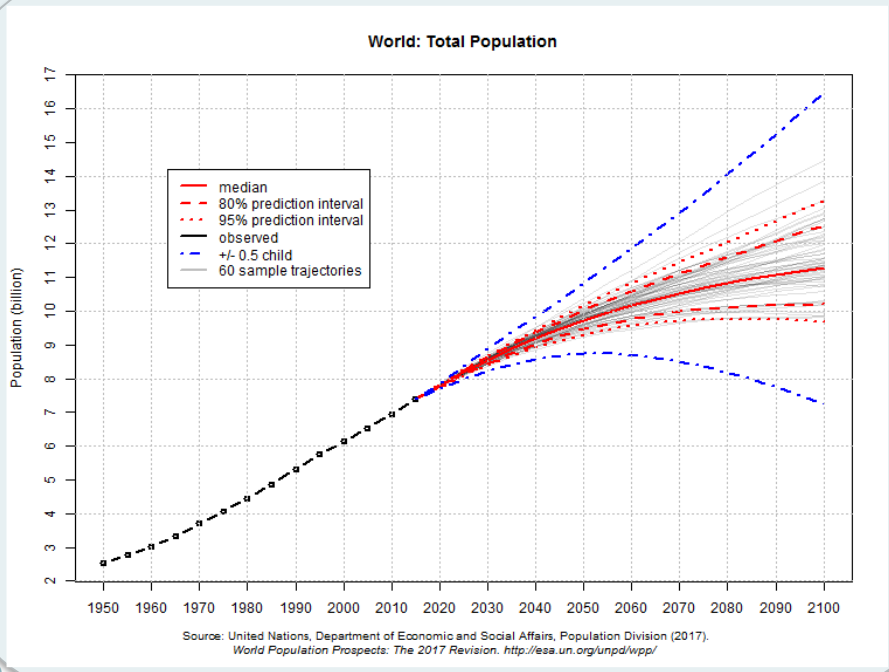
Models and Scenarios

Drivers

- **Lifetime Distribution**
  - Weibull, Normal,
  - Log, Beta
  - …
- **Demographic drivers**
  - Population, Urbanization
  - Marriage, divorces
  - Families and households
  - …
- **Socio-economic drivers**
  - Gross domestic product
  - Employees
  - Per capita floor area
  - …







Model uncertainty analysis

Model uncertainty

- To examine the nature of uncertainty **("Why")**
- To assess existing approaches **("How")**
- To identify requirements to survey and report uncertainty **("procedure")**

Model uncertainty analysis

Nature of uncertainty

- Aleatory variability and epistemic uncertainty
- Causes of uncertainty
- Sources of uncertainty
- Types of uncertainty

Model uncertainty analysis

Nature of uncertainty

- **Aleatory variability and epistemic uncertainty**
- **Causes of uncertainty**

  • Statistical variation • Variability • Inherent randomness and unpredictability • Subjective judgment • Disagreement • Linguistic imprecision • Approximation
- **Sources of uncertainty**

  • Non-deterministic behaviour of a system • Uncertainty of model parameter values and model structure • Uncertainty due to external influence factors or numerical solutions of model equations
- **Types of uncertainty**

  • Parameter uncertainty • Scenario uncertainty • Model uncertainty

Model uncertainty analysis

Approaches to deal with uncertainty

- Data classification
- Uncertainty analysis
- Sensitivity analysis
- Comparison of model structure

Model uncertainty analysis

Approaches to deal with uncertainty

- **Data classification**
  - *Asymmetric intervals • Symmetric intervals*
  - *PEDIGREE Matrix • Information defects • Combinations*
- **Uncertainty analysis**
  - *STAN Software • Mathematical MFA*
  - *Probabilistic MFA • Fuzzy set theory*
- **Sensitivity analysis**
  - *Identify critical model parameters and develop scenarios in descriptive and exploratory MFA*
- **Comparison of model structure**
  - *The differences in system boundaries and definition of flows and processes are highlighted - often done qualitatively*

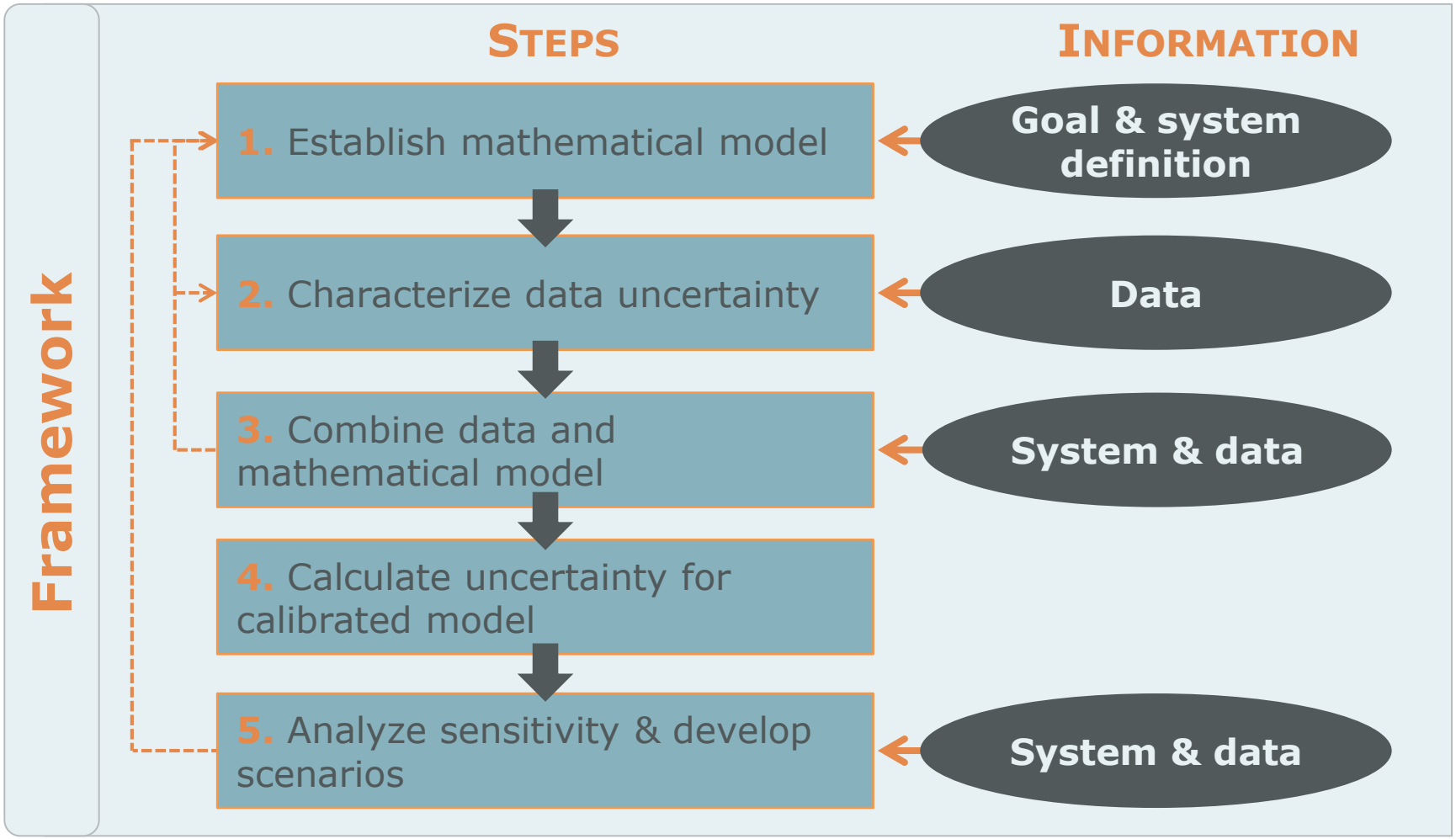
Model uncertainty analysis

Framework

- Should facilitate transparent uncertainty analysis in MFA
- Is suitable to accommodate any of the approaches presented
- Provide a systematic way to consider uncertainty in MFA
- Should form a basis for consistently communicating the approach

→ **STEP–WISE FRAMEWORK**

Model uncertainty analysis



Pyramide: Design Principles

Pyramide: Conclusion

- To handle uncertainty, define the elements of the **system** and the mathematical relationships between them (mass balance principle)
- **Data** often originates from different sources
  - Collected data is unavoidably of varying quality and often the limiting factor
  - If sufficient empirical evidence is available, statistical techniques can be applied
- A **model** is a simplified version of the real system
  - Model parameters approximate the real properties of the system
  - Assumptions/simplifications are made that lead to uncertainty regarding the validity of the model predictions
- **Indicators** are often quantified as possible output based on a set of uncertain input (e.g. sensitivity analysis is used to evaluate the effects of parameter variation on the model outputs)
- The results are typically inherently limited in terms of accuracy and, thus, in their reliability in subsequent **decision-making processes**

Pyramide: Design Principles

→DISCUSSION

MinFuture

Thank You for Your Attention!

TU Wien, 07.06.2018

MinFuture is funded by the Horizon 2020 Framework Programme of the European Union under Grant Agreement no. 730330. The contents of this document are the sole responsibility of MinFuture and can in no way be taken to reflect the views of the European Union.