hybrid-VPP4DSO: 2nd Stakeholder Workshop

Economic appraisal of VPP Use Cases: 1. Market-, 2. Network access-, 3. DSO-driven

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Outline

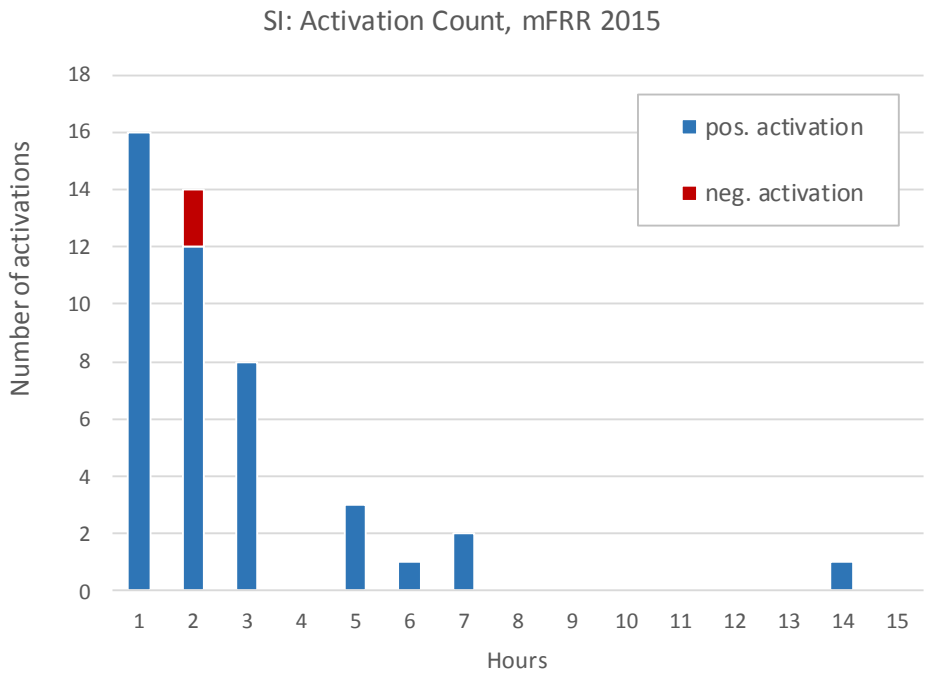
1. **Market-driven VPP** (with and without DSO restrictions)
   a. Stakeholders; Information-, Flexibilities- and Cash flows
   b. Input data, Slovenian Tertiary control market
   c. Break-even analyses incl. sensitivity
   d. Dynamic investment calculation for *hybrid*-VPP
2. **Client network access-driven VPP: Generators and Consumers**
   a. Multi-stakeholder analyses
   b. Economic appraisal for different stakeholders (customer, VPP)
3. **DSO-driven use cases: Discussion of use cases and input data**
   a. Avoided network construction
   b. Maintenance

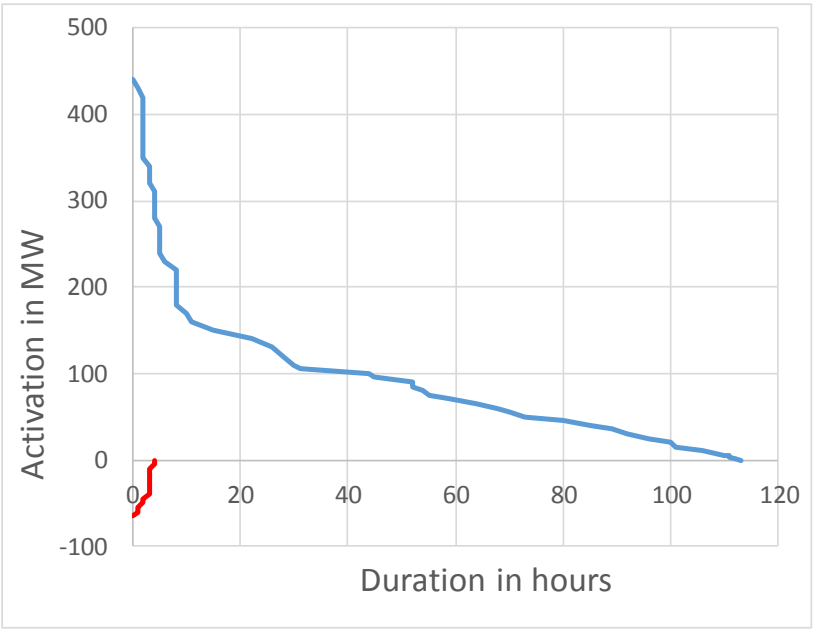
Case 1a.:

VPP for Flexibility Markets in Austria and Slovenia

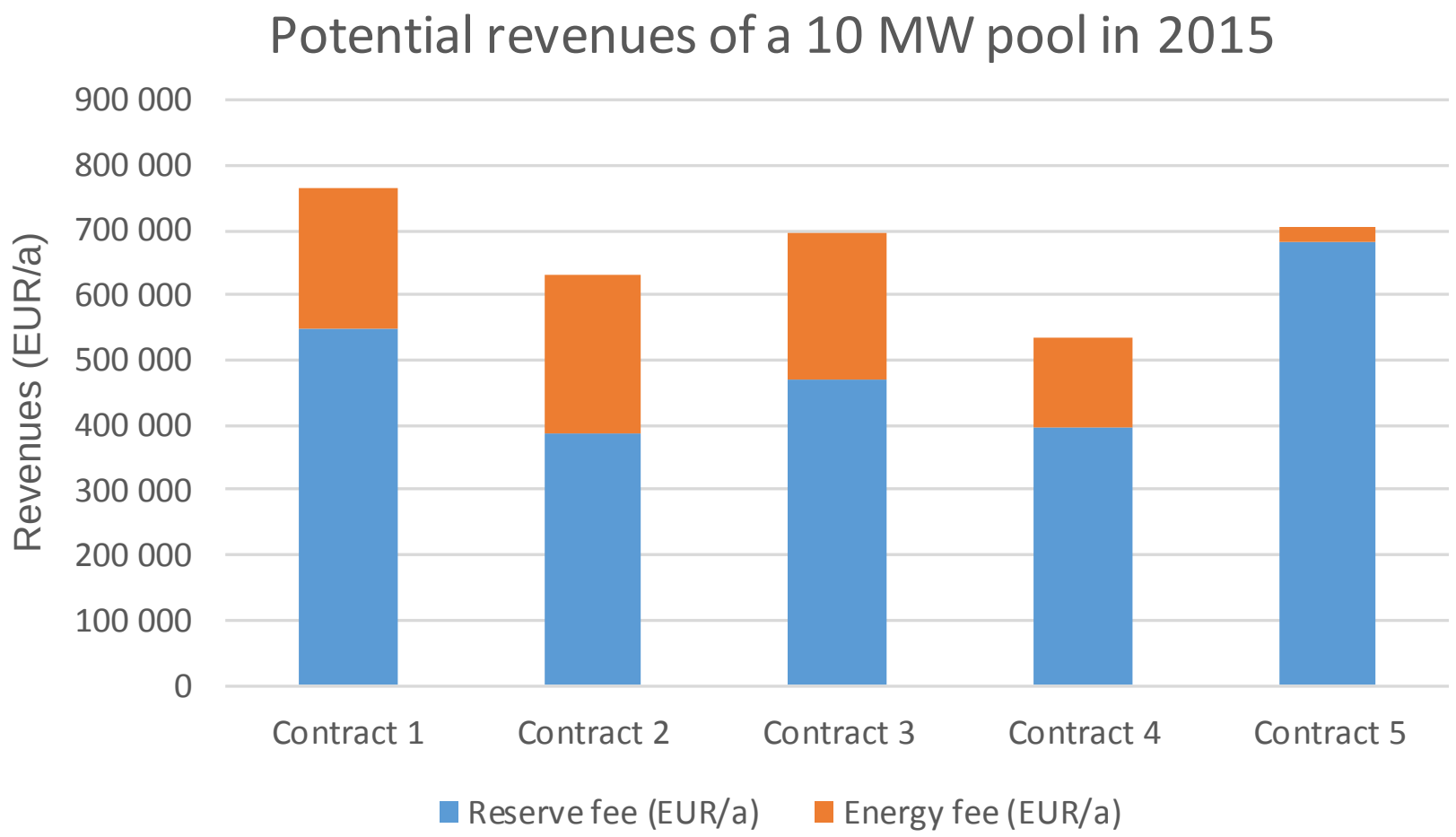
Overview of Slovenian mFRR market

- mFRR market in Slovenia is small but transparent
- All yearly tender results are published (5 contracts): volume: 10-139 MW, reserve fee **38.900**-68.300 EUR/MW/a, energy fee **200**-270 EUR/MWh
- There is mainly positive mFRR, neg. mFRR market is neglectable



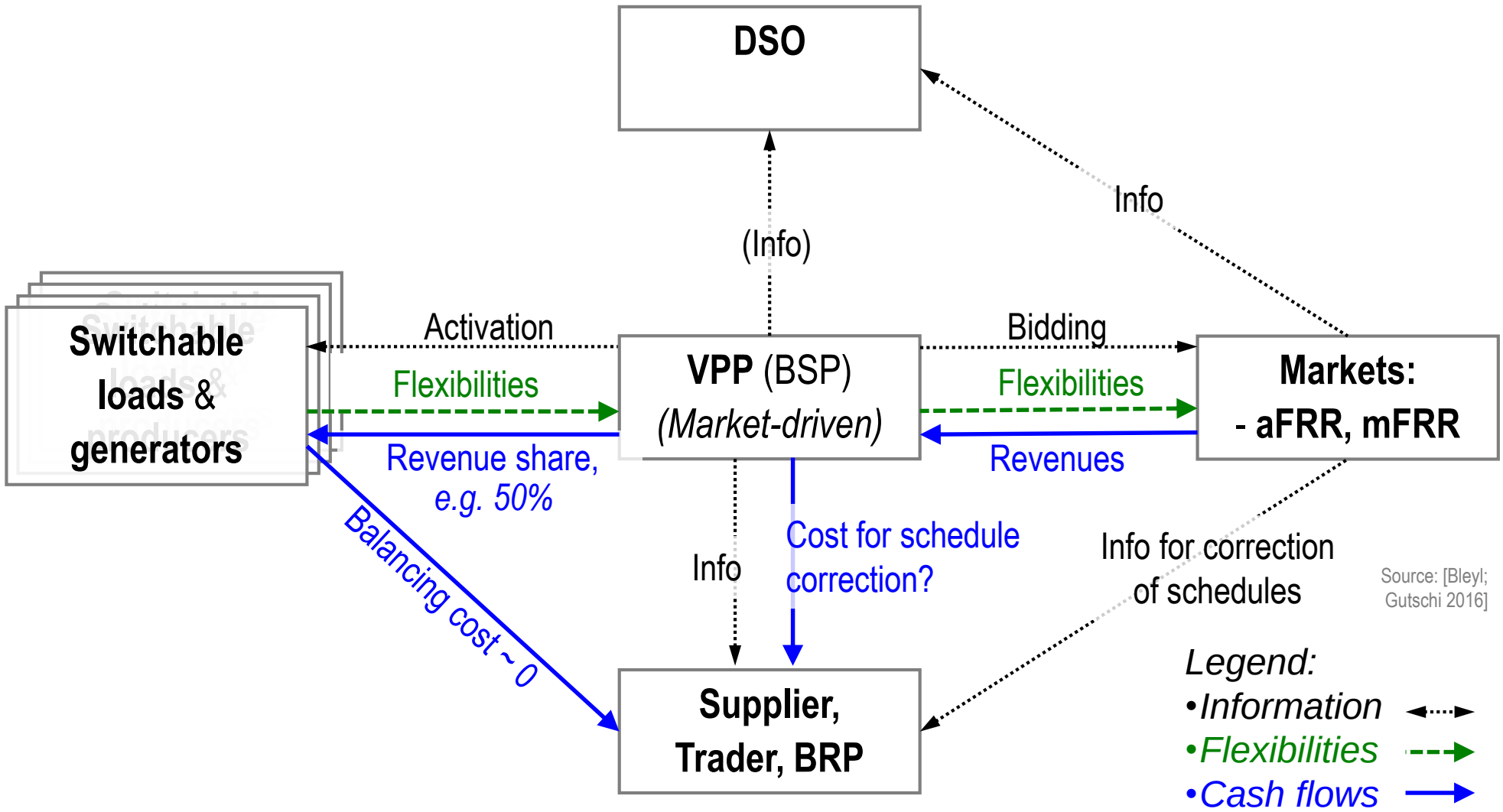


Comparision of contracts in 2015



1a. VPP for Flexibility Markets

Stakeholders: Information, Flexibilities & Cash flows



1a. **CAPEX**: a) **Fix**, b) **Variable per MW**

Slovenia:

	unit	cost	*Explanations and remarks*
a) **CAPEX** (per VPP system < 100 MW):	[EUR]	**50.000**	
VPP System	[EUR]	**50.000**	*VPP System installation; Pre-qualification APG; TSO connection*
Connection to DSO NOC	[EUR]	**0**	*Network operation center connection (manpower + hardware)*
Trading floor infrastructure	[EUR]	0	*not considered*
Trading license	[EUR]	0	*Softcost not considered*
Balancing group	[EUR]	0	*50.000 EUR Security, refundable*
b) **CAPEX** (per flexibility of ~ ± 1MW):	[EUR/MW]	**3.000**	
Per flexibility connected	[EUR/MW]	**2.000**	*Technician + hardware at client*
Transaction cost VPP client	[EUR/MW]	**1.000**	*Sales, marketing, drawing up of contract*

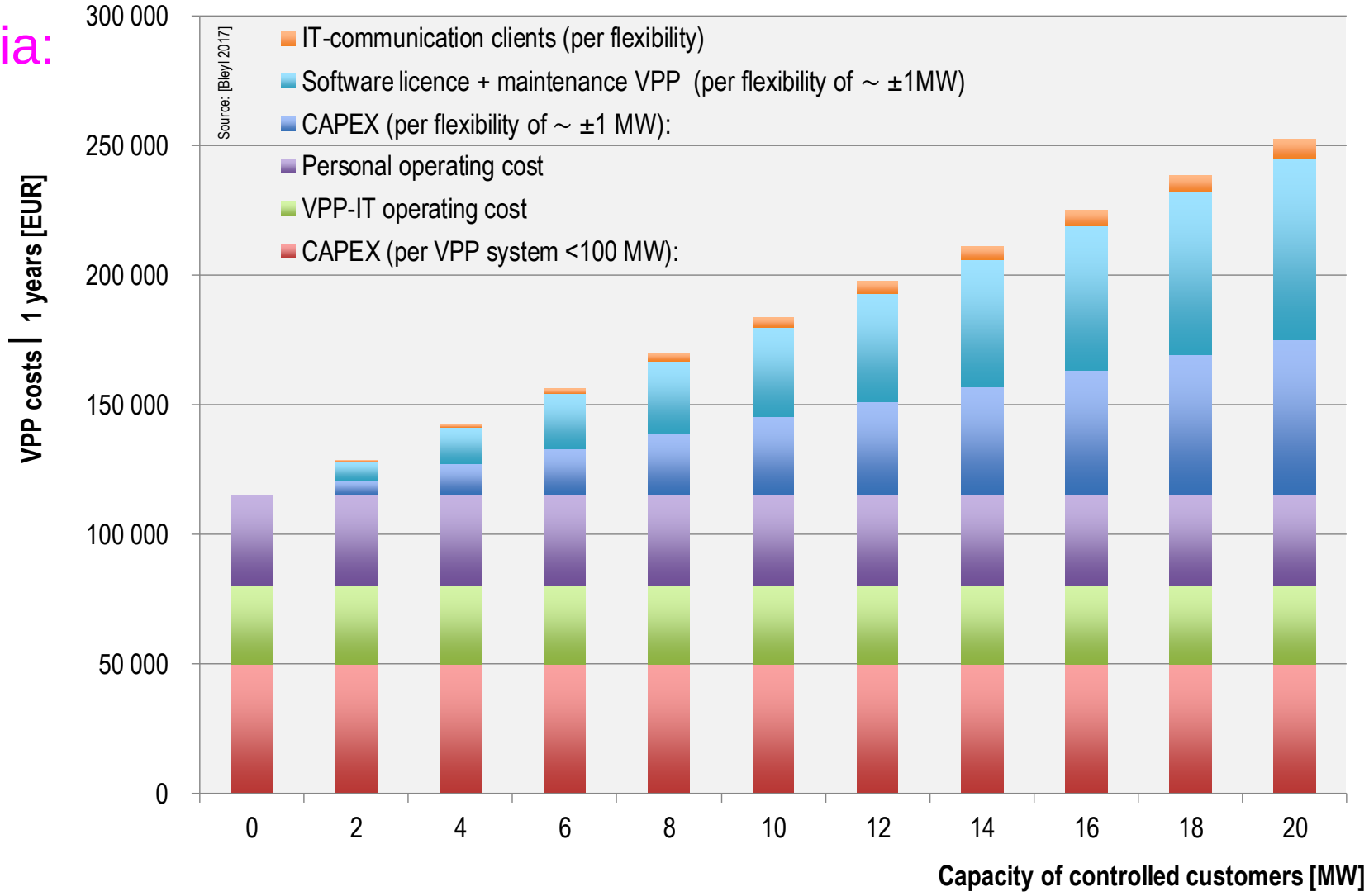
1a. **OPEX**: c) **Fix per year**; d) **Variable per MW, year**

Slovenia:

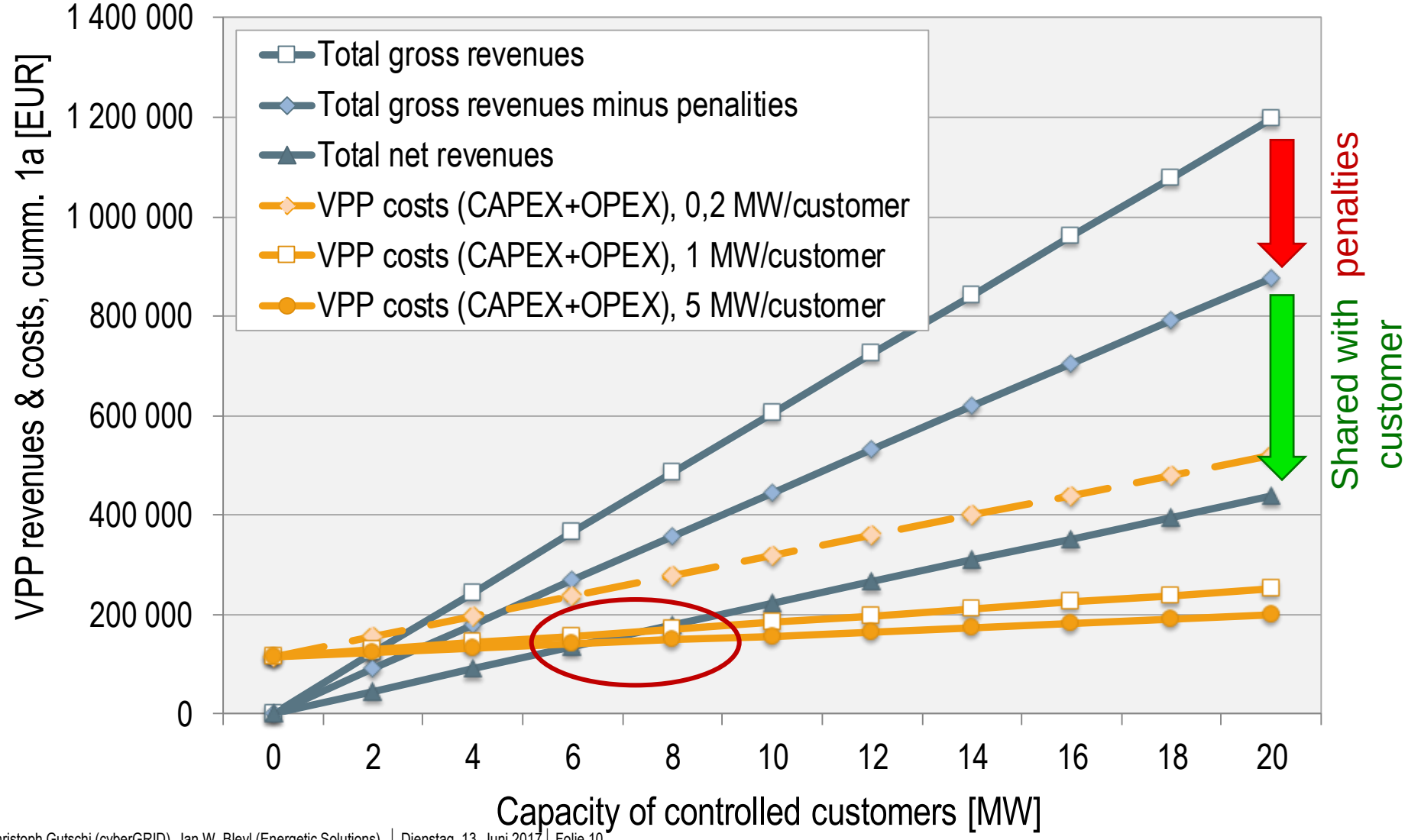
	unit	cost	*Explanations and remarks*
c) **OPEX** (fix per VPP system per year):	[EUR/a]	**65.240**	
VPP-IT operating cost	[EUR/a]	**30.000**	*IT-System hosting, maintenance, support*
IT-communication TSO	[EUR/a]	**200**	*IT-communication with TSO*
IT-communication DSO	[EUR/a]		*IT-communication with DSO*
Personal operating cost			
VPP operation incl. trading	[EUR/a]	**35.040**	*24/7: 0,1 person equivalents/a (876 h/a @ 65 EUR/h;)*
d) **OPEX** (variable per client per year):	[EUR/a]	**3.860**	
Software licence VPP (per flexibility of ~ ±1MW)		**3.500**	
TRL only	[EUR/a]	**3.500**	*including day-ahead, intraday ...*
IT-communication clients (per flexibility)	[EUR/a]	**360**	**Mobile communication, private APN**
Average 0,5 + 5 MW	[EUR/a]	**360**	

1a. Cost structure = f(MW): Fix + variable;1 year operation time

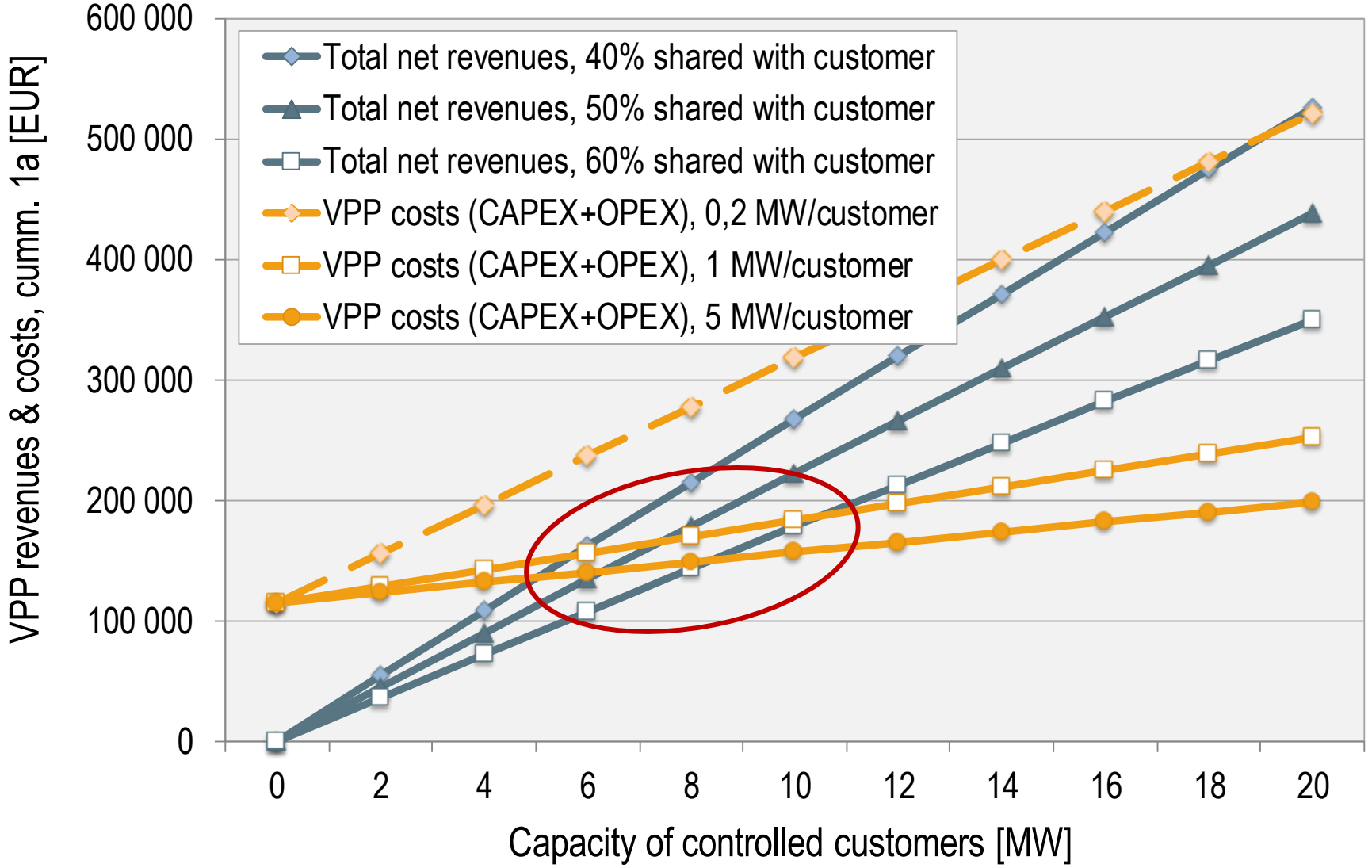
Slovenia:



1a, c. **Break-even: Revenues (tertiary control) vs. VPP cost; 1 year; Slovenia**



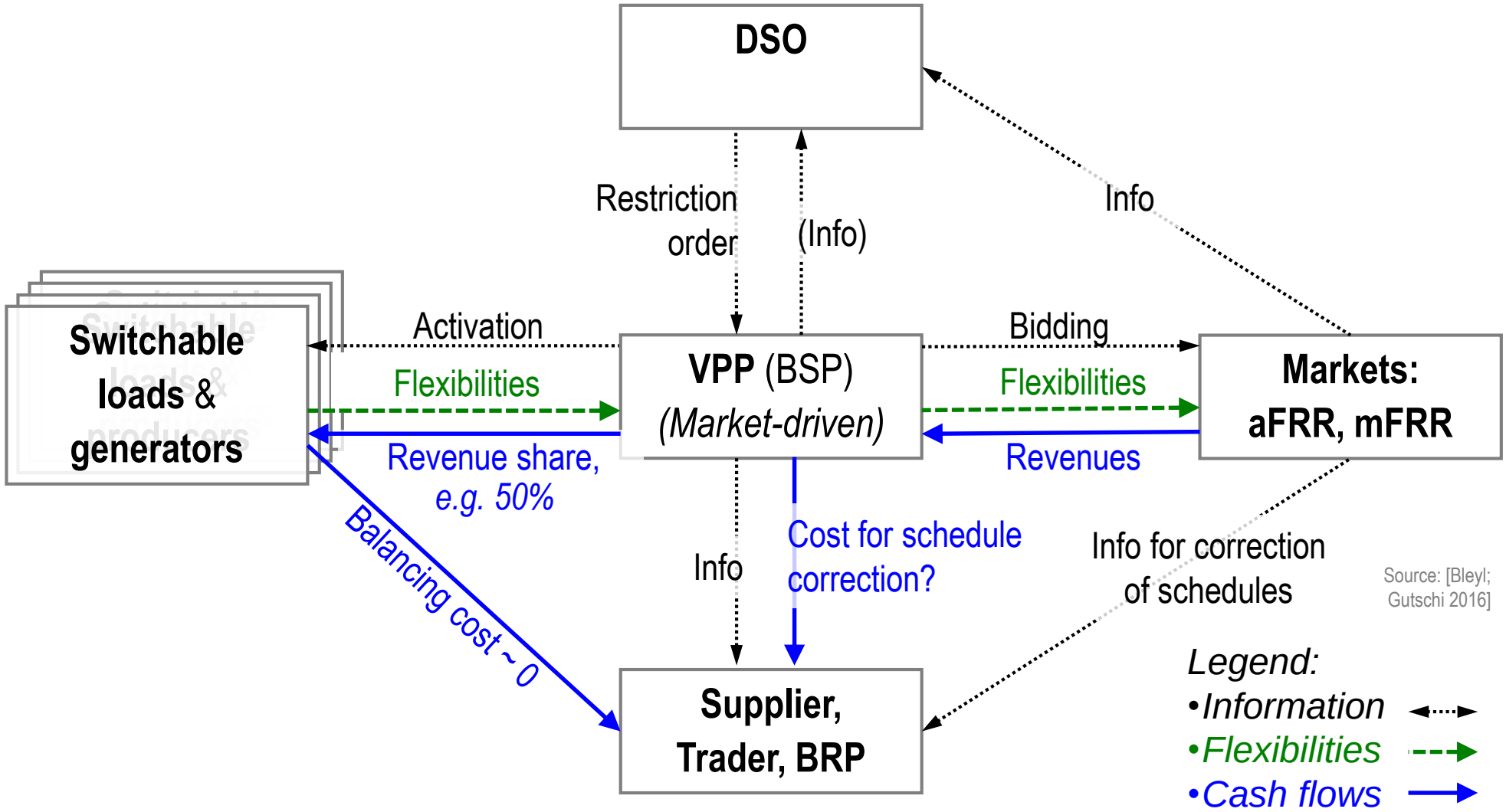
1a. Break-even: Revenues vs. cost = f(MW; Rev.-share); 1 years operation time



Case 1b.:

VPP for Flexibility Markets with Operating Restrictions from DSO in Slovenia

1b. VPP for Flexibility Markets with restrictions from network operation



1b. ***Revenues***
CAPEX: a) **Fix**, b) **Variable per MW**

Assumption: **Revenues** in EUR/MW/a **reduced per -10%** because of network restrictions (more backup needed)

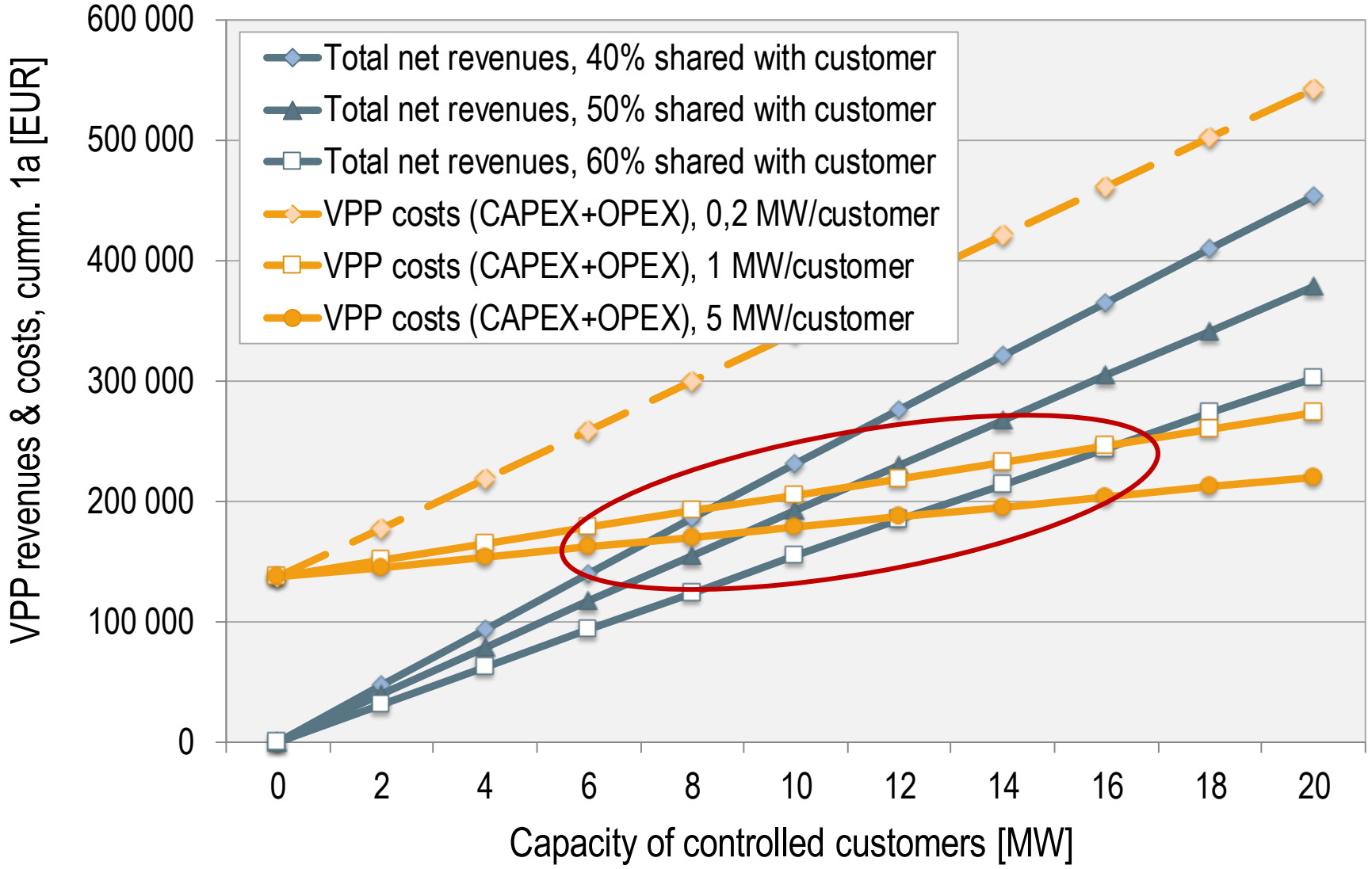
	unit	cost	*Explanations and remarks*
a) **CAPEX** (per VPP system <100 MW):	[EUR]	**70.000**	
VPP System	[EUR]	**50.000**	*VPP System installation; Pre-qualification APG; TSO connection*
Connection to DSO NOC	[EUR]	**20.000**	*Network operation center connection (manpower + hardware)*
Trading floor infrastructure	[EUR]	0	*not considered*
Trading license	[EUR]	0	*Softcost not considered*
Balancing group	[EUR]	0	*50.000 EUR Security, refundable*
b) **CAPEX** (per flexibility of ~ ±1MW):	[EUR/MW]	**3.000**	
Per flexibility connected	[EUR/MW]	**2.000**	*Technician + hardware at client*
Transaction cost VPP client	[EUR/MW]	**1.000**	*Sales, marketing, drawing up of contract*

1b.

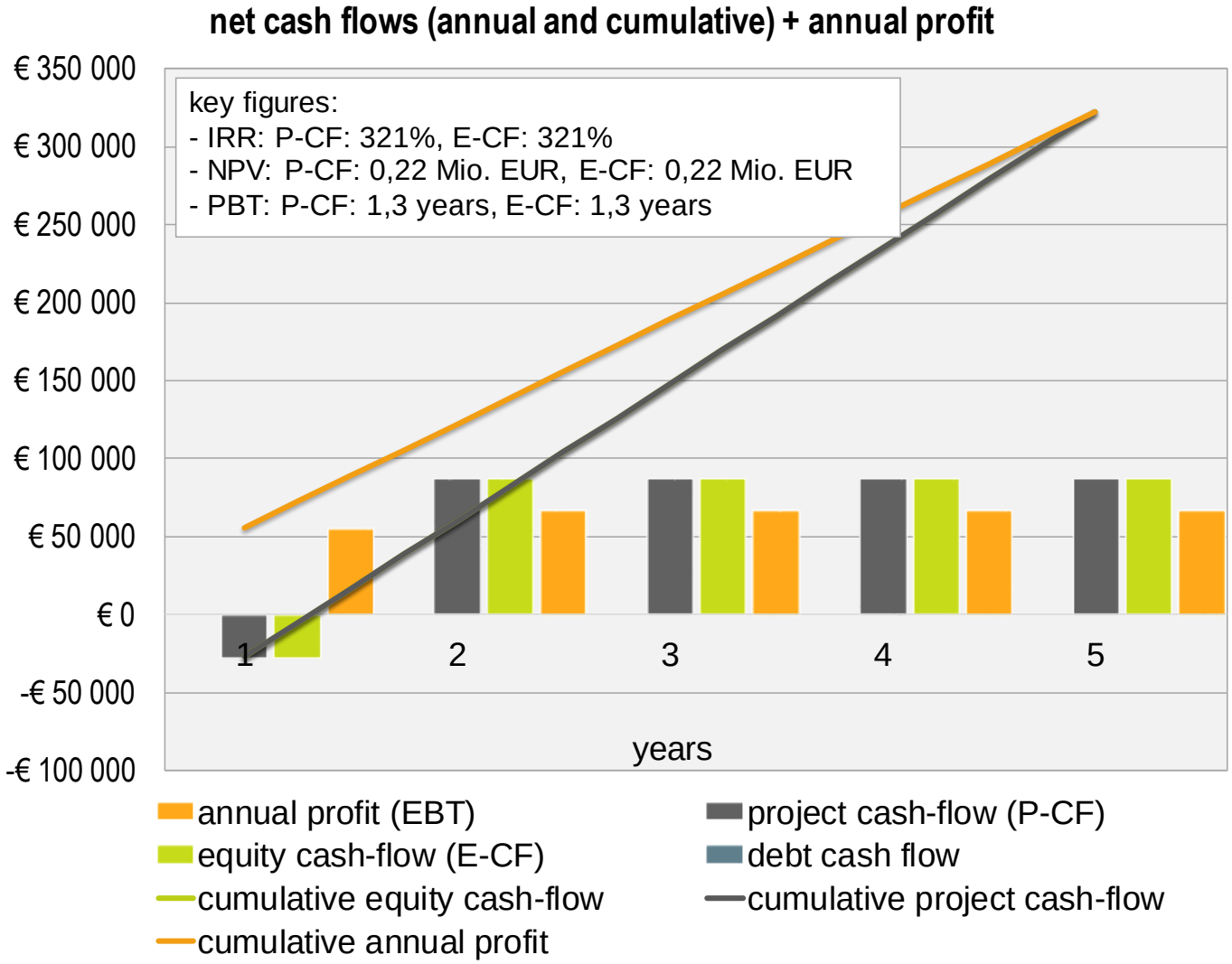
OPEX: c) **Fix per year**; d) **Variable per MW, year**

	unit	cost	*Explanations and remarks*
c) **OPEX** (fix per VPP system per year):	[EUR/a]	**66.440**	
VPP-IT operating cost	[EUR/a]	**30.000**	*IT-System hosting, maintenance, support*
IT-communication TSO	[EUR/a]	**200**	*IT-communication with TSO*
IT-communication DSO	[EUR/a]	**1.200**	*IT-communication with DSO*
Personal operating cost			
VPP operation incl. trading	[EUR/a]	**35.040**	*24/7: 0,1 person equivalents/a (876 h/a @ 65 EUR/h;)*
d) **OPEX** (variable per client per year):	[EUR/a]	**3.860**	
Software licence VPP (per flexibility of ~ ±1MW)		**3.500**	
TRL only	[EUR/a]	**3.500**	*including day-ahead, intraday ...*
IT-communication clients (per flexibility)	[EUR/a]	**360**	**Mobile communication, private APN**
Average 0,5 + 5 MW	[EUR/a]	**360**	

1b. Break-even: Revenues vs. cost = f(MW; Rev.-share; availability); 1 year operation time



1b. Dynamic investmentappraisel
10 MW VPP, 5 year operation time



Reduced revenues in the first year, because pool is still being developed. Even in this conservative case (1b) the payback time is only 1,3a and over 5a an IRR of 76%/a is reached.

1b. VPP for Flexibility Markets with restrictions from network operation

Advantages	Disadvantages
Flexibilities located in stressed grid sections can be integrated into a pool	Increased costs of VPP per „MW available flexibility“
Even if only temporarily available, such flexibilities can serve as backup to other ressources in the pool	New communication interface between DSO and VPP needed (costs, security issue)
Larger pool size achieveable	Planning of available capacity becomes more complex for the aggregator.
Cooperation between VPP operator and DSO required	Cooperation between VPP operator and DSO required
DSO can get additional information about grid status (from local measurements provided by VPP)	DSO SCADA may need an update to provide the required information to the VPP

Cases 2.:

VPP to minimize grid connection cost for new generators and consumers investigated in Austrian case

Network-VPP: New 2 MW Wind/PV, Styria
Research question and method

Research question based on use case:

Economic comparison of

- **new grid connection or reinforcement of grid connection**
- **vs. participation in a network-driven VPP?**

Methodology:

- **Project cycle cost comparison** (NPV) from customer's perspective
- **Break even analysis** from VPP perspective

Further assumptions:

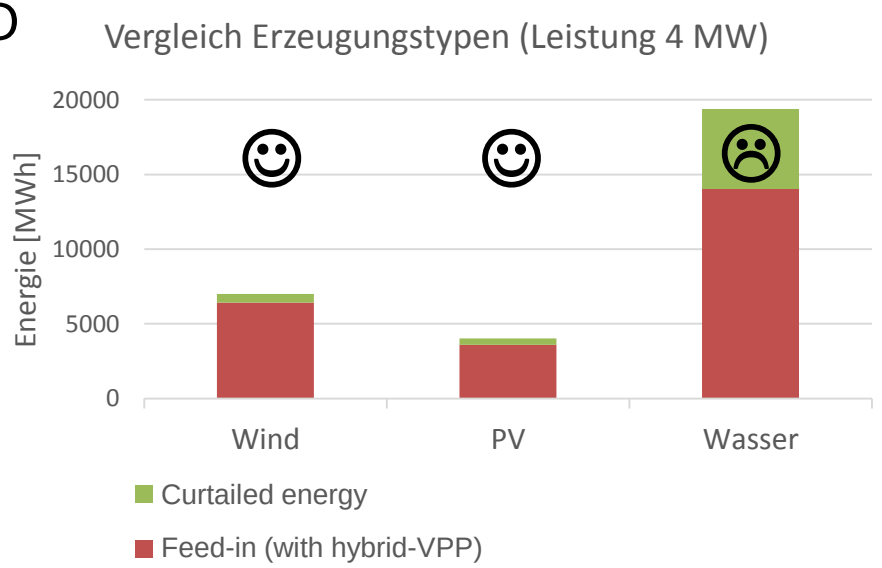
- VPP only operated for the purpose of customer curtailment for grid operation

Case 2a: New generator applies for grid access in already stressed grid section

DSO can offer two options:

- **Standard approach:** customer has to pay for the required grid enhancement
- **Innovative approach:** customer can connect to the existing infrastructure but agrees to be curtailed in critical hours
  - Local P=f(U) feed-in control is the preferred option but may be problematic in some grid topologies
  - Curtailment via VPP (driven by DSO commands) is a versatile solution

- **Generators‘ perspective:** compare costs of grid enhancement vs. value of curtailed energy (lost revenue)

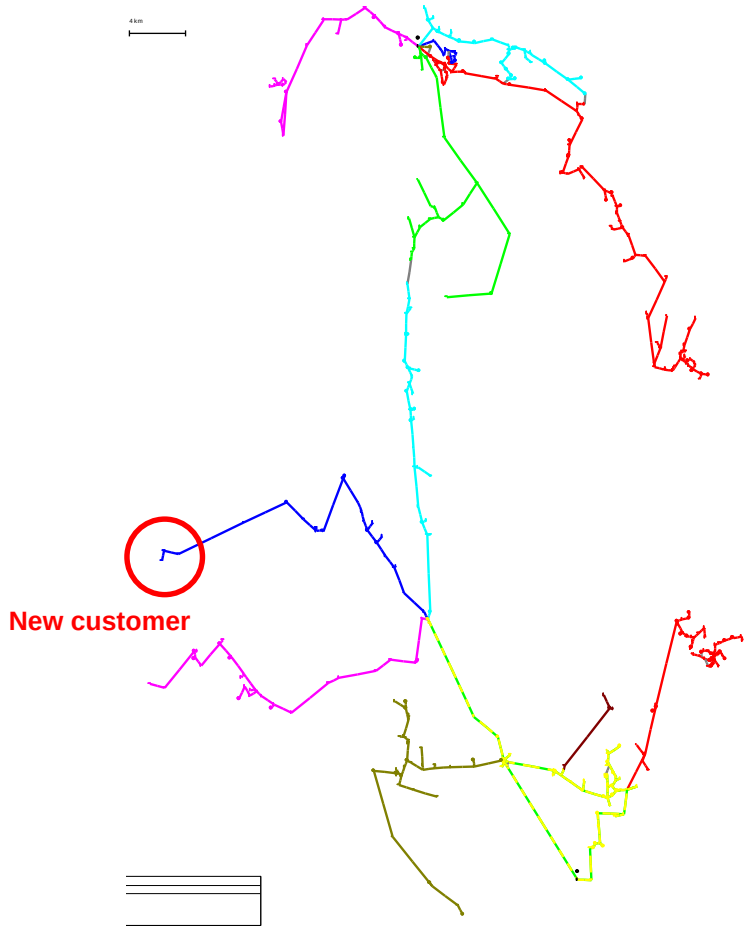


Source: Spreitzhofer

Use Case: Minimization of grid connection costs: **New 2 MW Wind/PV, Styria** (2020)

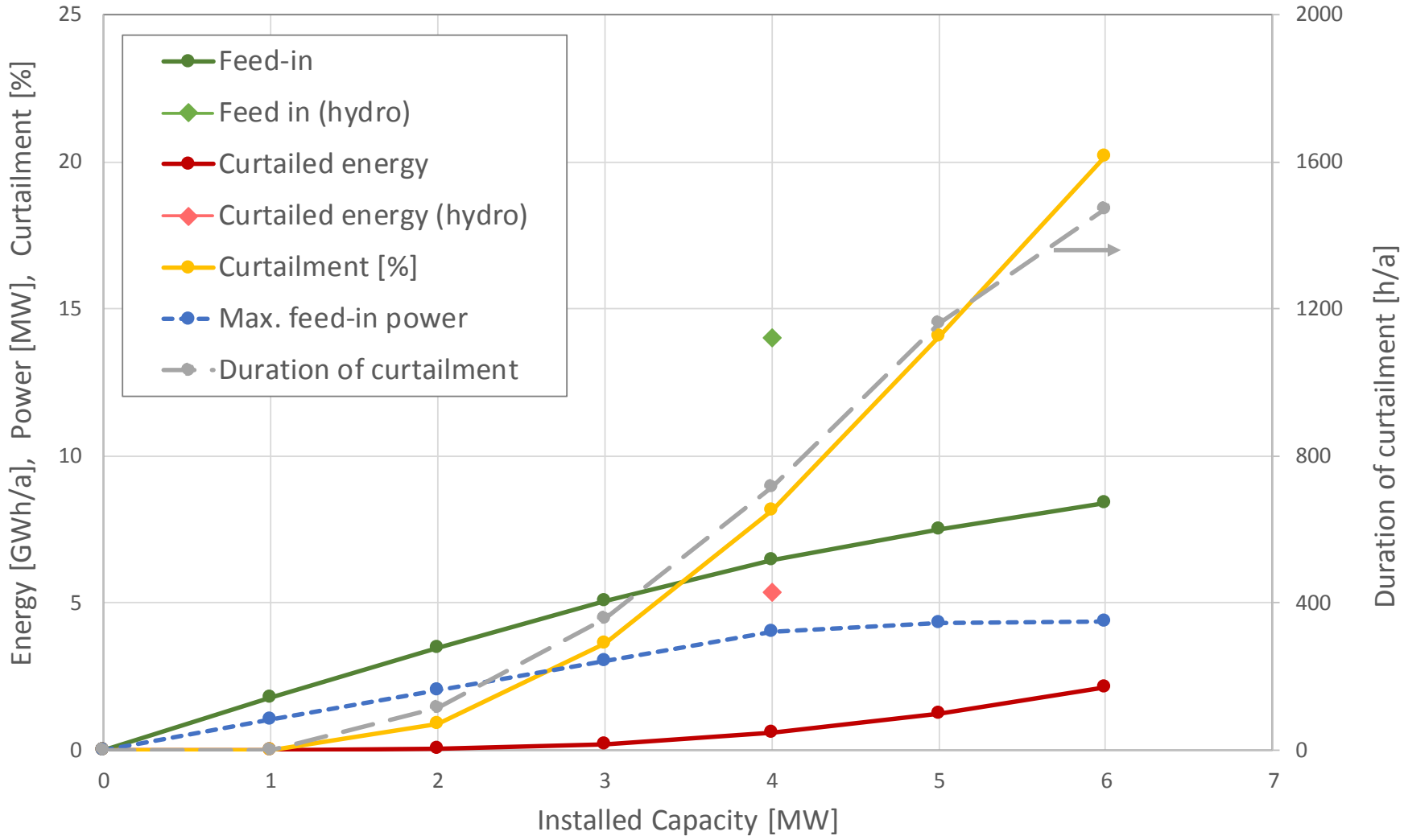
Additional customer (Wind/PV-plant, 2 MW peak) wants to connect at blue feeder, which already has a lot of hydro-units connected:

1. **„Classic“ approach**:
   Customer has to invest into new line to suitable connection point: ca. **15 km** for **2.400.000 €**
2. **Network-VPP approach**:
   Feed-in is restricted during critical hours
   (Wind: **50,91** MWh; PV: **40,32** MWh per year)



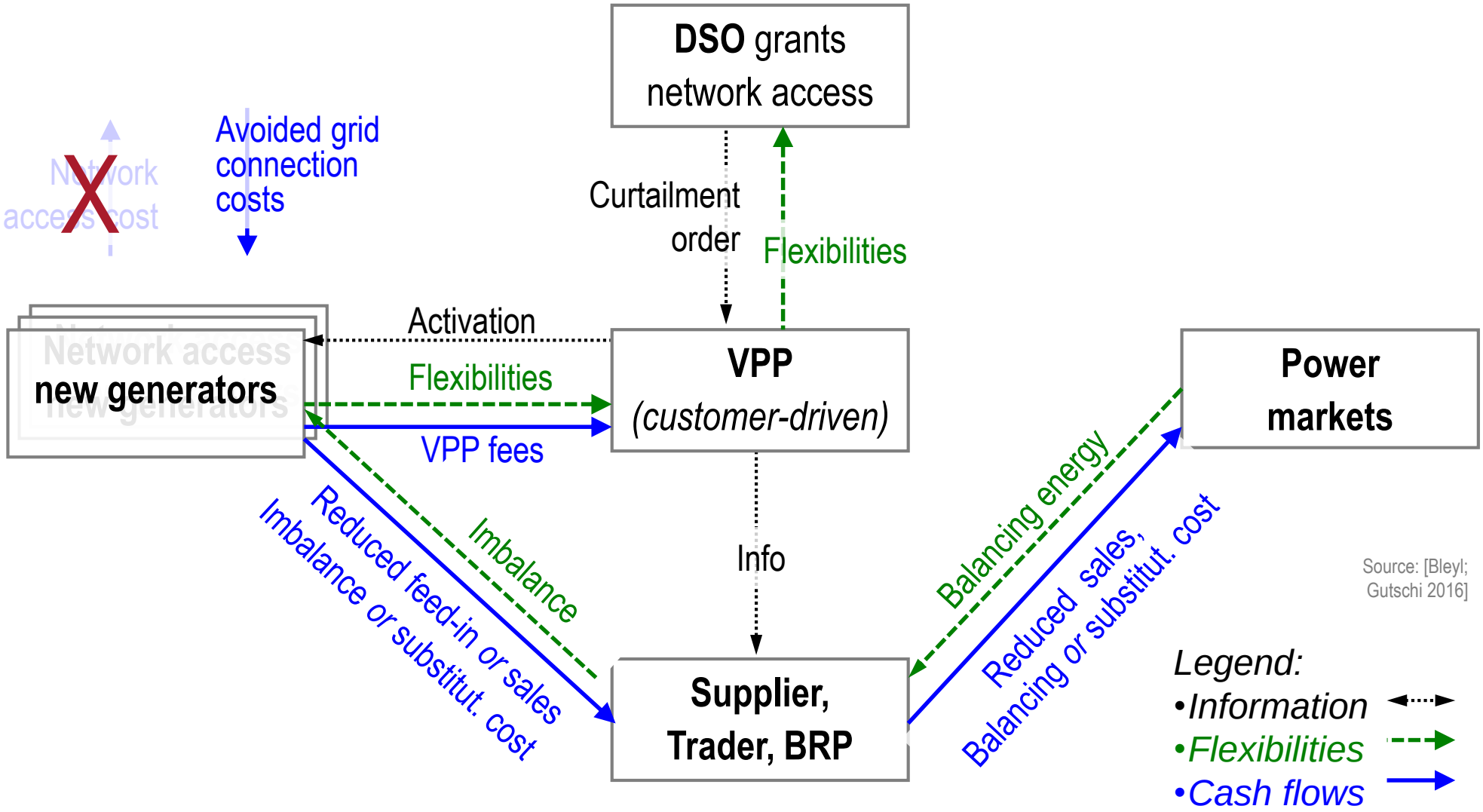
Calculation for monetary losses due to curtailment is based on feed-in tariffs:
Wind: **89,5** €/MWh
PV: **82,4** €/MWh

2a - Case study: Optimized capacity of new wind park in „hydro dominated“ grid



Source: Spreitzhofer

2a. VPP to minimize grid connection cost for new generators



2a. VPP to minimize grid connection cost
Generator: Cost-Benefit (qualitative)

	Generator: New grid connection (business as usual)	Generator: avoid new grid connection (hybrid-VPP)
Revenues, benefits	Additional feed-in revenues	Avoided investment cost
	-	Avoided maintenance cost
Cost, efforts	Investment cost	Lost feed-in revenues
	Additional maintenance cost	VPP service fee, Balancing cost
Economic appraisal	- - high CAPEX - - long payback	++ avoided CAPEX
Other benefits or risks	+ Reinforced network access	- Network connection at limit

++	very positive
+	slightly positive
0	neutral
-	slightly negative
- -	very negative

2a. VPP to minimize grid connection cost

All stakeholders: Cost-Benefit (qualitative)

	Generator: New grid connection (business as usual)	Generator: avoid new grid connection (hybrid-VPP)
Revenues, benefits	Additional feed-in revenues	Avoided investment cost
	-	Avoided maintenance cost
Cost, efforts	Investment cost	Lost feed-in revenues
	Additional maintenance cost	VPP service fee, Balancing cost
Economic appraisal	- - high CAPEX - - long payback	++ avoided CAPEX
Other benefits or risks	+ Reinforced network access	- Network connection at limit

++	very positive
+	slightly positive
0	neutral
-	slightly negative
- -	very negative

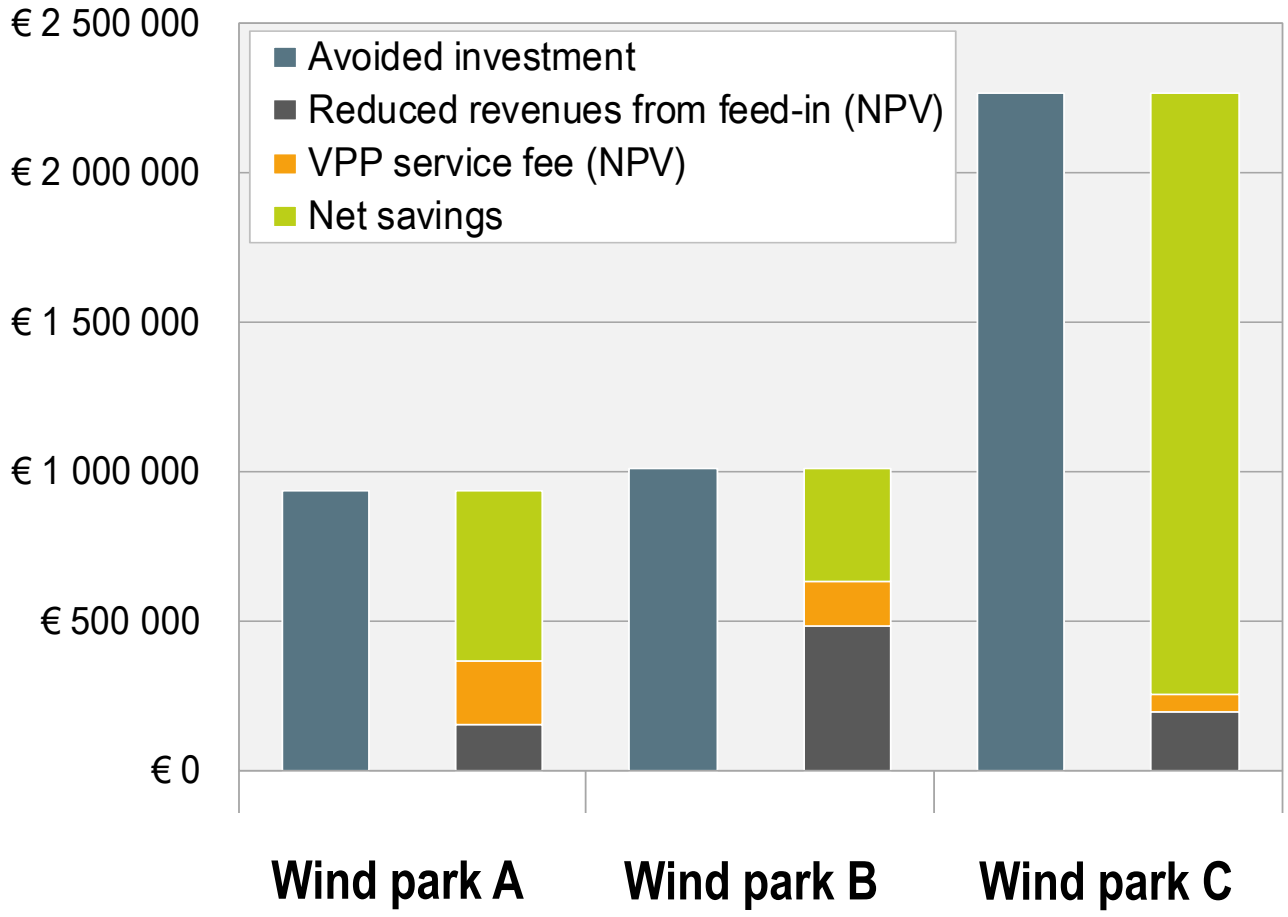
2a. VPP to minimize grid connection cost

Cost items: Fix & variable per MW, year

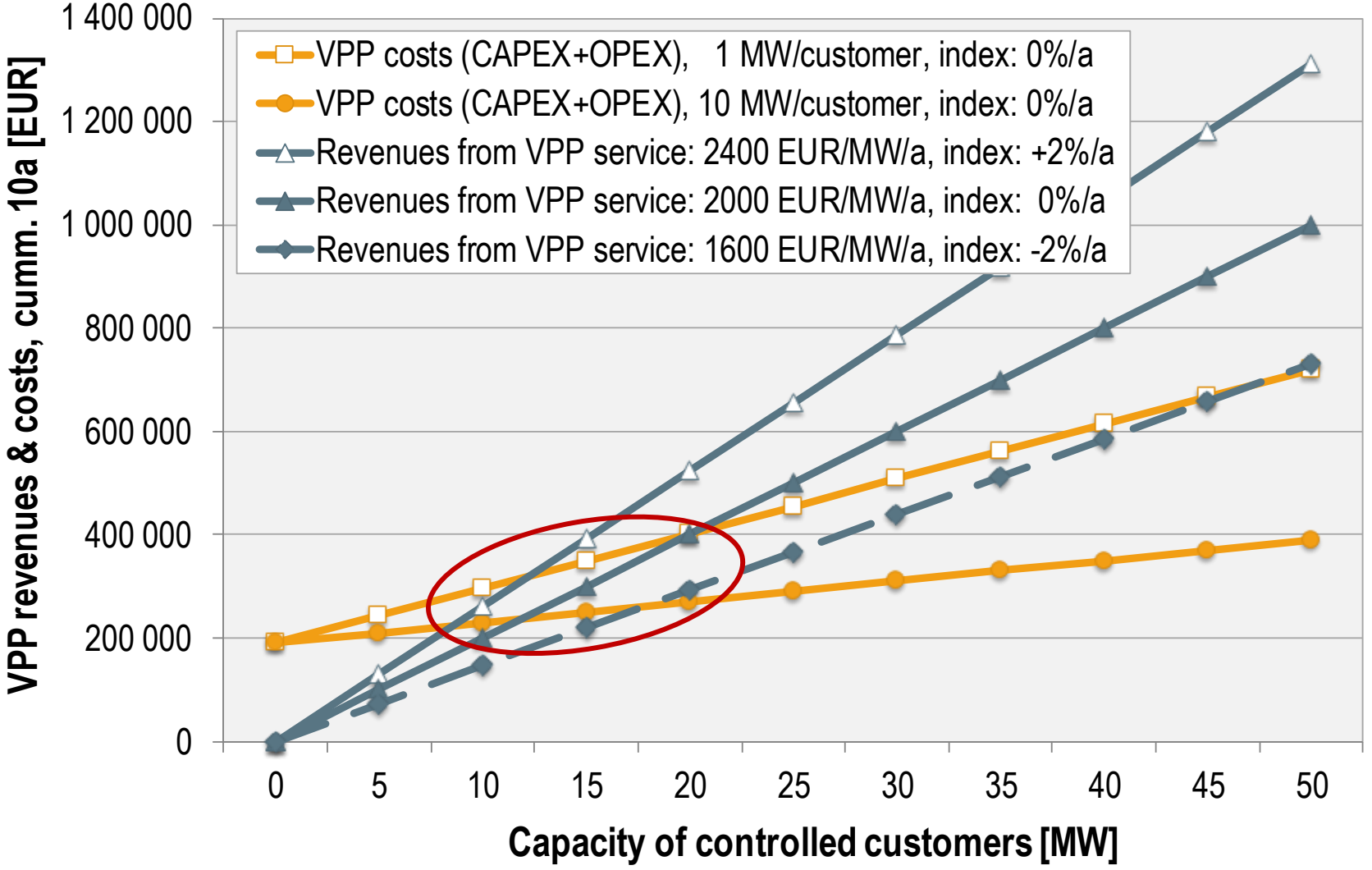
	unit	cost	*Explanations and remarks*
a) **CAPEX** (per VPP system < 100 MW):	[EUR]	**50.000**	
VPP System	[EUR]	**30.000**	*VPP System installation (DSO-internal)*
Connection to DSO NOC	[EUR]	**20.000**	*Network operation center connection (manpower + hardware)*
b) **CAPEX** (per flexibility of ~ ±1MW):	[EUR/MW]	**4.000**	
Per flexibility connected	[EUR/MW]	**3.000**	*Technician + hardware at client site*
Transaction cost VPP client	[EUR/MW]	**1.000**	*Sales, marketing, drawing up of contract*

	unit	cost	*Explanations and remarks*
c) **OPEX** (fix per VPP system per year):	[EUR/a]	**14.000**	
VPP-IT operating cost	[EUR/a]	6.000	*IT-System hosting, maintenance, support (w/o TSO connection, r*
IT-communication TSO	[EUR/a]	0	*IT-communication with TSO (not needed)*
IT-communication DSO	[EUR/a]	1.200	*IT-communication with DSO*
Personal operating cost			
VPP surveillance of automatic operation	[EUR/a]	6.800	*2h/week ≙ 102 h/a @ 65 EUR/h (no trading needed)*
d) **OPEX** (variable per client per year)	[EUR/a]	**900**	
Software licence VPP (per flexibility of ~ ±1MW)			
DSO only	[EUR/a]	**300**	*support for DSO operation, w/o tertiary market*
IT-communication clients (per flexibility)			*DSL encrypted*
Average 0,5 + 5 MW	[EUR/a]	**600**	

2a) **Economic assessment from customer's perspective (20a life cycle)**



2. Break-even analysis from VPP perspective; 10 years operation time



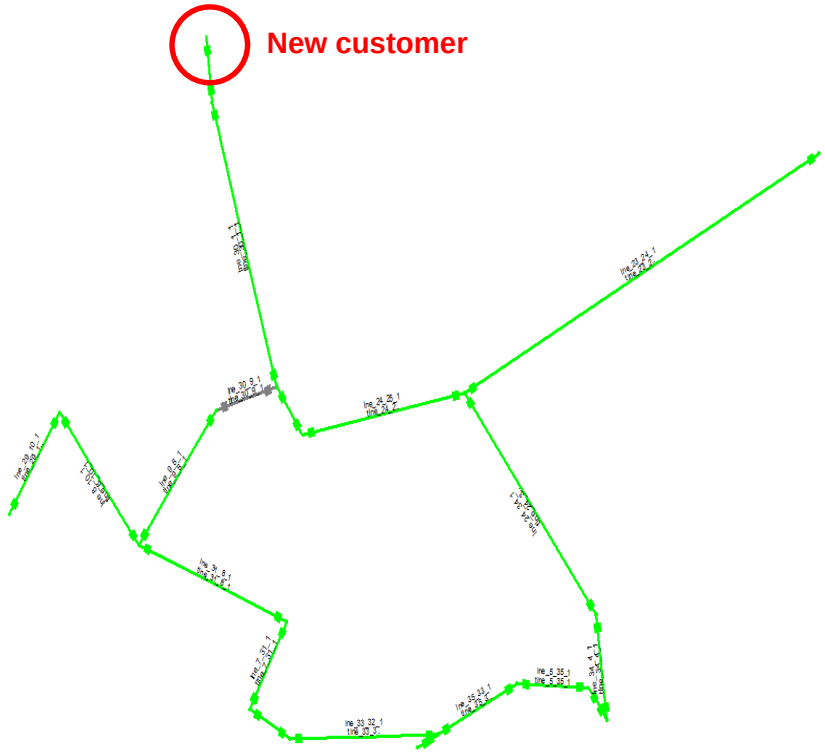
Case 2b: Industrial consumer *applies for grid access in already stressed grid section*

- The DSO can offer same options as for the generator (2a)
  - Payment for grid reinforcement
  - Agreement to curtail consumption (or increase internal generation) during critical hours
- Unlike the generators‘ case this case is rather driven by overload of equipment and simple local control P=f(U) is no option.
- **This case cannot be generalized** because not only grid topology but also the internal structure of production industry must be taken into account.
  - Load is not curtailed but shifted (e.g. afternoon → night)
    This may require shift of production cycles and increased labour costs
  - Internal generation of goods storage can eventually provide required flexibility for low costs
  - Opportunity costs mainly depend on type of facility, can be very low in some cases but are likely to be much higher than price of energy (ca. 500 EUR/MWh)

2b: Minimization of grid connection costs:
1,5 MW industrial load, Slovenia

Additional customer (industrial load, 1,5 MW)
wants to connect at the end of the grid:

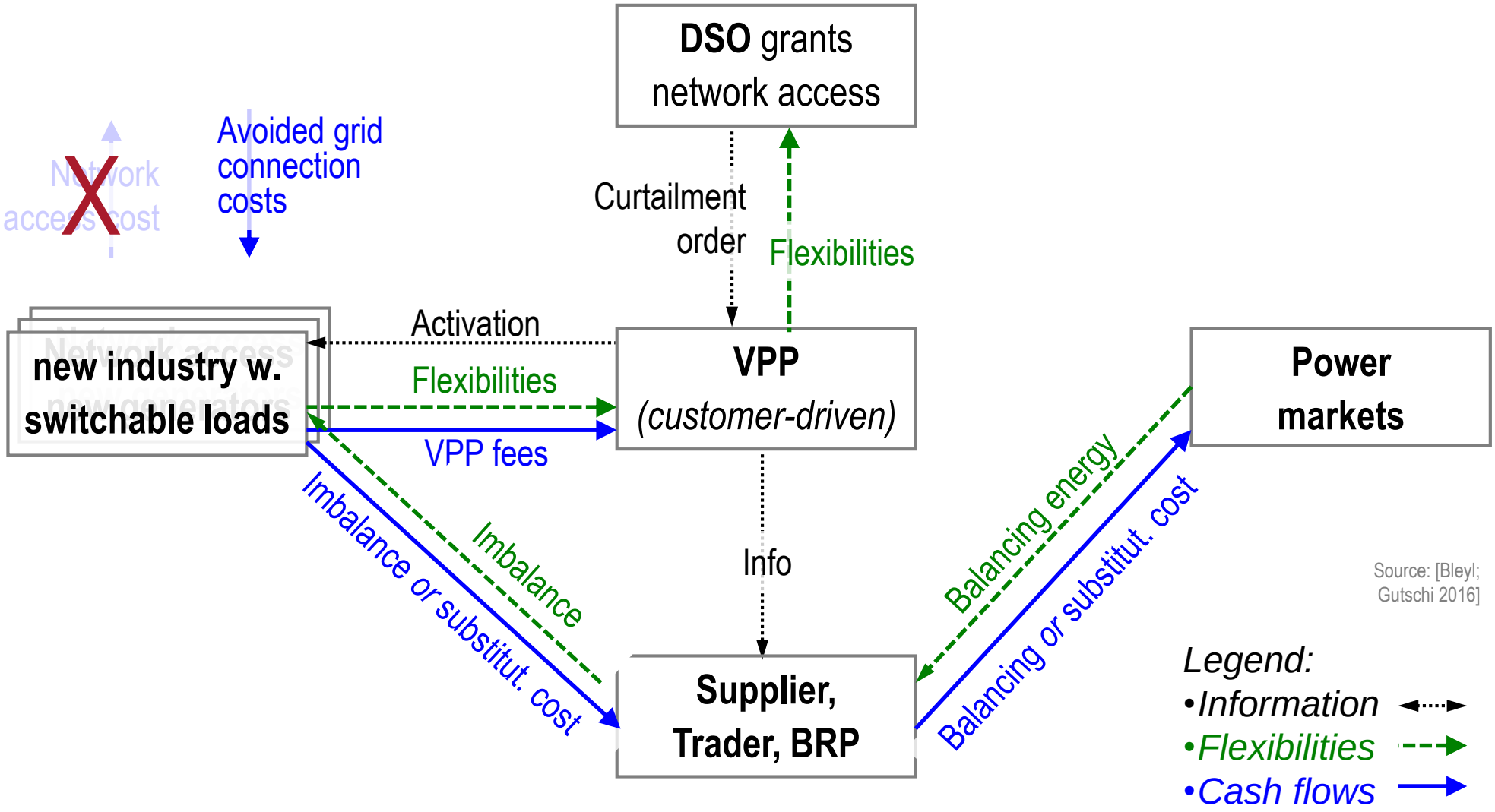
1. **„Classic“ approach**:
   customer has to invest into grid reinforcement: 1,3 km for 97.000 €
2. **Network-VPP approach**:
   consumption is curtailed during critical hours of the year (max. consumption of 50%)
   – 266 h/a
   – load shift: 117 MWh/a
   (1,4% of annual consumption)



2 calculation methods for monetary losses due to curtailment or load shifting:

- NPV at shifting costs of 200 €/MWh
- Marginal shifting costs to reach NPV = 0

2b. VPP to minimize grid connection cost for new generators

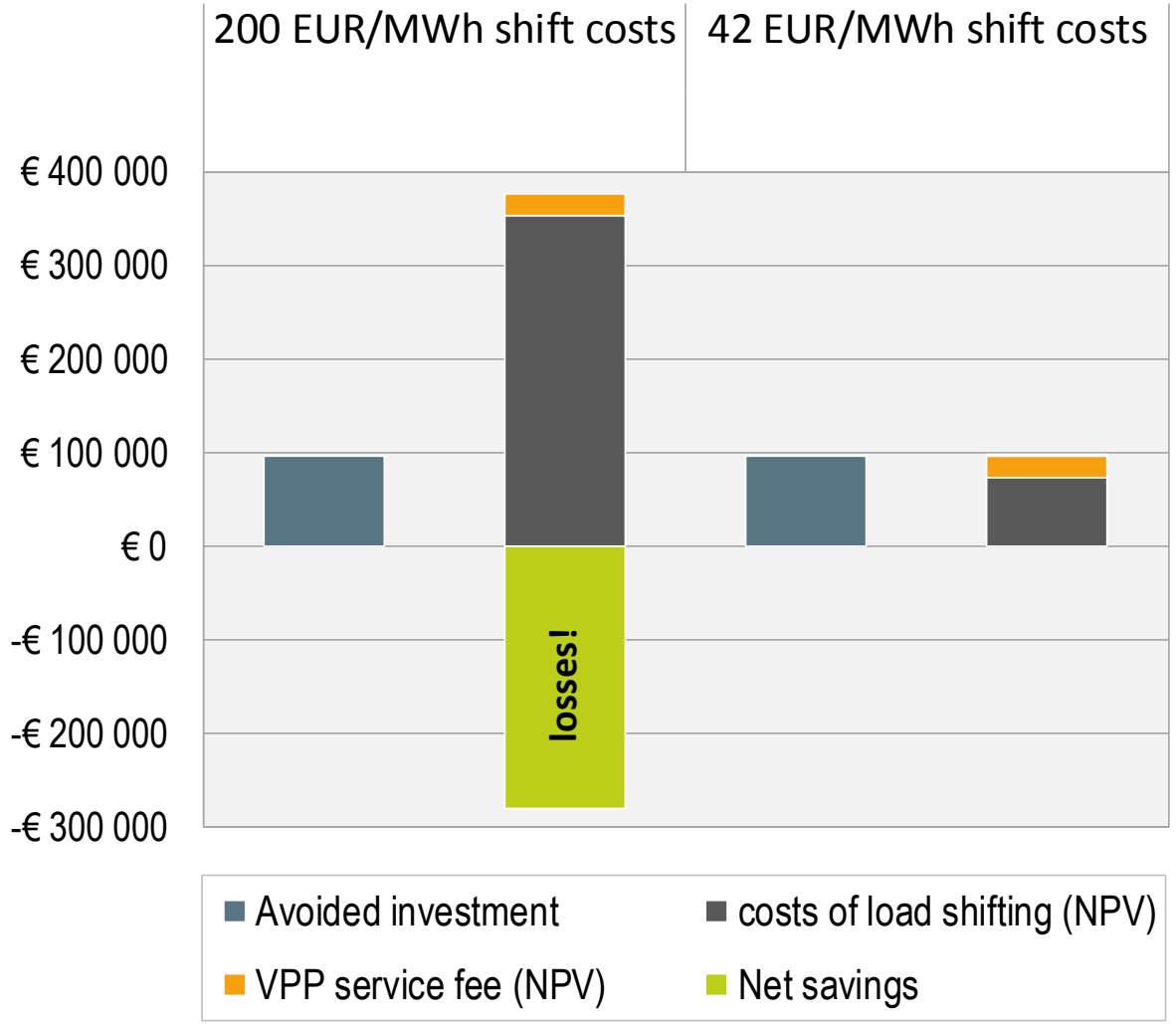


2b: Minimization of grid connection costs: **1,5 MW industrial load, Slovenia**

Comparison of discounted cost showed that in the given example grid investment is the better option if costs of load shifting exceed 42 EUR/MWh.

Assumed lifetime: 20a
discount rate: 5%

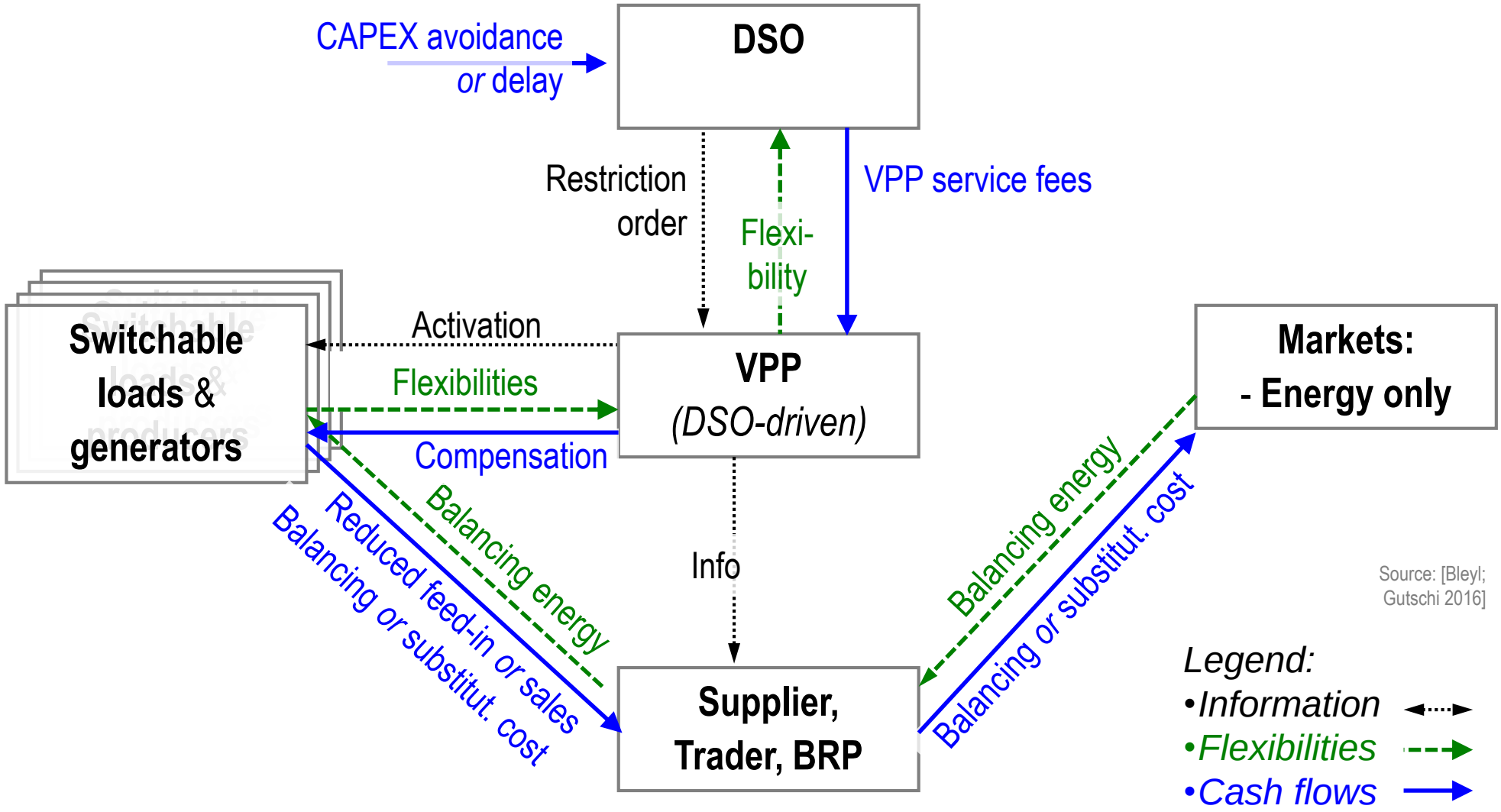
VPP service fee has low impact.



Cases 3a-c.:

VPP for DSO in Slovenia and Austria

3a. VPP for optimization of grid investments of DSO



3a.

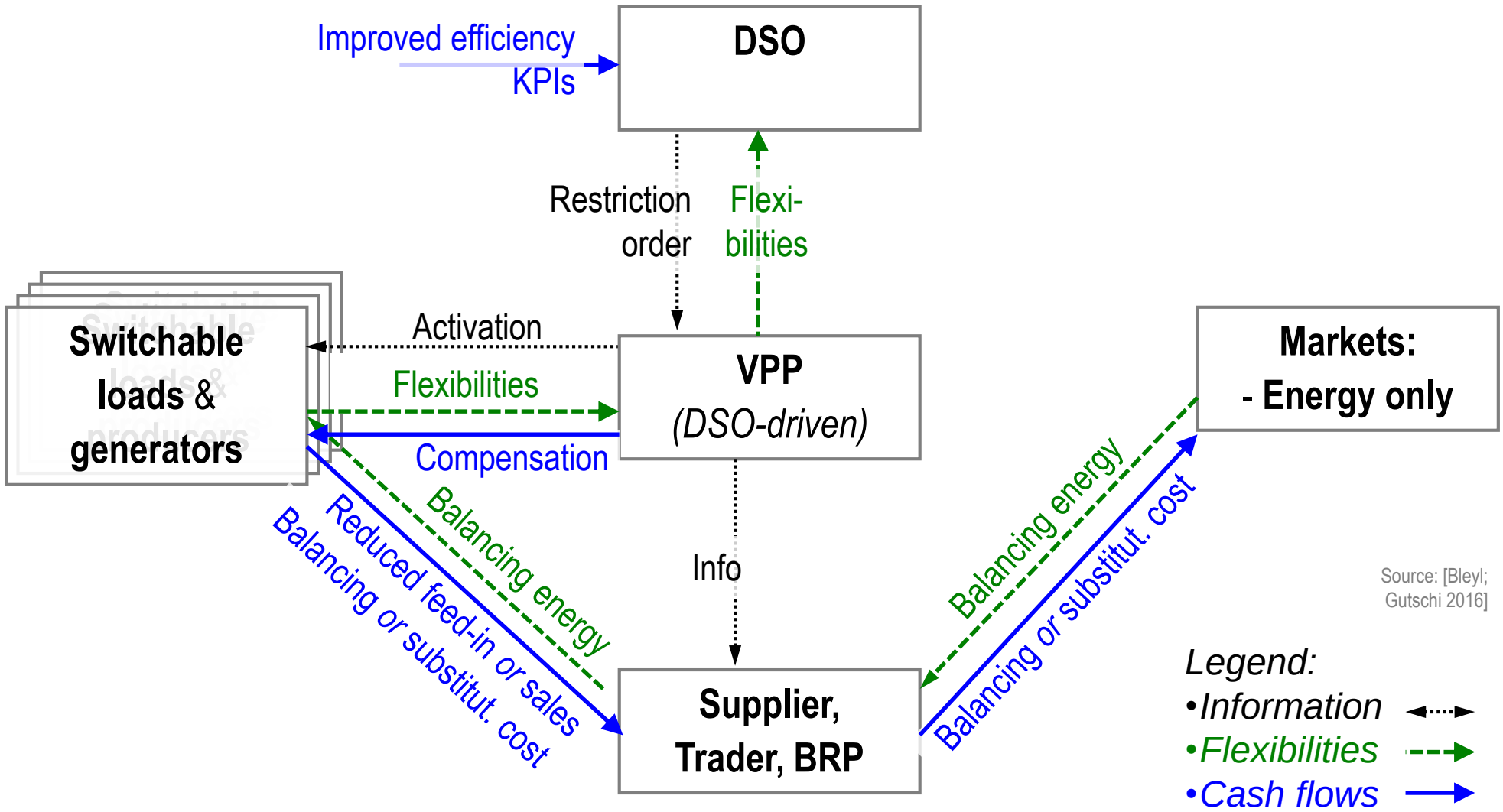
All stakeholders: Cost-Benefit (qualitative)

	Generator or consumer	*hybrid*-VPP	DSO	Supplier, Trader, BRP	Markets	*Explanations and remarks*
Revenues / Benefits	Additional income from VPP	Additional income from DSO	Avoided investment (reduced CAPEX)	Balancing energy (from customer)	Balancing energy	
	-	-	-	-	-	
Cost	Balancing cost	Operation cost	VPP service fee (OPEX) *(?)*	Balancing energy of balance group	-	
		Communication cost	SCADA update, Communication interface	-	-	
Economic appraisal	+ Additional income	+ Minor additional income	*To be discussed: efficiency KPIs, ROI*	0	0 (low impact)	++ clearly positiv + slightly positiv 0 mainly neutral - slightly negativ - - clearly negativ
Other benefits or risks		+ Access to new flexibilities	+ Add. network operation data + Customer relation	- Minor administr. efforts - Forecast more complex		

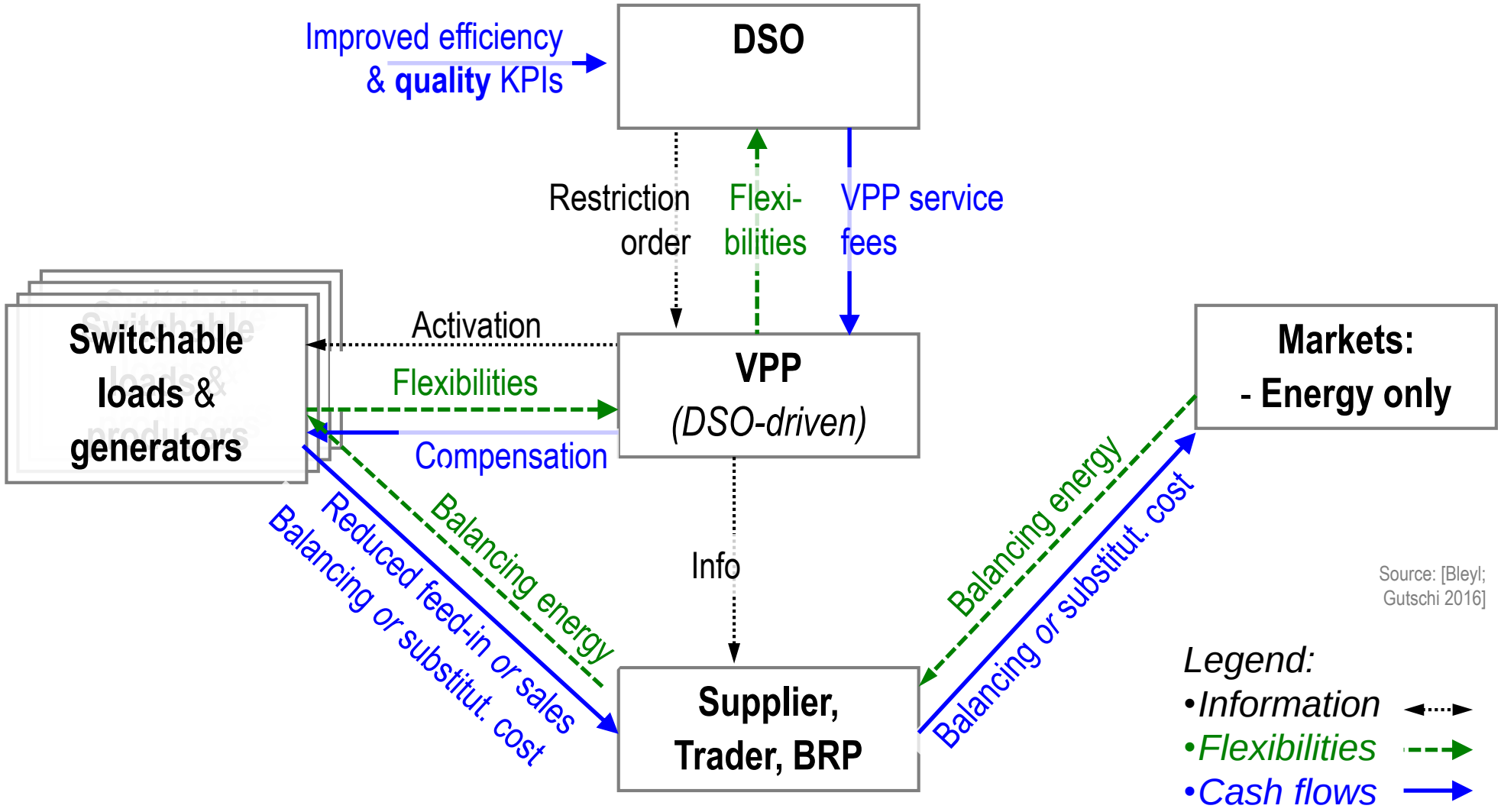
3a: **Avoided grid investment Exemplary case in Slovenia**

- Siska region, required grid reinforcement:
  - 2,45 km (180.600 EUR)
- Alternative: hybrid-VPP curtails loads during critical hours
  - Max 1 MW load curtailment
  - 183 MWh/a
  - VPP service fee of 2000 EUR/MW/a
- Assessment over 20a and 5% discount rate:
  Marginal costs of curtailed energy: 54 EUR/MWh
- Assessment over 50a and 5% discount rate:
  Marginal costs of curtailed energy: 26 EUR/MWh
- Conclusions:
  - **In the given case, the VPP can be used to delay investment or as bridging solution.**
  - **But it is not economic to replace the investment by a VPP service**.

3b. VPP to support grid operation during maintenance and special switching states



3c. VPP to support grid operation with quality regulation regime



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Thank you very much for your kind attention!

Your feedback is appreciated!

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Ljubljana, June 9th, 2017