

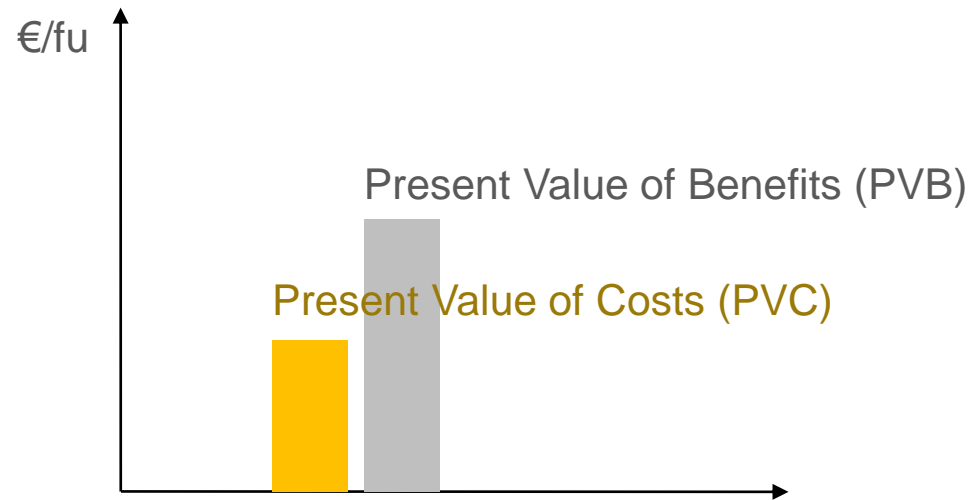
Cost-benefit analysis of PHA-based plastics with improved barrier properties

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Goal

- To identify economic weak points of the (PHA)-based polymers with improved barrier properties, taking into account costs of externalities
- To estimate magnitude of revenues that is needed to make PHA-based polymers with improved barrier properties a sound investment

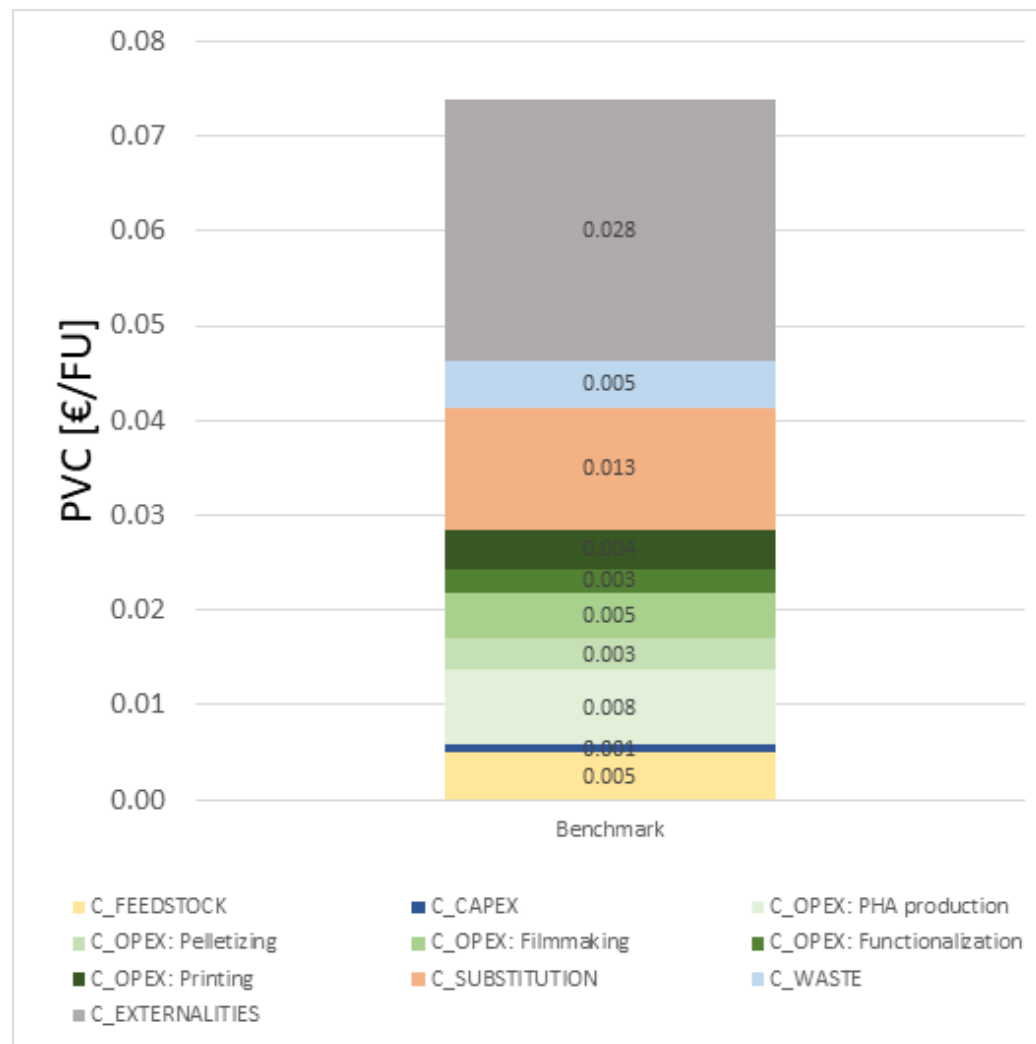


Present Value of Costs (PVC)

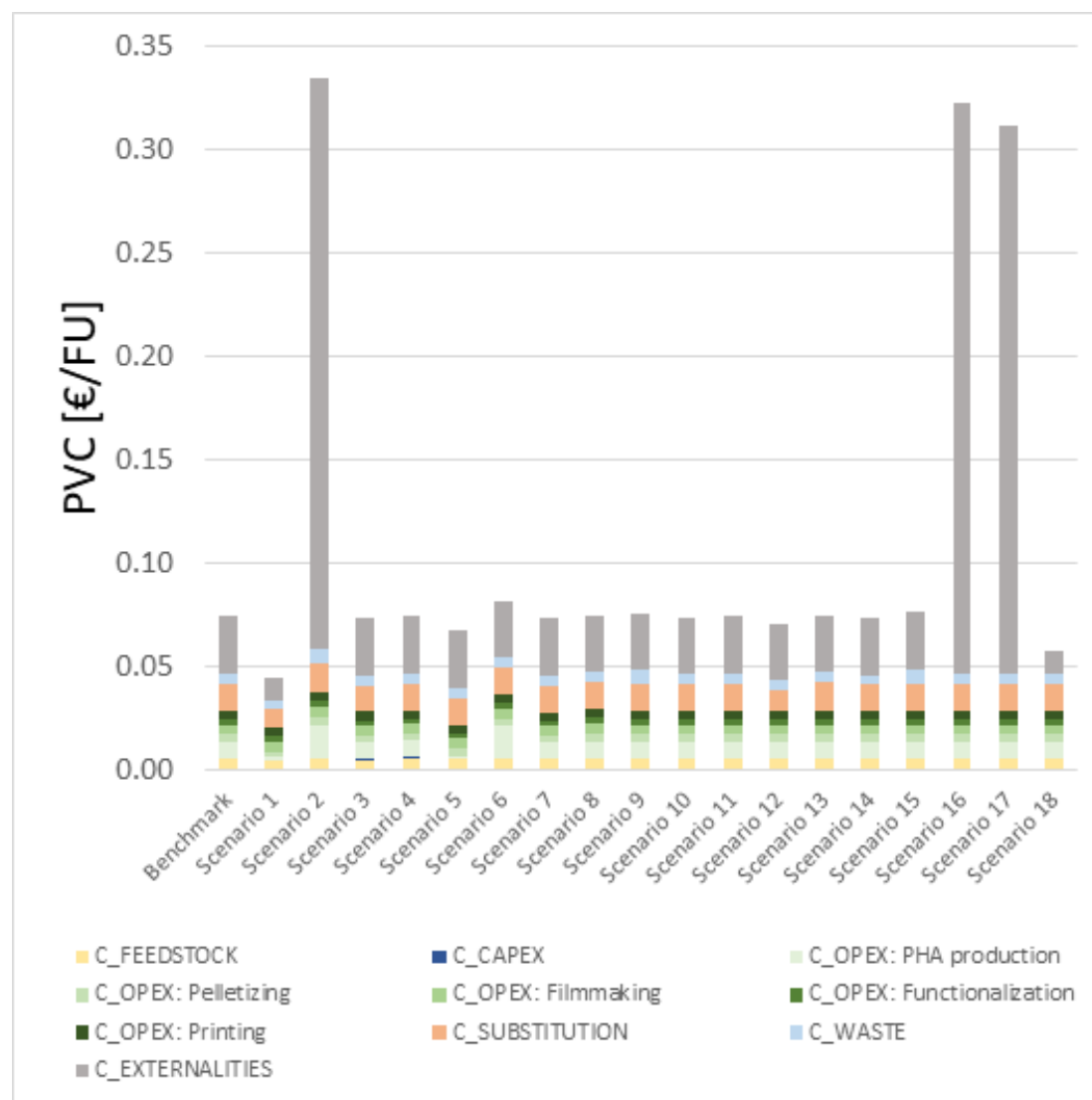
$$PVC = C_{\text{feedstock}} + C_{\text{CAPEX}} + C_{\text{OPEX}} + C_{\text{substitution}} + C_{\text{waste}} + C_{\text{externalities}}$$

Cost	Source of data	Description
$C_{\text{feedstock}}$	Maravic et. al (2015)	Production of molasses as by-product of sugar from sugar-beet. Costs of four different years (2007, 2009, 2010, 2011) are averaged to calculate default cost.
C_{CAPEX}	Saavedra del Oso et. al (2021)	PHA production cover biomass separation, pretreatment, recovery, separation and purification. Costs of eight different processes (H1, H2, H3, H4, L1, L2, L3, L4) are averaged to calculate default cost.
$C_{\text{OPEX}} - \text{PHA production}$	Saavedra del Oso et. al (2021)	PHA production cover biomass separation, pretreatment, recovery, separation and purification. Costs of eight different processes (H1, H2, H3, H4, L1, L2, L3, L4) are averaged to calculate default cost.
$C_{\text{OPEX}} - \text{Pelletizing}$	statista (2021)	Assumed to be equal to cost of required electricity. Cost of electricity for industry in Italy for high (>20 000 Mwh) and low (500 – 2000 Mwh) consumers are averaged to calculate default cost.
$C_{\text{OPEX}} - \text{Filmmaking}$	Roes et. al (2021)	Assumed to be equal to film production of conventional plastic films. Only one value given and used.
$C_{\text{OPEX}} - \text{Functionalization}$	Biobarr project partners	PHA-based films are either functionalized by Al/AIOx metallization or PLA lamination. Al metallization modelled in the default scenario.
$C_{\text{OPEX}} - \text{Printing}$	Biobarr project partners, statista (2021)	Printing costs are composed of ink costs and costs for required electricity for surface treatment, lamination and printing itself. No range is given for ink cost. Cost of electricity for industry in Italy for high (>20 000 MWh) and low (500 – 2000 MWh) consumers are averaged to calculate default cost.
$C_{\text{substitution}}$	Milan Chamber of Commerce (2021), Tran et al. (2021)	Cost of barley grain used for production of animal feed. Average cost of barley grain in 2021 is used as default cost.
C_{waste}	Gibbs et al. (2014)	PHA-based films are either landfilled and incinerated in Italy, or incinerated in Germany after end-of life. A 50% landfilling and 50% incineration rate in Italy is modelled in the default scenario.
$C_{\text{externalities}}$	LCA, Dong et al. (2019), Weidema et al. (2015)	Environmental impacts are monetized using ReCiPe 2016, EPS 2015 and LIME 2 LCIA methods. A combination of EPS 2015 and ReCiPe 2016 (scenario A) is used as default.

Present Value of Costs (PVC)



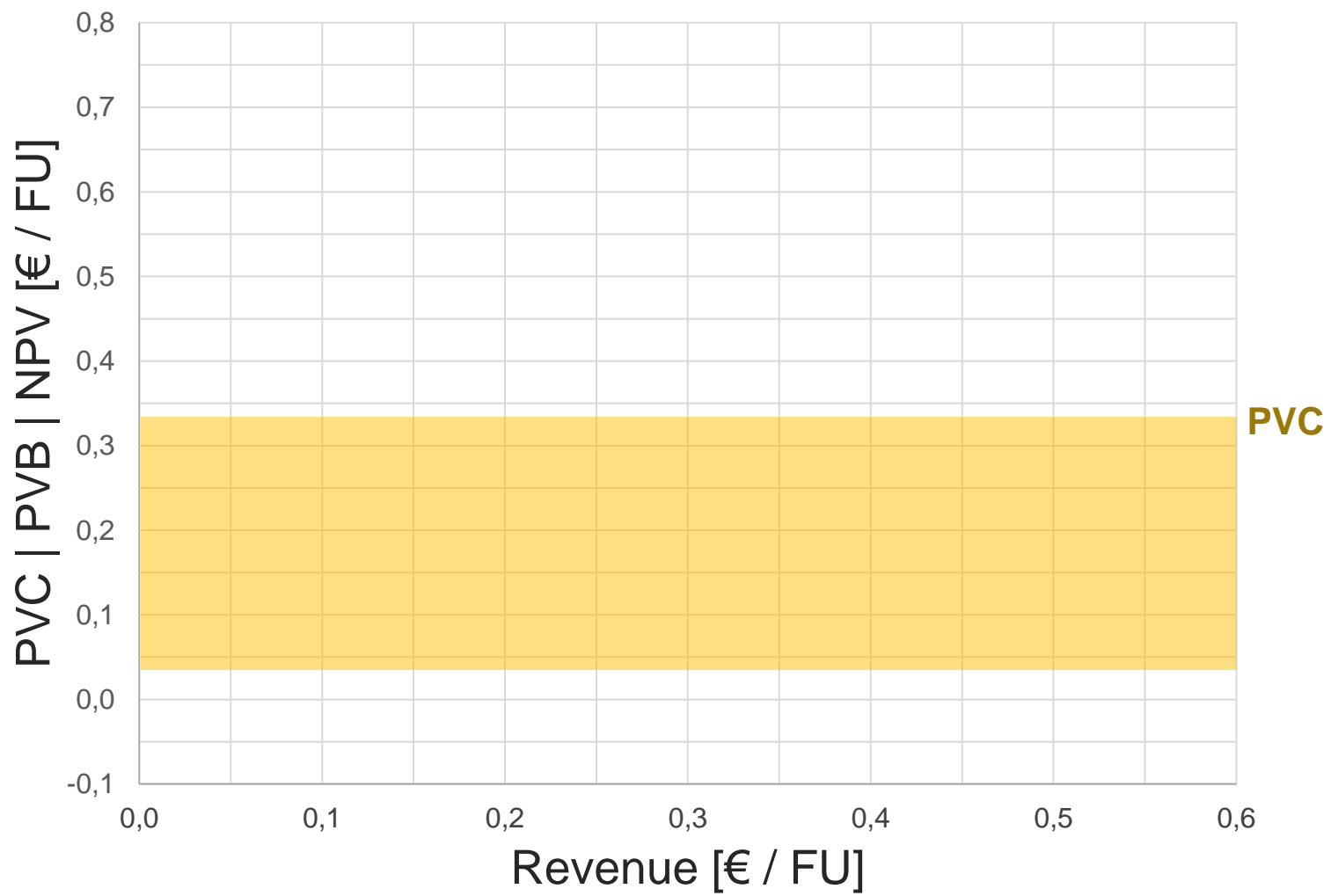
Variability and uncertainty in the PVC

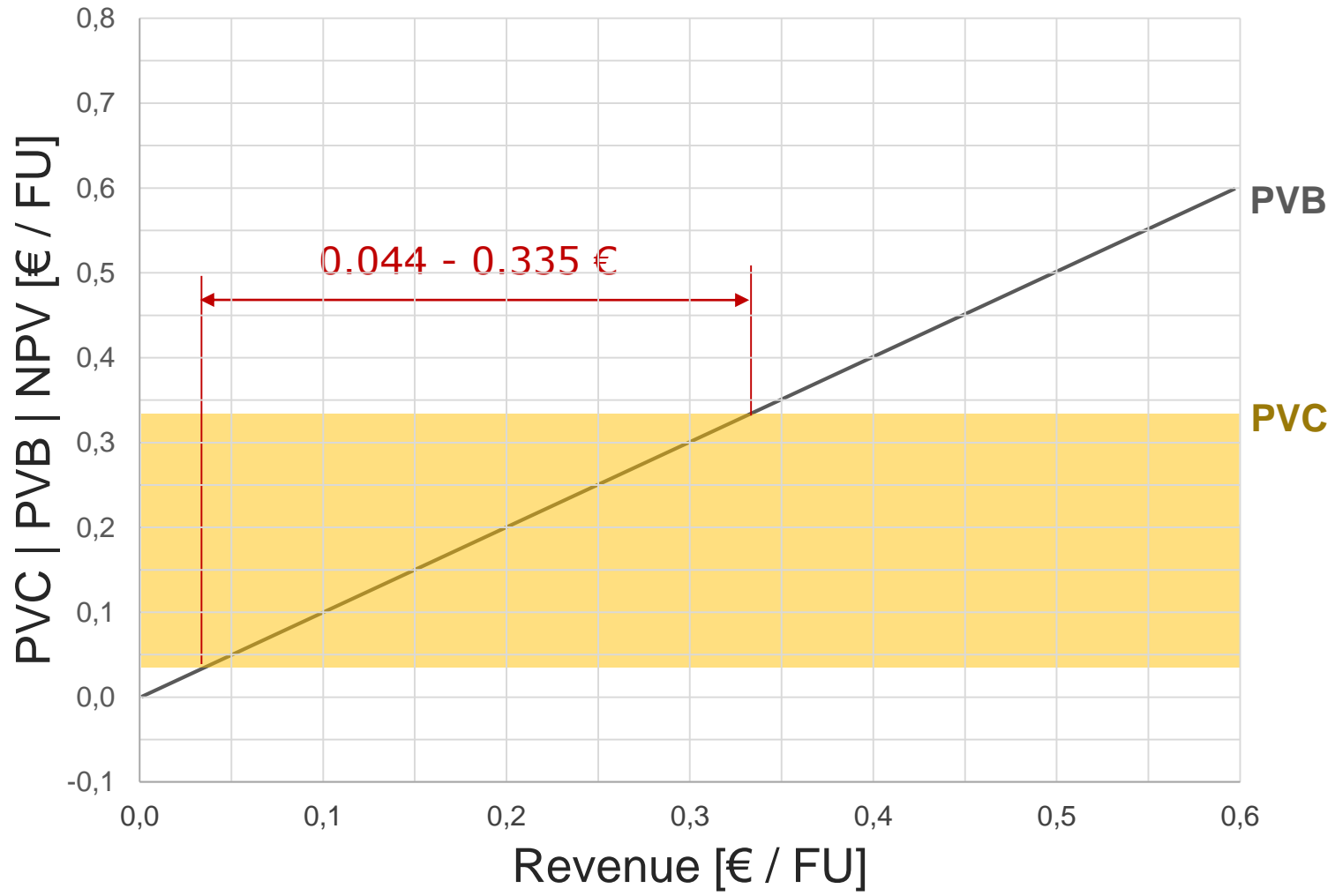


Present Value of Benefits (PVB)

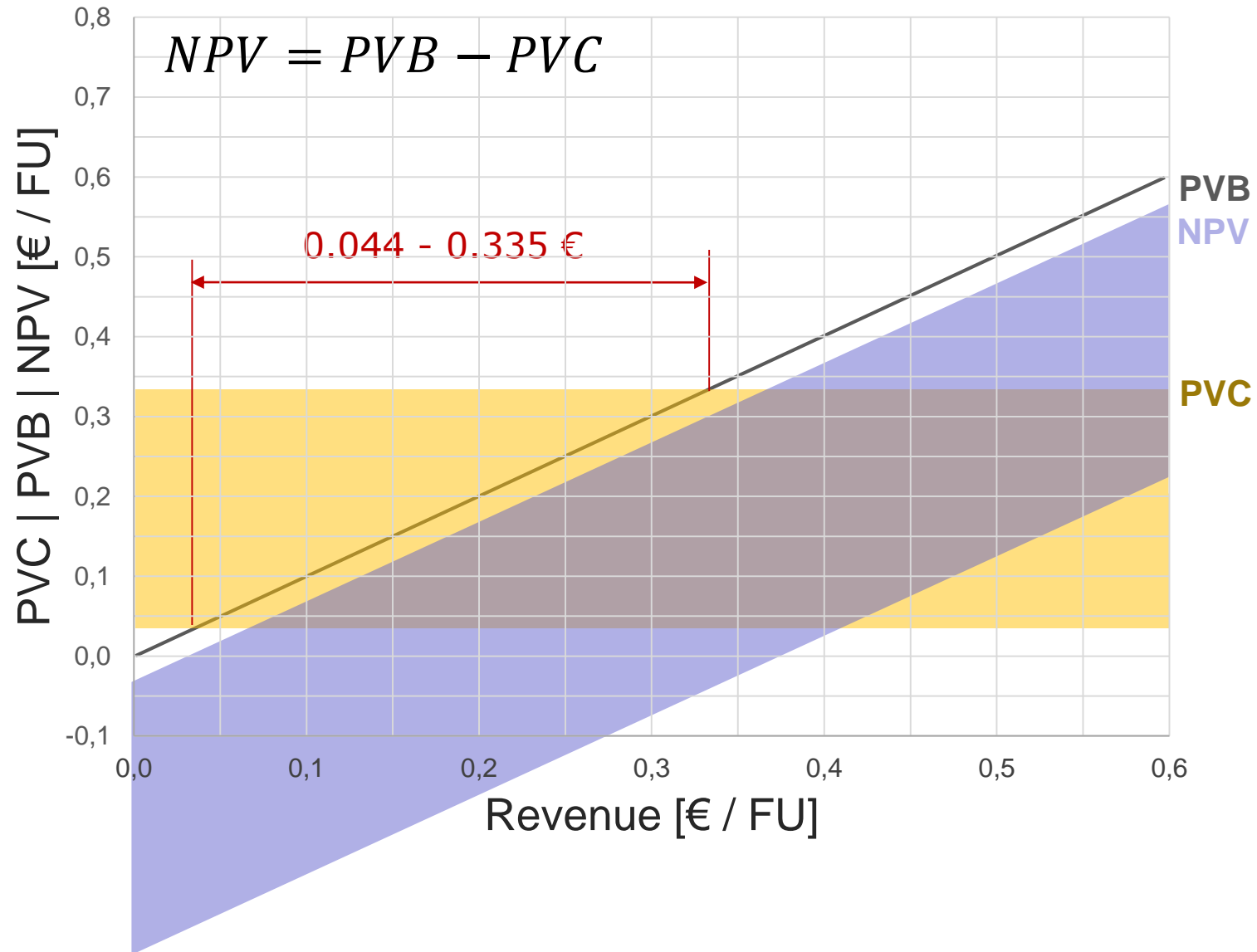
$$PVB = C_{\text{revenue}} + C_{\text{barrier}}$$

- Benefits from barrier properties challenging to estimate, and hence not modelled
- Revenues from PHA-based polymers with improved barrier properties not known
- We calculated the range of revenues that would make the PHA-based polymers a sound investment





Net Present Value (NPV)



Main findings

- Benefits from revenues of PHA-based plastic packaging should be in range of 0.044 - 0.335 € per 1 croissant to outweigh costs
- Monetized environmental impacts are the largest contributors to the present values of costs
- Sugar beet molasses used as feedstock is an economic weak point