Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Material needs for greenhouse gas neutral mobility systems

Decarbonisation and Resource Efficiency – 100% Renewable Energy and more

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Introduction

- **The decarbonisation of the global mobility system up to 2050 will cause tremendous effects and shifts of global material supply chains!**
- **The rising new mobility age will generate “material winners” and “material losers”!**
- **The supply chain shifts will produce significant economic, social and ecological impacts – positive and negative ones!**
- **From a prediction perspective the „declining supply chains“ are easier to identify!**
  - **The rising material needs are more difficult to predict in a long term perspective due to competitive new technologies and possible upcoming innovations within the next 3 decades!**

Declining supply chains and consequences for material needs

- **Declining share and declining absolute units of internal combustion engines (ICE) for passenger cars and partly (?) for trucks & busses!**
- **Declining supply chains for fossil fuels: oil production, pipelines, oil refineries, fuel distribution including gas stations!**
- **Decreasing need for steel, cast iron, cast aluminium and lead acid battery components (declining demand for ICE components)!**
- **Decreasing need for automotive catalysts: decreasing demand for PGM (platinum, palladium and rhodium) and the rare earth element cerium!**
- **Further decreasing components & materials: large catalysts for oil refineries etc. (declining demand for molybdenum, PGM etc.)!**

Rising supply chains

- **Rising share and rising absolute units of electric drive trains for passenger cars!**
- **Rising units of electric bicycles!**
- **Rising units of fuel cells (passenger cars??, electric bicycles?, busses, trains etc.)!**
- **Increasing relevance (probably) of overhead hybrid electric trucks (OH-trucks) including appropriate infrastructure (overhead wiring)!**
- **Rising demand for H2 and Power-to-X infrastructure (for trucks, wheel loaders, vessels, aircrafts) and rising demand for electricity storage!**

Consequences for material needs caused by the “rising stars”

- **Rising demand for batteries will lead to significantly increasing demand for lithium and other battery materials (copper, cobalt, nickel etc.)!**
- **Rising demand for electric motors could lead to tremendously larger demand for rare earths like neodymium, dysprosium etc.: but alternative motor technologies without rare earths are already available (mainly for BEV)!**
- **Rising demand for fuel cell technology could cause e.g. significant demand for platinum!**
- **Rising demand for H2 and Power-to-X infrastructure will increase demand for copper, nickel, platinum, iridium, cobalt etc.**
- **Rising demand for copper in a large scale for many technologies!**

Lithium and rare earths demand for passenger cars

- **Next slides show some selected results of the on-going project *"Substitution as a strategy for reducing the criticality of raw materials for environmental technologies - Determination of potentials for second-best solutions (SubSKrit)"****
- **Potential demand growth for lithium, dysprosium and neodymium will be presented!**
- **The selected metals are key materials for batteries and electric motors!**
- **The estimations include material demand for passenger cars only!**

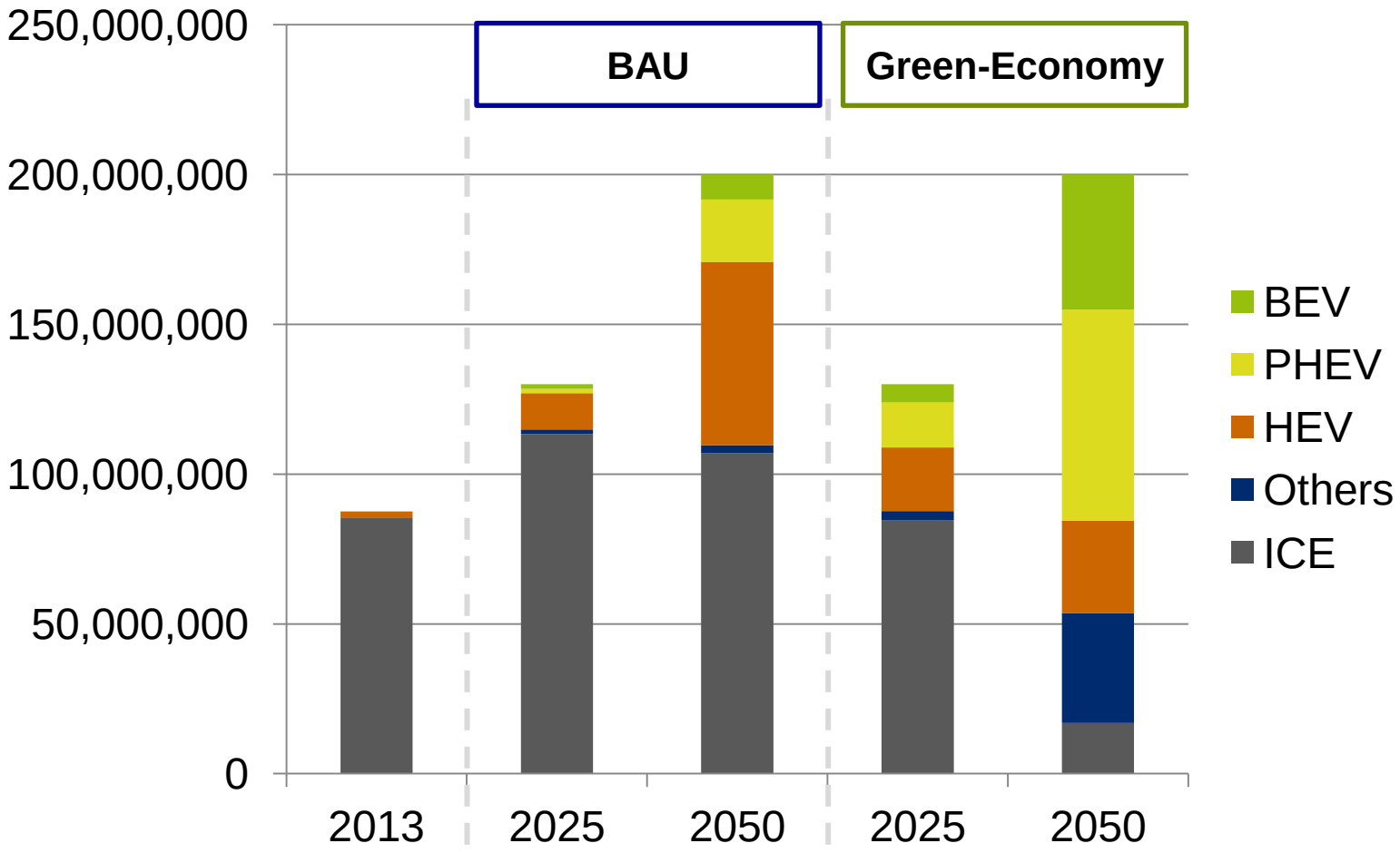
* Oeko-Institut and IZT commissioned by Umweltbundesamt (2014 – 2017)

Scenarios for annual global passenger car production I/II

Global		Business-As-Usual		Green-Economy	
	2013	2025	2050	2025	2050
Total passenger car sales	87.595.998	130.000.000	200.000.000	130.000.000	200.000.000
thereof HEV	**2.000.260**	**12.082.616**	**61.119.671**	**21.144.578**	**30.960.075**
thereof BEV	**110.200**	**1.510.327**	**8.320.493**	**6.041.308**	**45.074.534**
thereof PHEV	**41.800**	**1.510.327**	**20.852.594**	**15.103.270**	**70.436.777**
thereof ICE	85.417.114	113.386.403	106.933.744	84.690.189	16.939.435
thereof others (e.g. fuel cell)	26.623	1.510.327	2.773.498	3.020.654	36.589.180

Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013)

Scenarios for annual global passenger car production II/II



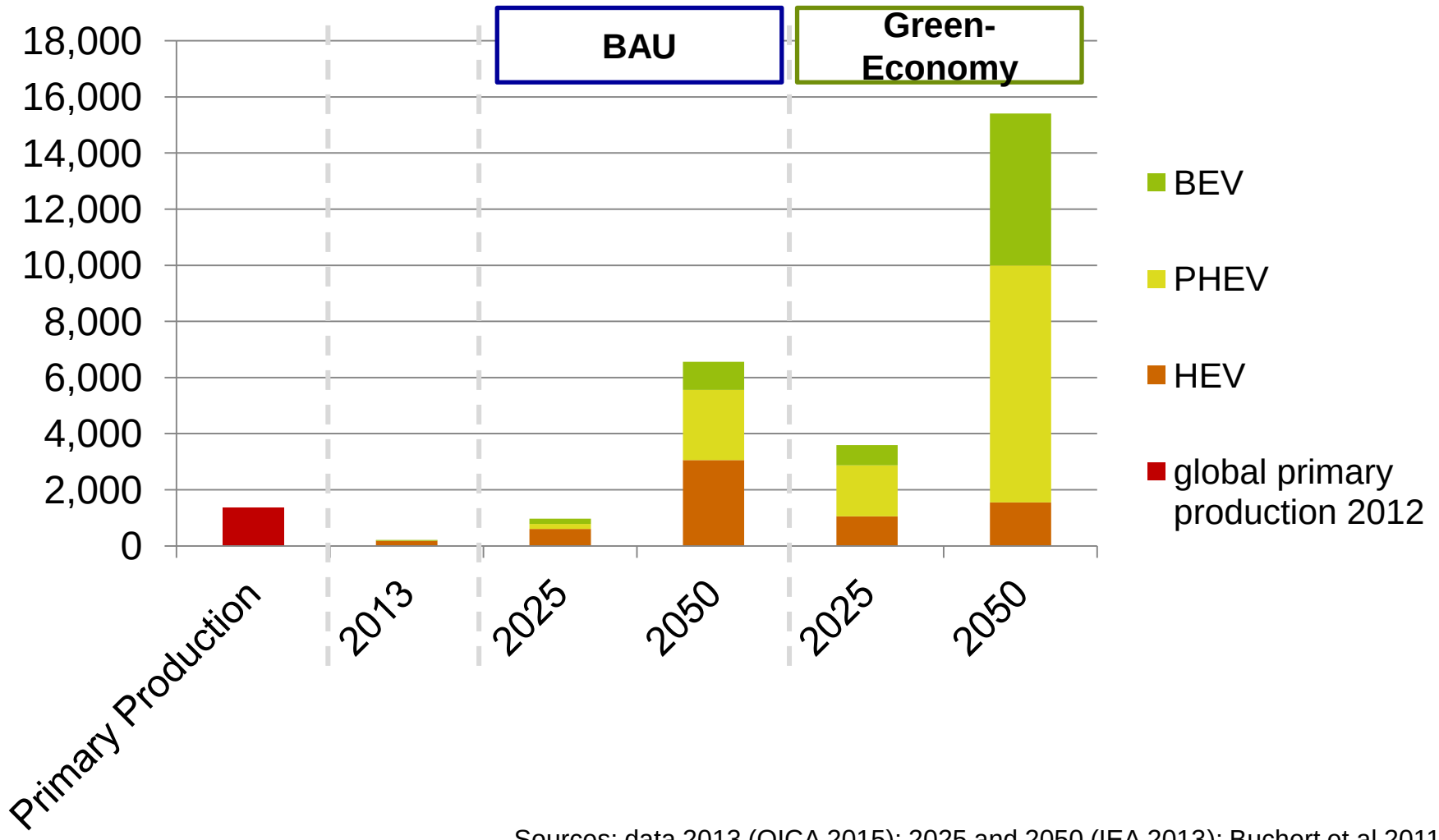
Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013)

Rough estimate of dysprosium demand in metric tonnes I/II

Global		Business-As-Usual		Green-Economy	
	2013	2025	2050	2025	2050
Total passenger car sales	n.a.	n.a.	n.a.	n.a.	n.a.
thereof HEV	**180**	**604**	**3.056**	**1.057**	**1.548**
thereof BEV	**23**	**181**	**998**	**725**	**5.409**
thereof PHEV	**9**	**181**	**2.502**	**1.812**	**8.452**
thereof ICE	-	-	-	-	-
thereof others (e.g. fuel cell)	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013); Buchert et al 2011

Rough estimate of annual DYSPROSIUM demand for HEV, PHEV and BEV [in metric tonnes] II/II



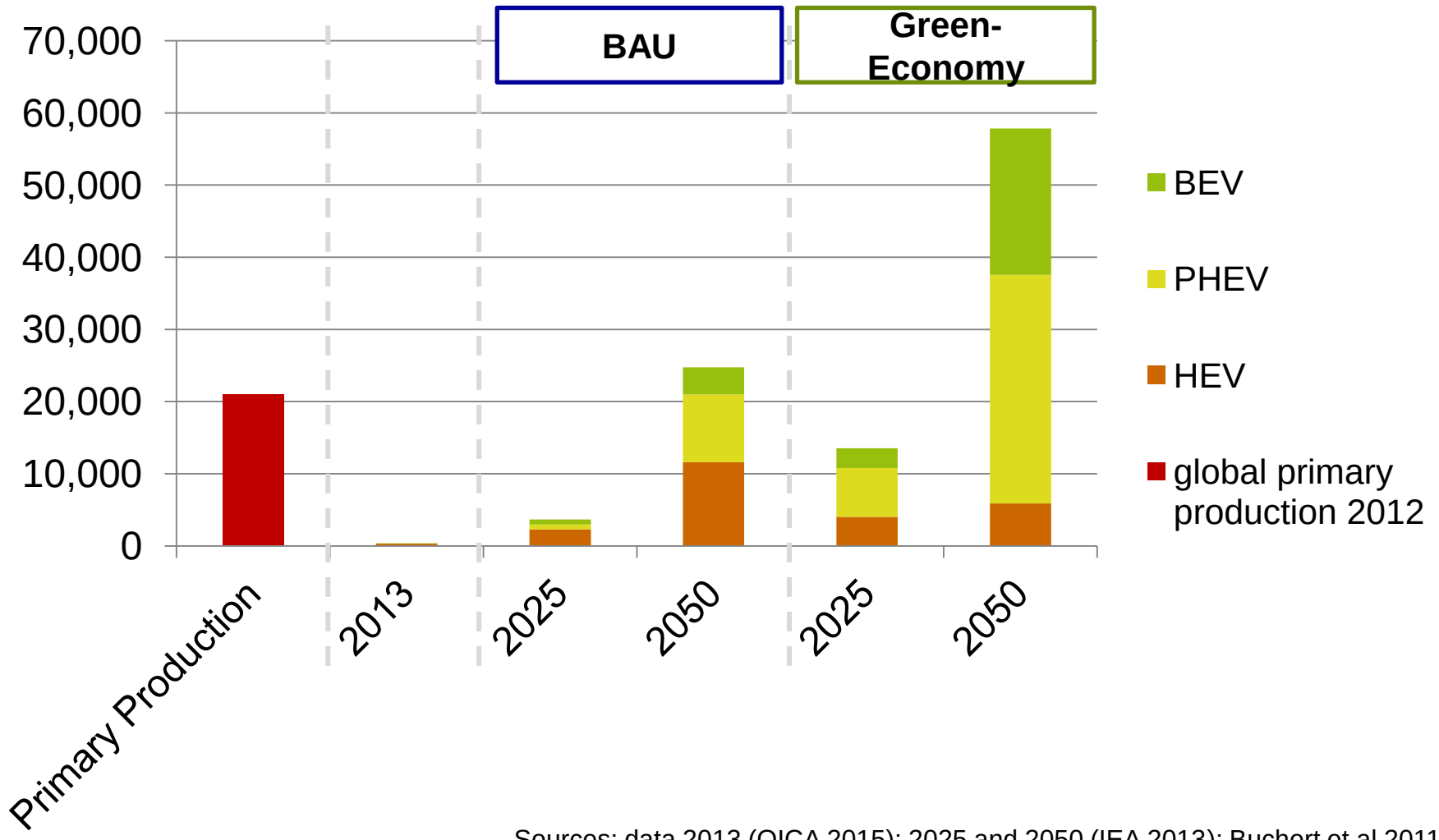
Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013); Buchert et al 2011

Rough estimate of neodymium demand in metric tonnes I/II

Global		Business-As-Usual		Green-Economy	
	2013	2025	2050	2025	2050
Total passenger car sales	n.a.	n.a.	n.a.	n.a.	n.a.
thereof HEV	**300**	**2.296**	**11.613**	**4.017**	**5.882**
thereof BEV	**40**	**680**	**3.744**	**2.719**	**20.284**
thereof PHEV	**15**	**680**	**9.384**	**6.796**	**31.697**
thereof ICE	-	-	-	-	-
thereof others (e.g. fuel cell)	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013); Buchert et al 2011

Rough estimate of annual NEODYMIUM demand for HEV, PHEV and BEV [in metric tonnes] II/II



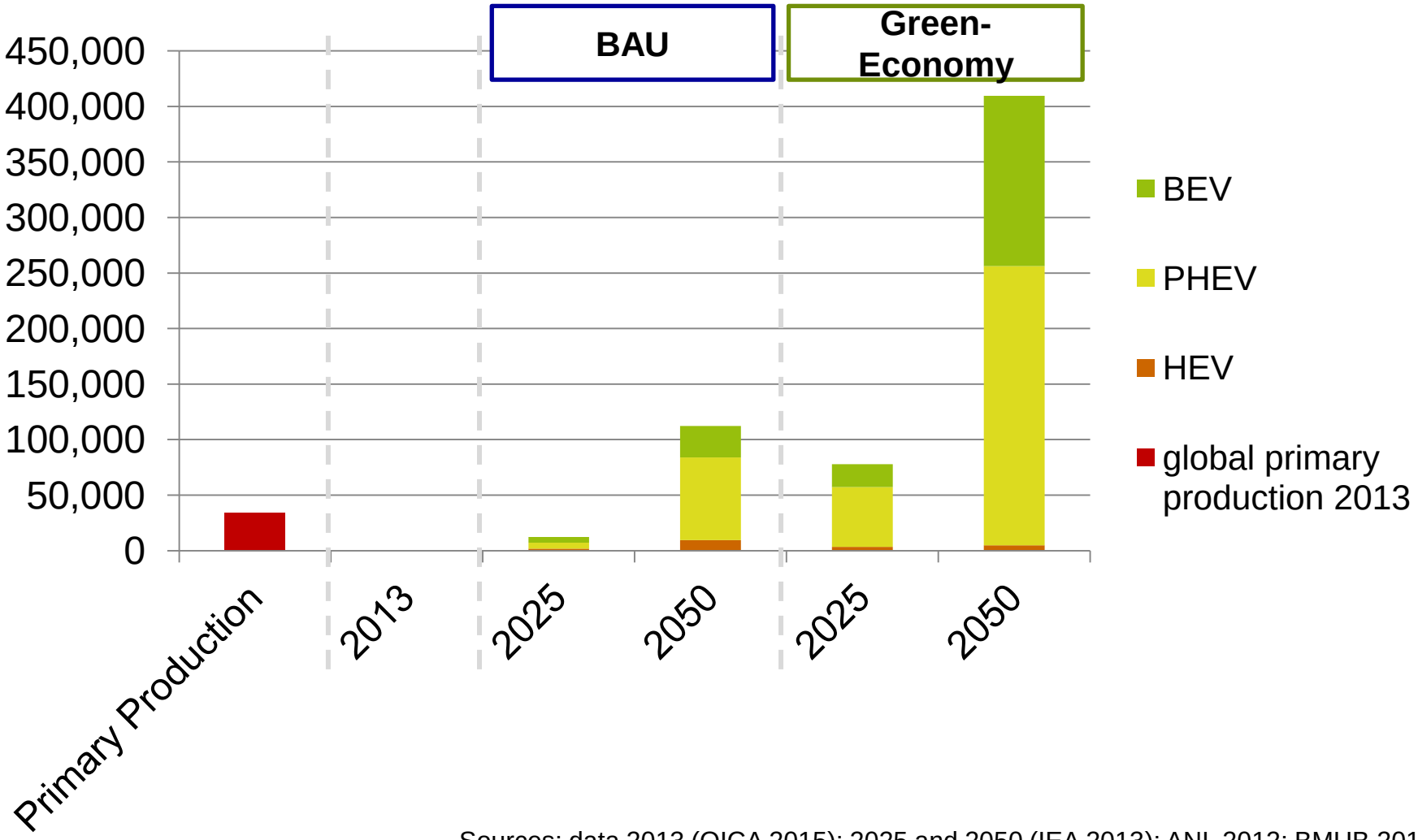
Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013); Buchert et al 2011

Rough estimate of lithium demand in metric tonnes I/II

Global		Business-As-Usual		Green-Economy	
	2013	2025	2050	2025	2050
Total passenger car sales	n.a.	n.a.	n.a.	n.a.	n.a.
thereof HEV	**314**	**1.898**	**9.601**	**3.321**	**4.863**
thereof BEV	**375**	**5.135**	**28.290**	**20.540**	**153.253**
thereof PHEV	**43**	**5.392**	**74.444**	**53.919**	**251.459**
thereof ICE	-	-	-	-	-
thereof others (e.g. fuel cell)	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013); ANL 2012; BMUB 2011

Rough estimations of annual LITHIUM demand for HEV, PHEV and BEV [in metric tonnes] II/II



Sources: data 2013 (OICA 2015); 2025 and 2050 (IEA 2013); ANL 2012; BMUB 2011

Interpretation of the lithium, dysprosium and neodymium demand developments

- **Due to the rising share and units of HEV, PHEV, BEV the global demand for lithium in this sector will grow significantly!**
- **Additionally growing demand for lithium will be triggered by other battery applications (hybrid busses, electric bicycles, power tools, wheel chairs, electricity storage etc.)!**
- **The development concerning rare earths elements (neodymium, dysprosium etc.) depends on the outcome of the current electric motor competition; especially for HEV the synchronous motors with permanent magnets (based on neodymium, dysprosium etc.) are classified as a stronghold!**
- **From an environmental point of view recycling of lithium, neodymium, dysprosium etc. will be a key task for the next decades!**

Outlook

- **The global transformation to a greenhouse gas neutral mobility system will generate “winning” and “losing” supply chains!**
- **Rising demand for metals like copper, lithium etc. is conceivable!**
- **Declining demand from the sector for PGMs, lead, steel etc. is possible!**
- **The main challenges are not necessarily material scarcity but reducing environmental impacts along the “winning” supply chains!**
- **Promoting new recycling infrastructure and recycling technologies e.g. for lithium are key tasks – but note: net economic profits for lithium ion battery recycling can not be expected!**

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Many Thanks for Your Attention!

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