hybrid-VPP4DSO: Stakeholder Workshop

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

(preliminary results for discussion)

Christoph Gutschi (Cybergrid)

Jan W. Bleyl (Energetic Solutions)

Vienna, 14. December 2016

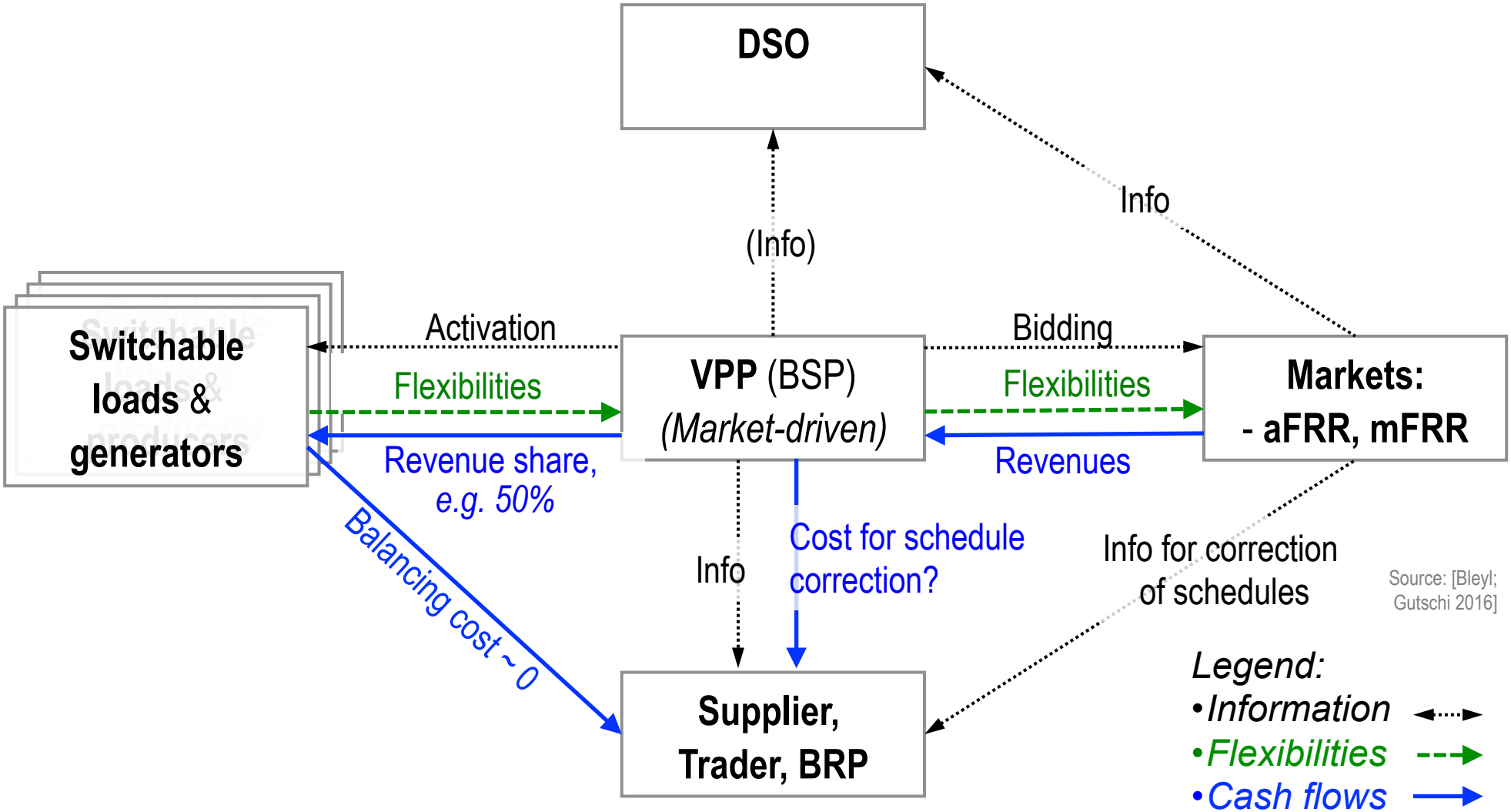
Outline

1. **Market-driven VPP** (with and without DSO restrictions)
   a. Stakeholders; Information-, Flexibilities- and Cash flows
   b. Input data: CAPEX and OPEX
   c. Break-even analyses incl. sensitivities
2. **Client network access-driven VPP** (for generators and consumers)
   a. Multi-stakeholder cost-benefit analyses (qualitative)
3. **DSO-driven VPP:**
   a. Use cases: 1. Avoided network construction and 2. Maintenance
   b. Stakeholder and cost-benefit perspectives
4. **Outlook:**
   a. hybrid-VPP: Use case mix?
   b. Dynamic investment calculation for *hybrid*-VPP

Case 1a.:

VPP for Flexibility Markets without restrictions from network operation

1a. VPP for Flexibility Markets without restrictions from network operation



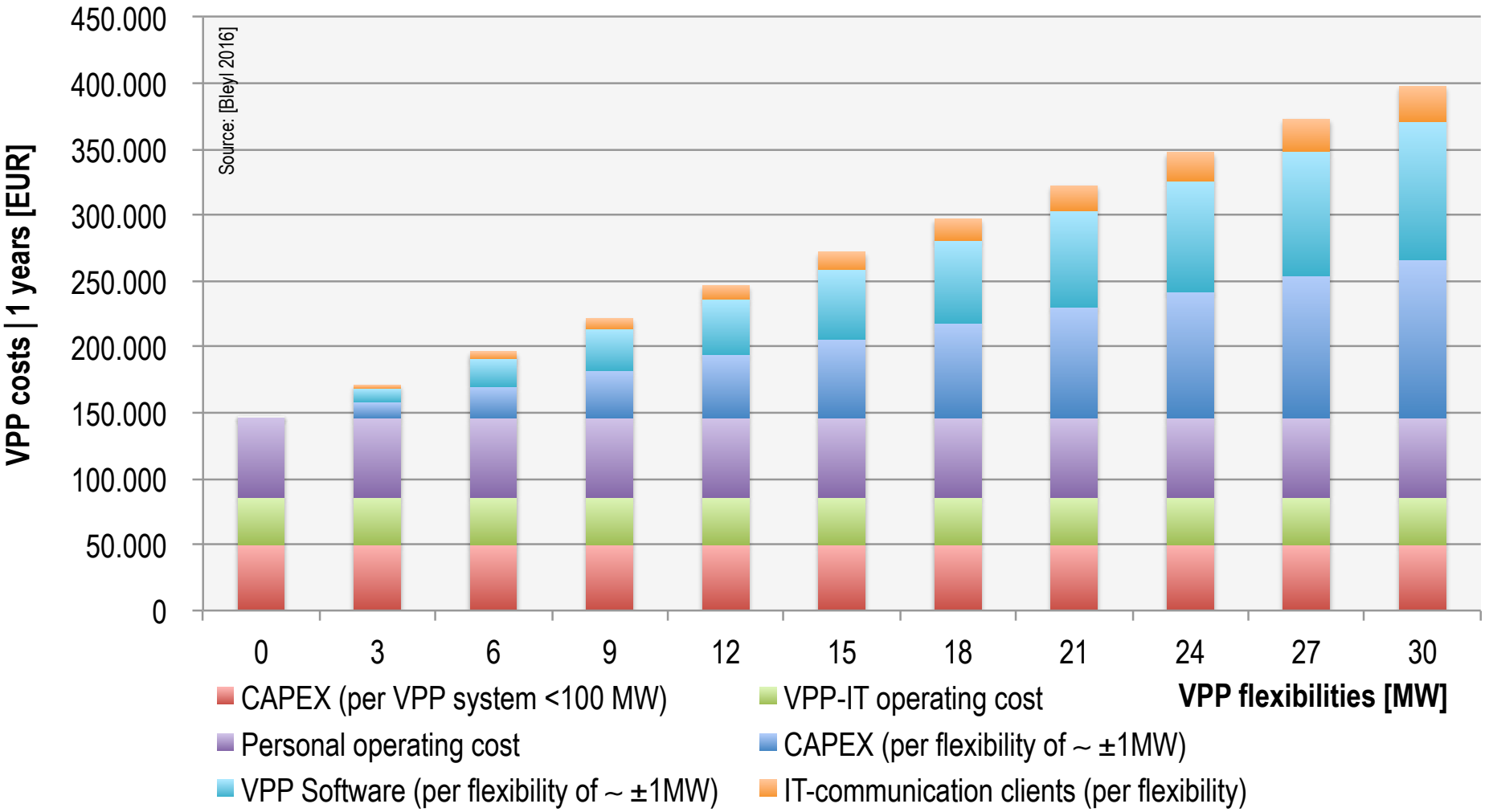
1a. **CAPEX**:
a) **Fix**, b) **Variable per MW**

	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]	**4.000**	
Per flexibility connected	[EUR/MW]	**3.000**	*Technician + hardware at client*
Transaction cost VPP client	[EUR/MW]	**1.000**	*Sales, marketing, drawing up of contract*

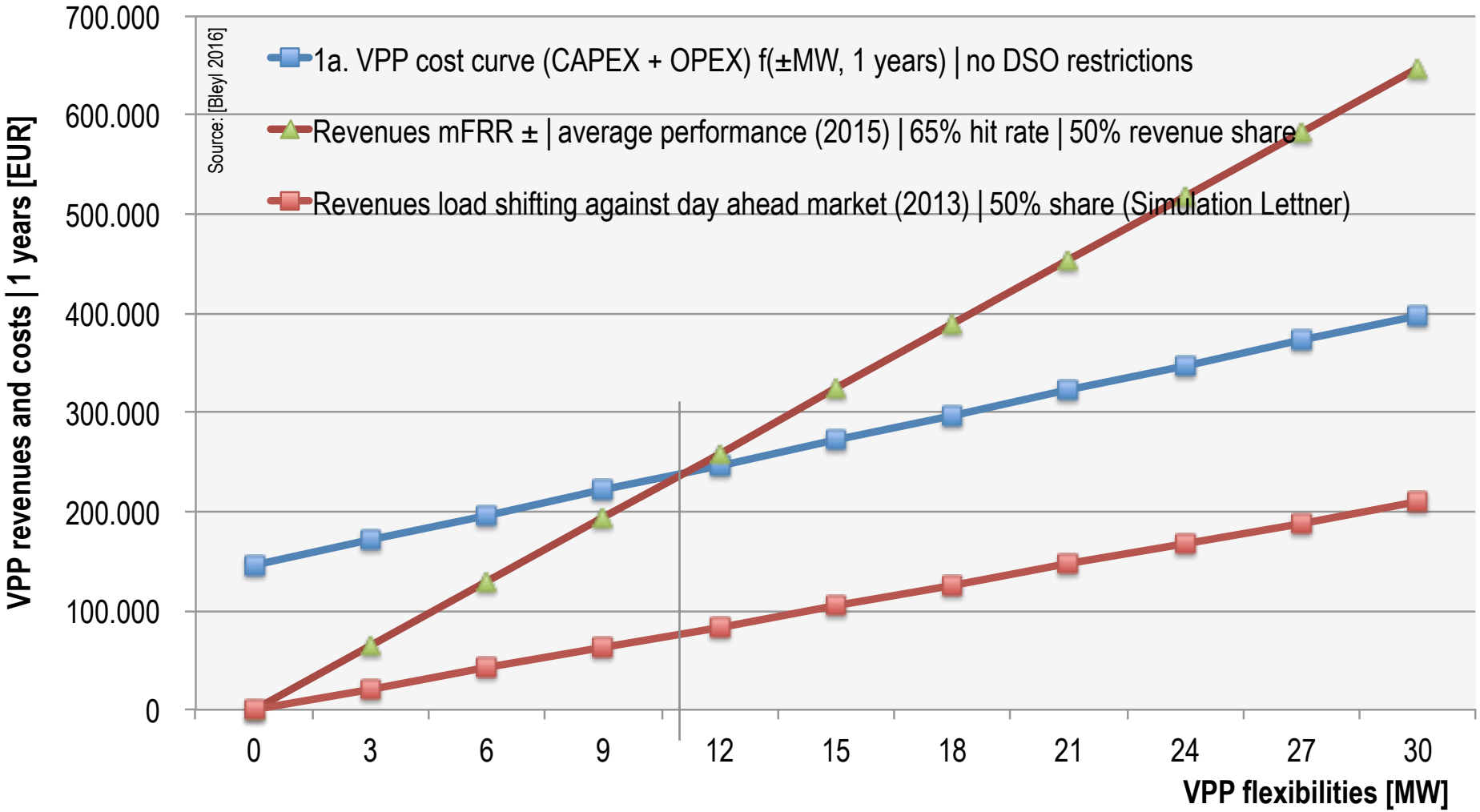
1a. **OPEX**:
c) **Fix per year**; d) **Variable per MW, year**

	unit	cost	*Explanations and remarks*
c) **OPEX** (fix per VPP system per year):	[EUR/a]	**96.000**	
VPP-IT operating cost	[EUR/a]	**30.000**	*IT-System hosting, maintenance, support*
IT-communication TSO	[EUR/a]	**6.000**	*IT-communication with TSO*
IT-communication DSO	[EUR/a]		*IT-communication with DSO*
Personal operating cost			
VPP operation incl. trading	[EUR/a]	**60.000**	*24/7: 0,1 person equivalents/a (876 h/a @ 65 EUR/h;)*
d) **OPEX** (variable per client per year):	[EUR/a]	**4.400**	
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]	**900**	*DSL encrypted*
Average 0,5 + 5 MW	[EUR/a]	**900**	
5 MW	[EUR/a]	**1.200**	*e.g. industrial site (DSL+firewall)*
0,5 MW	[EUR/a]	**600**	*e.g. small hydro (mobile connection)*

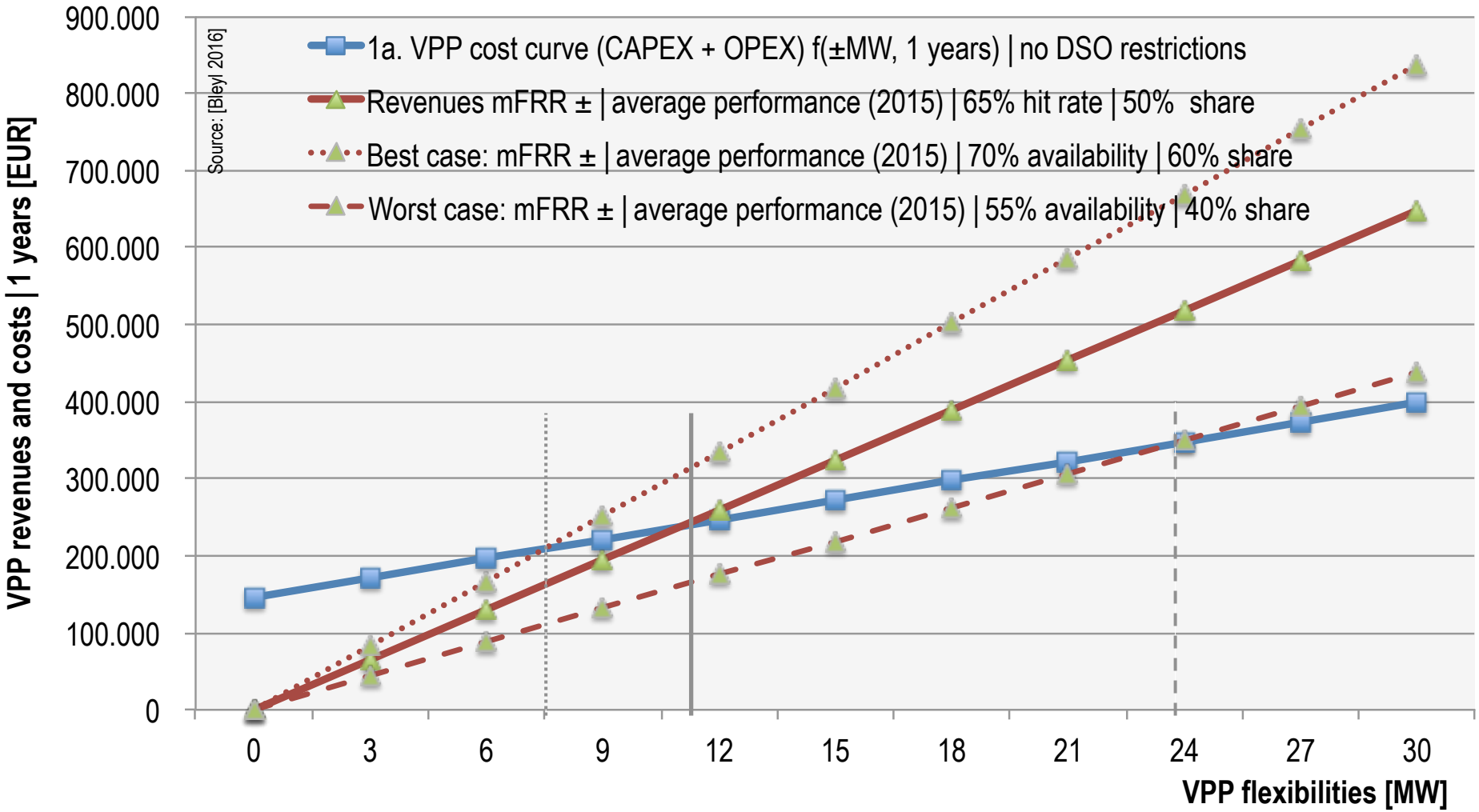
1a. Cost structure = f(MW): Fix + variable; 1 year operation time



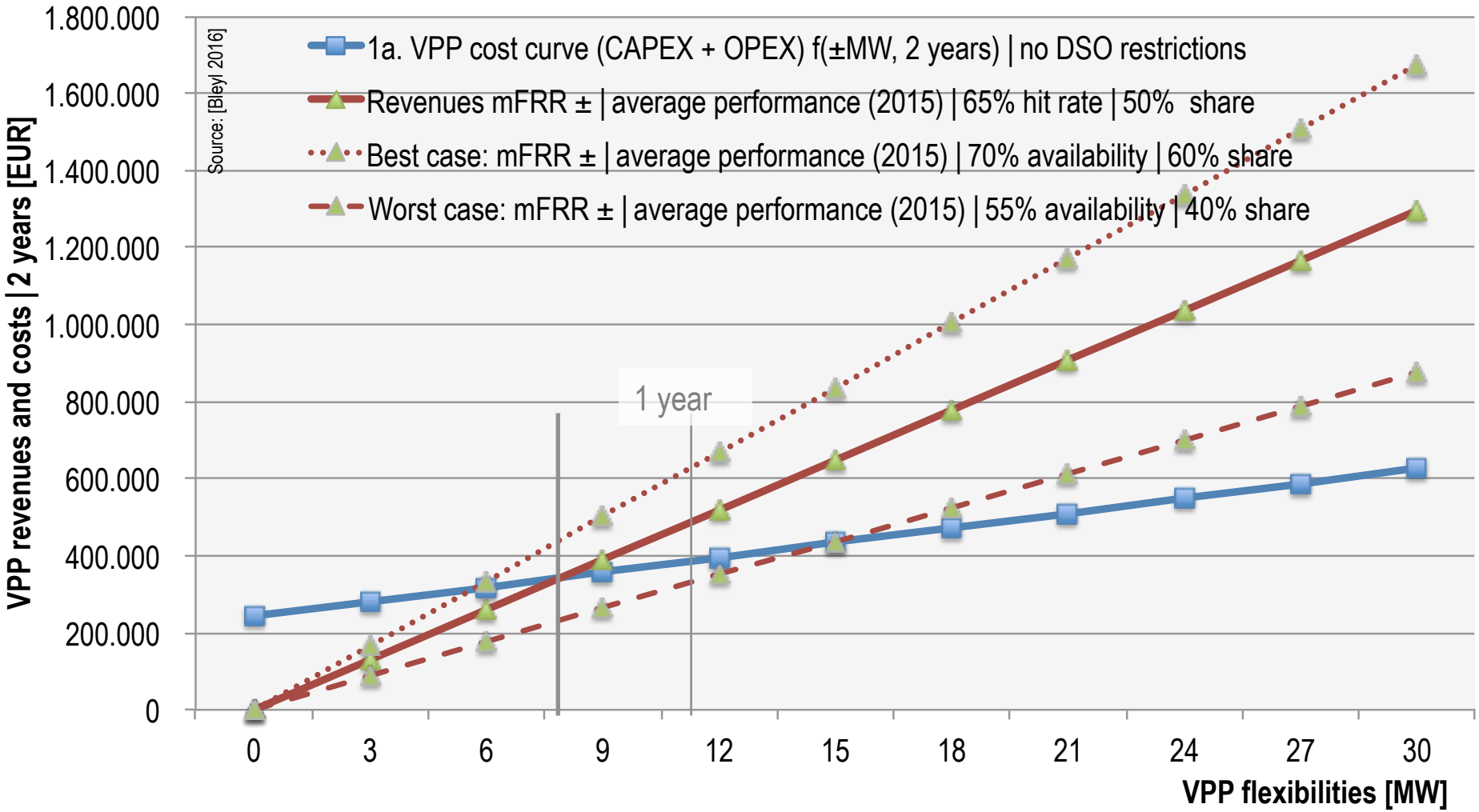
1a, c. Break-even analyses
Revenues vs. VPP cost; 1 year operation



1a. Break-even: Revenue sensitivity
Best, worst case; 1 year operation time



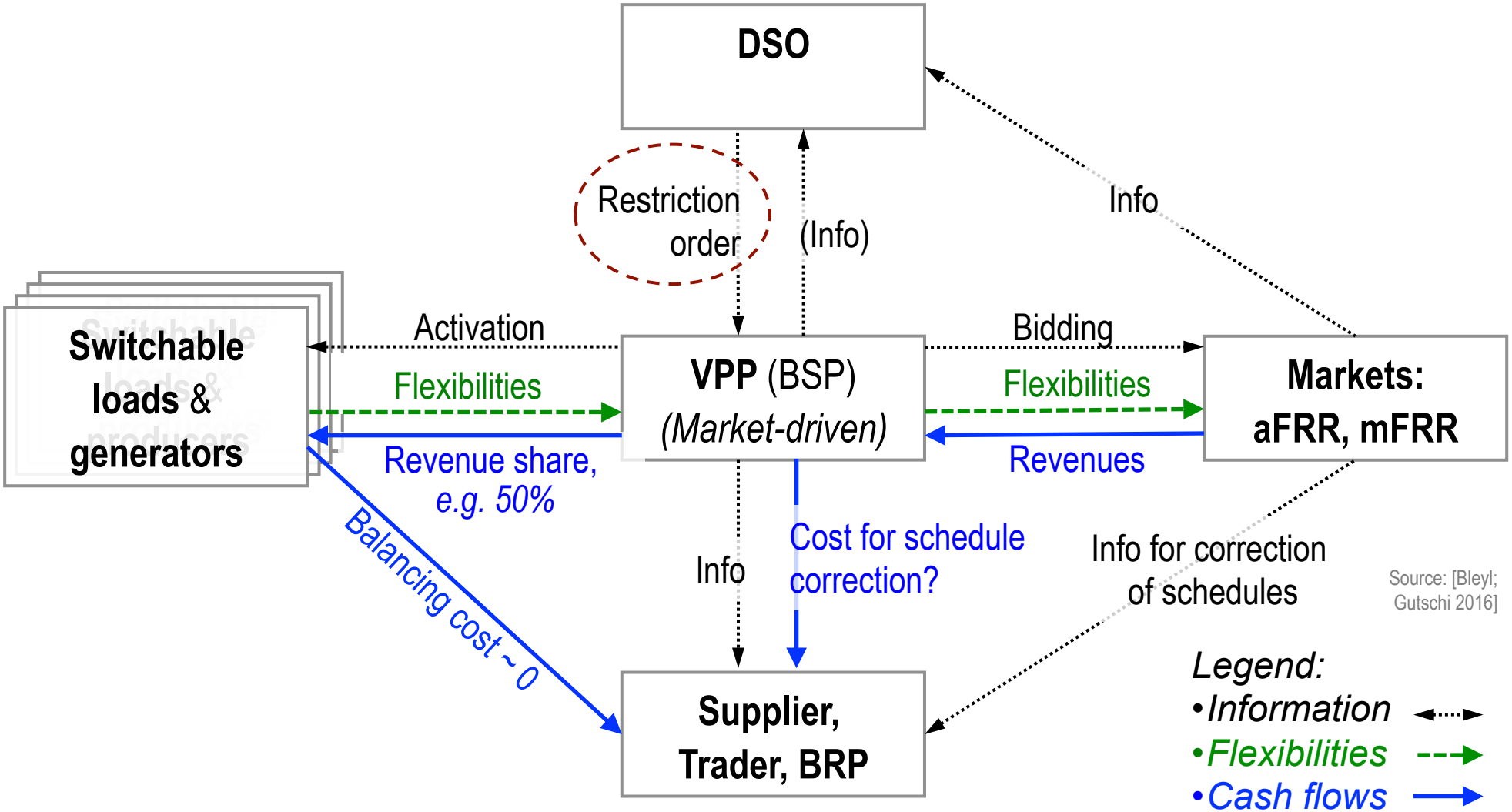
1a. **Break-even: Project term sensitivity**
2 years (vs. 1 year) **operation time**



Case 1b.:

VPP for Flexibility Markets with Operating Restrictions from DSO

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



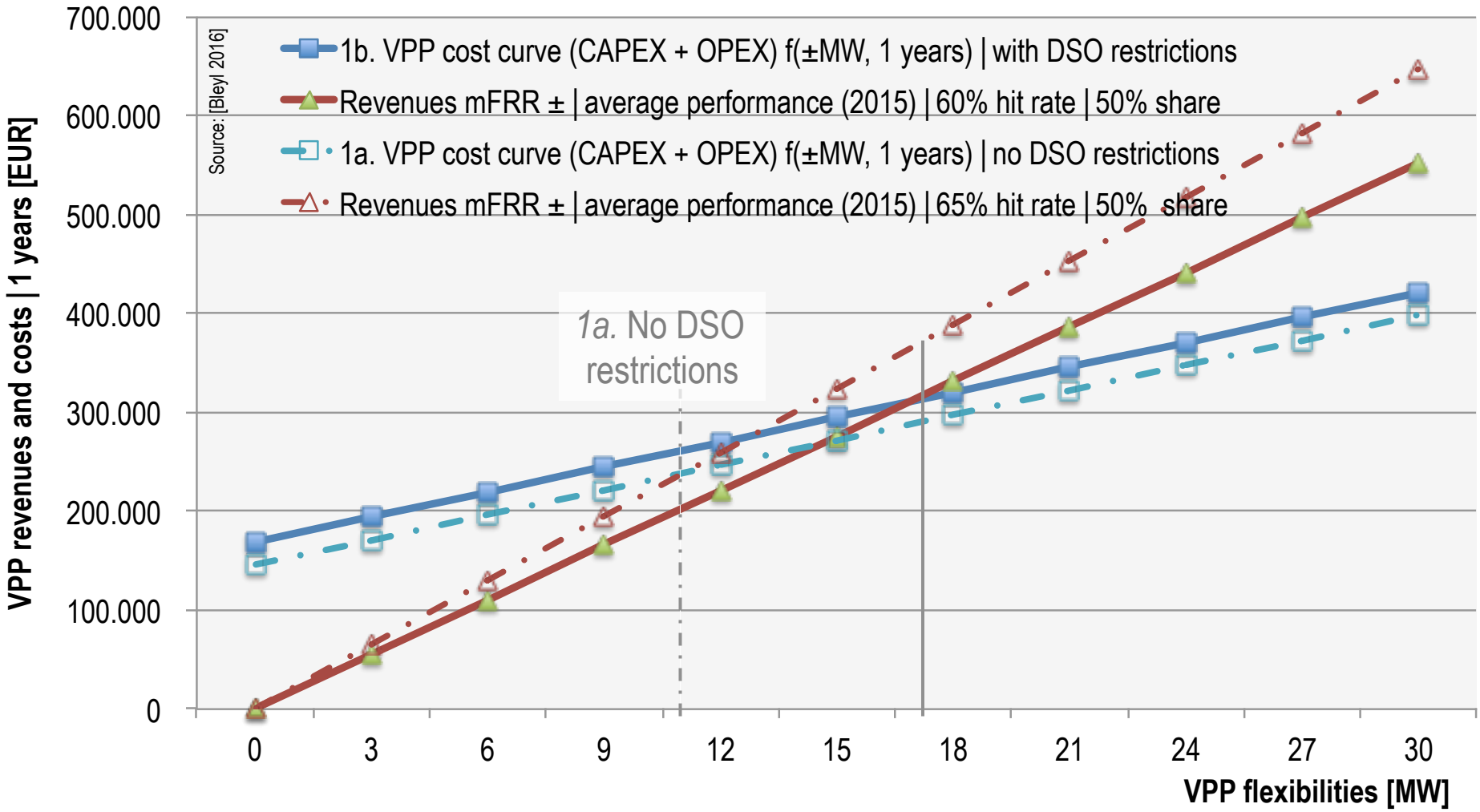
1b. **CAPEX:**
a) **Fix**, b) **Variable per MW**

	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]	**4.000**	
Per flexibility connected	[EUR/MW]	**3.000**	*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]	**99.000**	
VPP-IT operating cost	[EUR/a]	**30.000**	*IT-System hosting, maintenance, support*
IT-communication TSO	[EUR/a]	**6.000**	*IT-communication with TSO*
IT-communication DSO	[EUR/a]	**3.000**	*IT-communication with DSO*
Personal operating cost			
VPP operation incl. trading	[EUR/a]	**60.000**	*24/7: 0,1 person equivalents/a (876 h/a @ 65 EUR/h;)*
d) **OPEX** (variable per client per year):	[EUR/a]	**4.400**	
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]	**900**	*DSL encrypted*
Average 0,5 + 5 MW	[EUR/a]	**900**	
5 MW	[EUR/a]	**1.200**	*e.g. industrial site (DSL+firewall)*
0,5 MW	[EUR/a]	**600**	*e.g. small hydro (mobile connection)*

1b. **Break-even analyses** (+ comparison with *1a.*)
Revenues vs. **VPP cost**; **1 year operation**



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.:

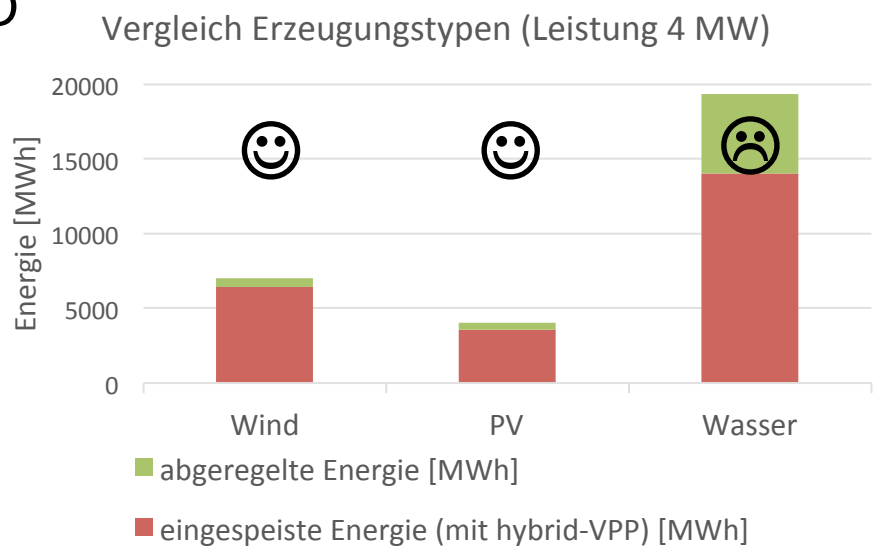
VPP to minimize grid connection cost for new generators and consumers

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

DSO can offer two options:

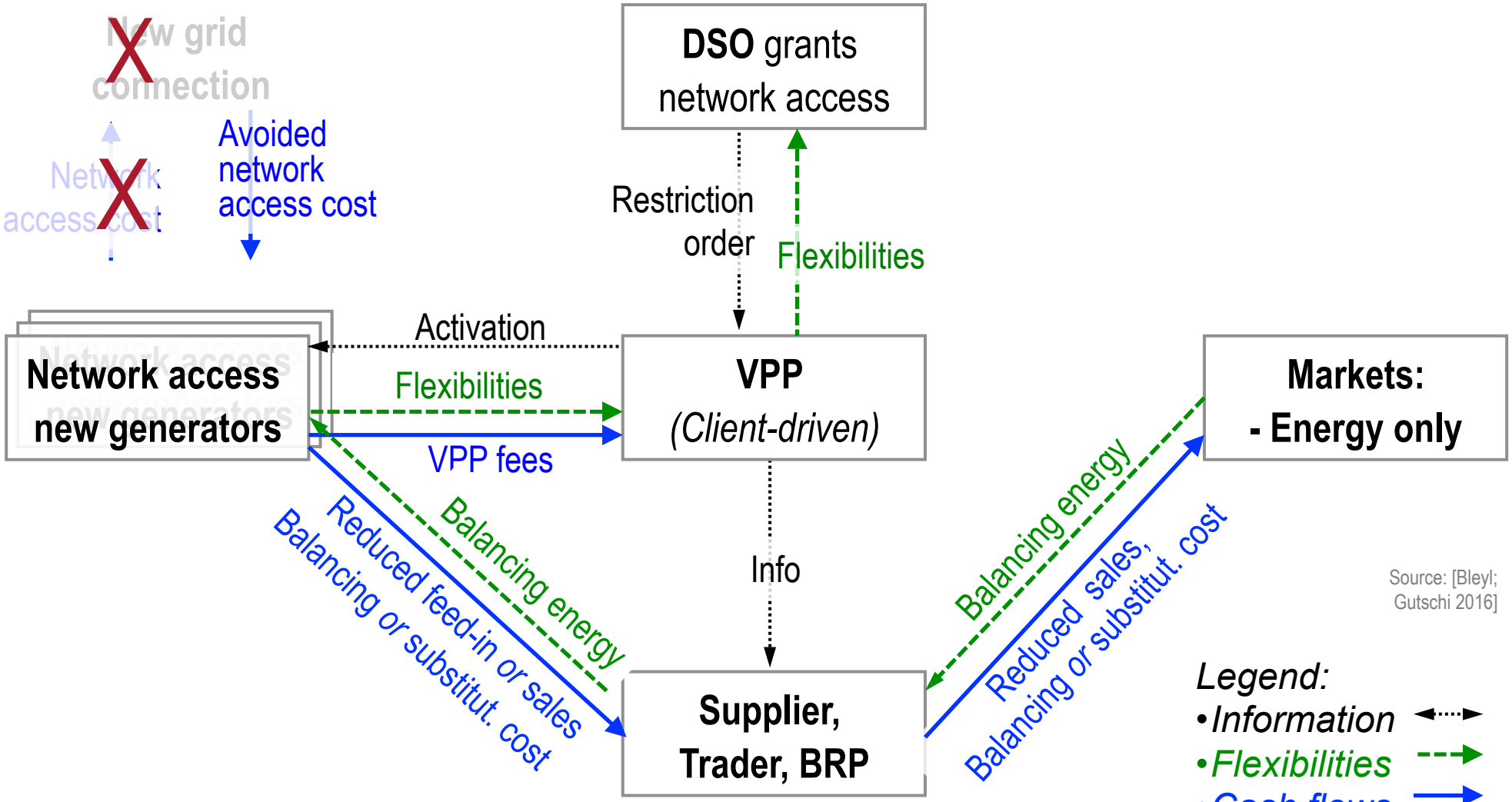
- **Standard approach:** customer has to pay for the required grid enhancement
- **Innovative approach:** customer can connect to the existing infrastructure but agrees to be curtailed in critical hours
  - Local P=f(U) feed-in control is the preferred option but may be problematic in some grid topologies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

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



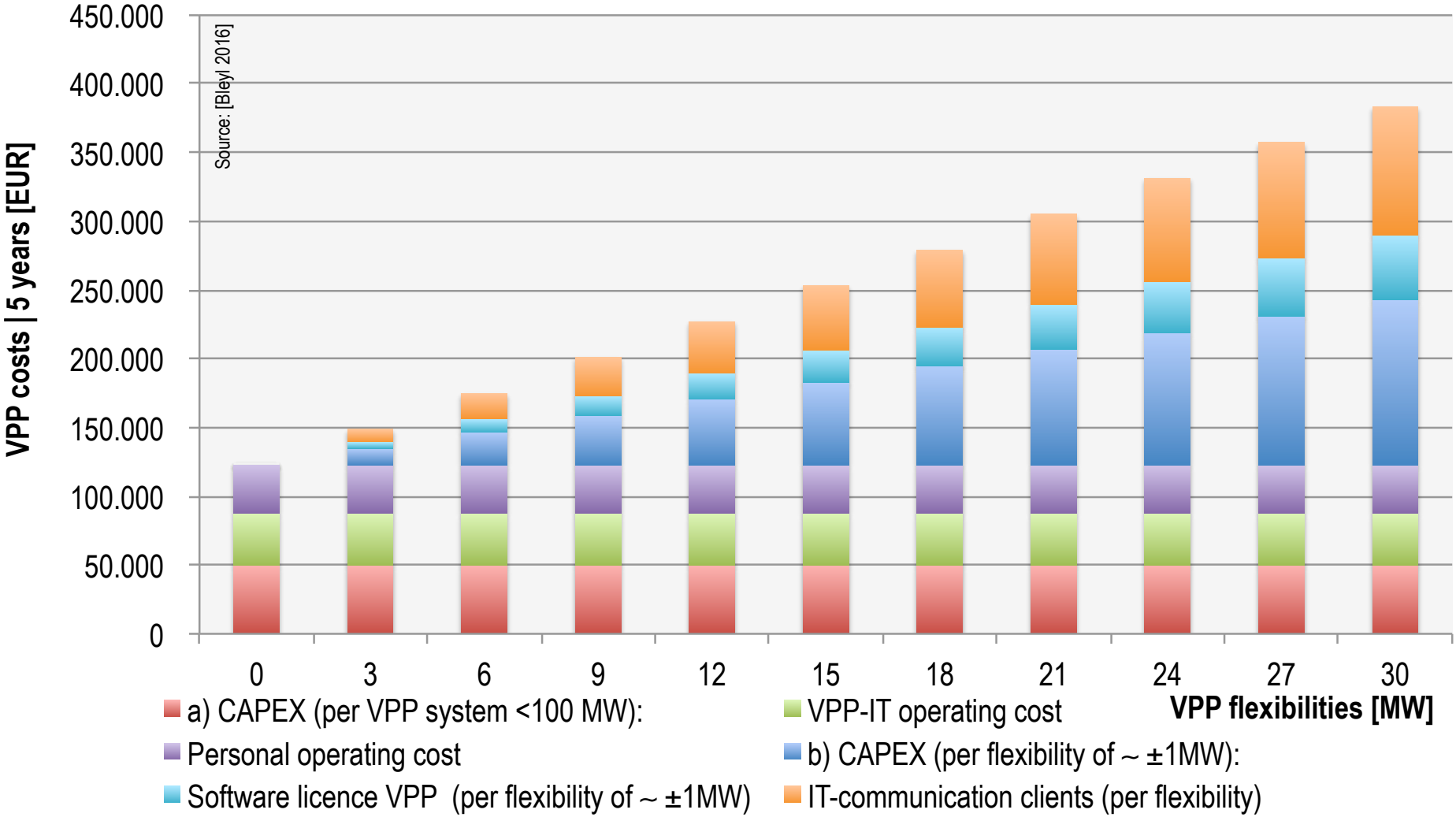
2a. VPP to minimize grid connection cost

Cost items: Fix & variable per MW, year

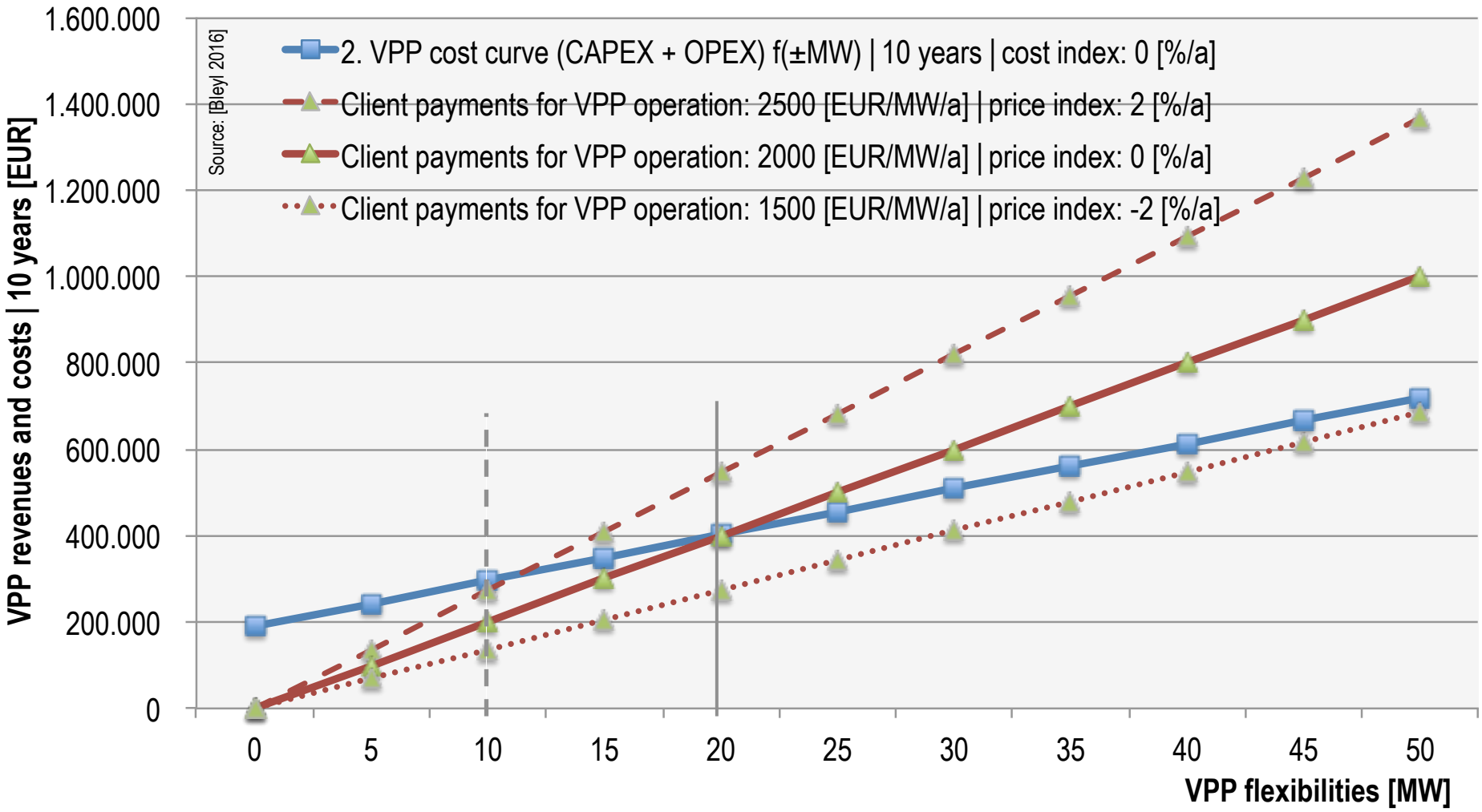
	unit	cost	*Explanations and remarks*
a) **CAPEX** (per VPP system <100 MW):	[EUR]	**50.000**	
VPP System	[EUR]	**30.000**	*VPP System installation (DSO-internal)*
Connection to DSO NOC	[EUR]	**20.000**	*Network operation center connection (manpower + hardware)*
b) **CAPEX** (per flexibility of ~ ±1MW):	[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, n*
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**	

2. Cost structure = f(MW): Fix + variable; 5 years operation time



2. Break-even: Revenues vs. cost = f(MW; Client payments); 10 years operation time



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

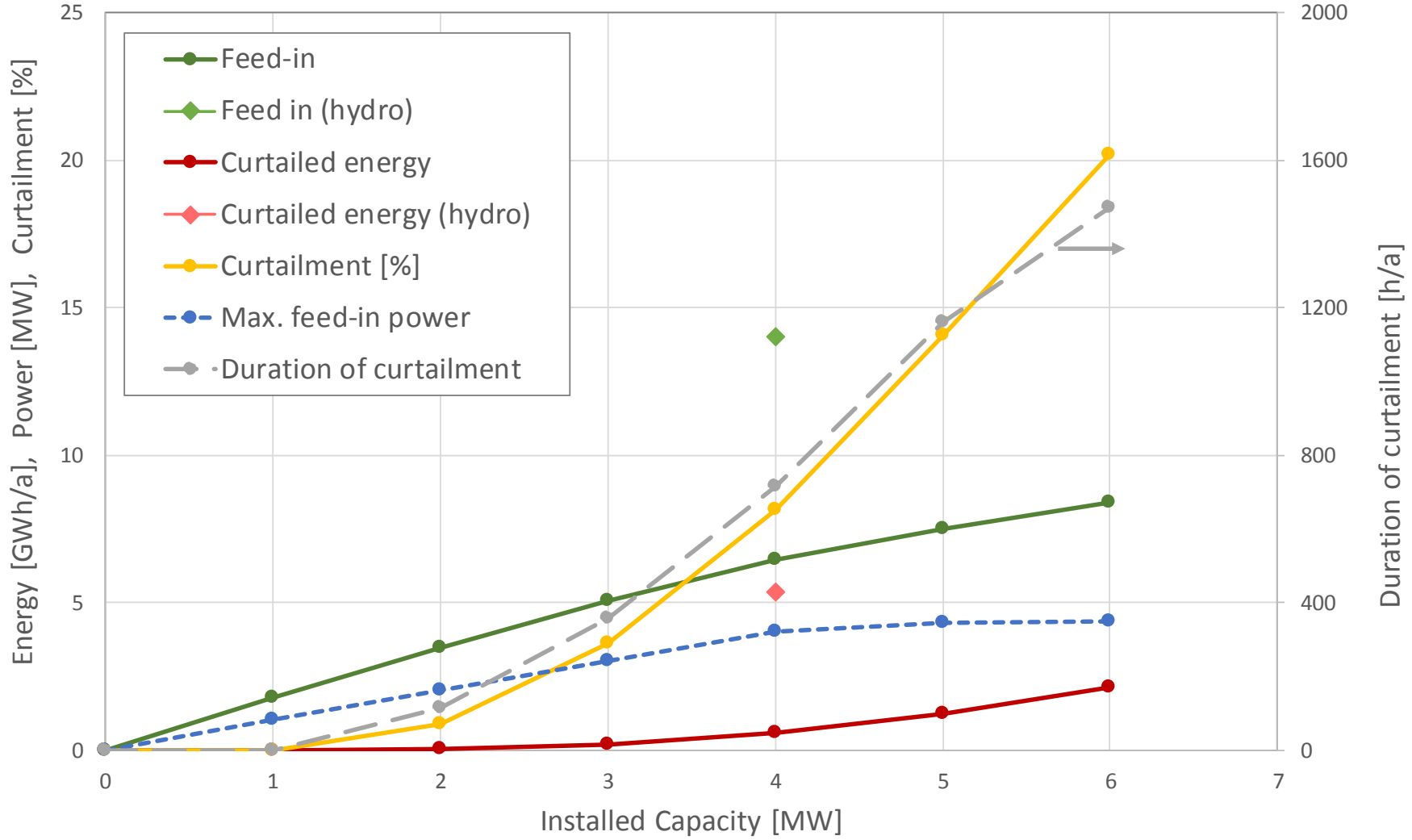
	Generator: New grid connection (Reference)	Generator: Avoided grid connection (w. VPP)
Revenues / Benefits	Additional feed-in revenues	**Avoided investment cost**
	-	**Avoided maintenance cost** *(?)*
Cost	Investment cost	**Lost feed-in revenues**
	Add. maintenance cost *(?)*	**VPP service cost, Balancing cost**
Economic appraisal	- - high CAPEX - - long payback	**++ avoided CAPEX**
Other benefits or risks	+ Improved network access	**- Weaker network access**

++	clearly positiv
+	slightly positiv
0	mainly neutral
-	slightly negativ
- -	clearly negativ

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

	Generator: New grid connection (Reference)	Generator: Avoided grid connection (w. VPP)	*hybrid*-VPP	DSO	Supplier, Trader, BRP	Markets	*Explanations and remarks*
Revenues / Benefits	Additional feed-in revenues	Avoided investment cost	Additional income from VPP services	Incentive regulation => higher RoI *(?)*	Balancing energy	Balancing energy	
	-	Avoided maintenance cost *(?)*	-	-	-	-	
Cost	Investment cost	Lost feed-in revenues	Operation cost	Communication interface	Balancing energy of balance group	-	
	Add. maintenance cost *(?)*	VPP service cost, Balancing cost	Communication cost	SCADA update	-	-	
Economic appraisal	- - high CAPEX - - long payback	++ avoided CAPEX	0 *(?)*	0 *(?)*	0	0 (low impact)	++ clearly positiv + slightly positiv 0 mainly neutral - slightly negativ - - clearly negativ
Other benefits or risks	+ Improved network access	- Weaker network access	+ Access to new flexibilities	+ Add. network operation data + Customer relation	- Minor administrative efforts	- Reduced RES share	

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



Source: Spreitzhofer

Cases 2b.:

VPP to minimize grid connection cost for new consumers

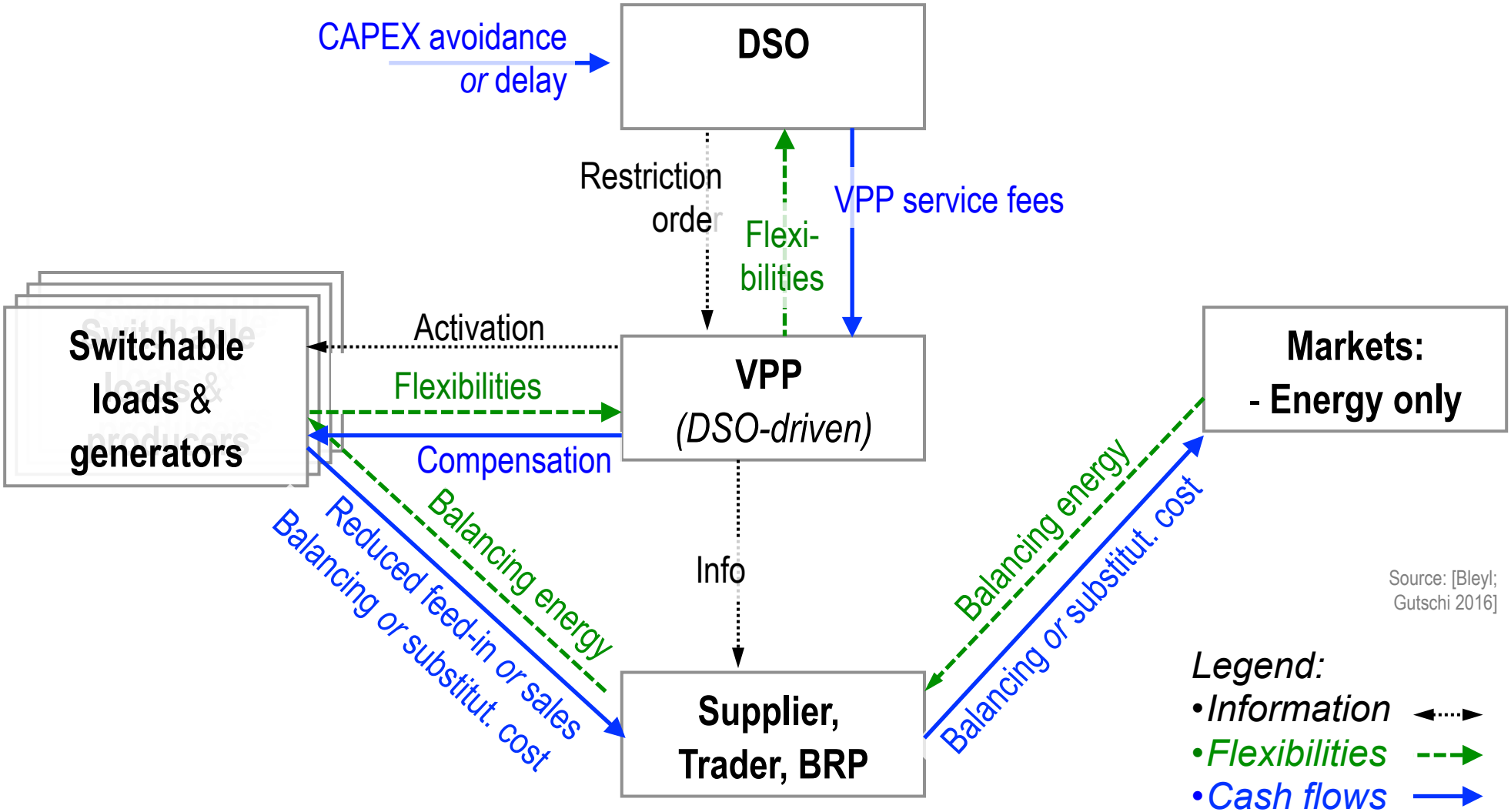
Case 2b: Industrial consumer *applies for grid access in already stressed grid section*

- The DSO can offer same options as for the generator (2a)
  - Payment for grid enhancement
  - 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 but are likely to be much higher than price of energy (> 500 EUR/MWh)

Cases 3a-c.:

VPP for DSO in Austria

3a. VPP for optimization of grid investments of DSO

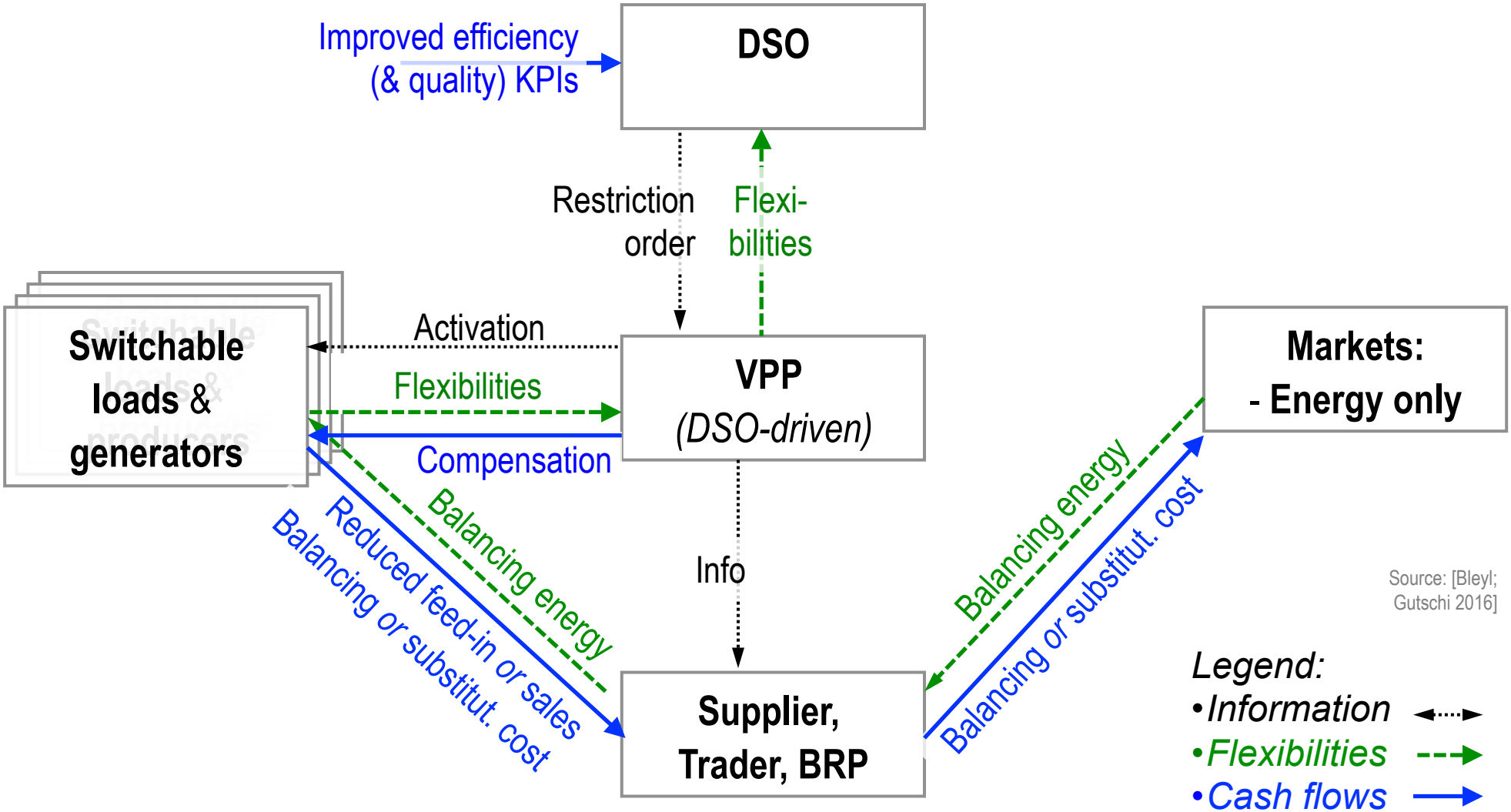


3a.
All stakeholders: Cost-Benefit (qualitative)

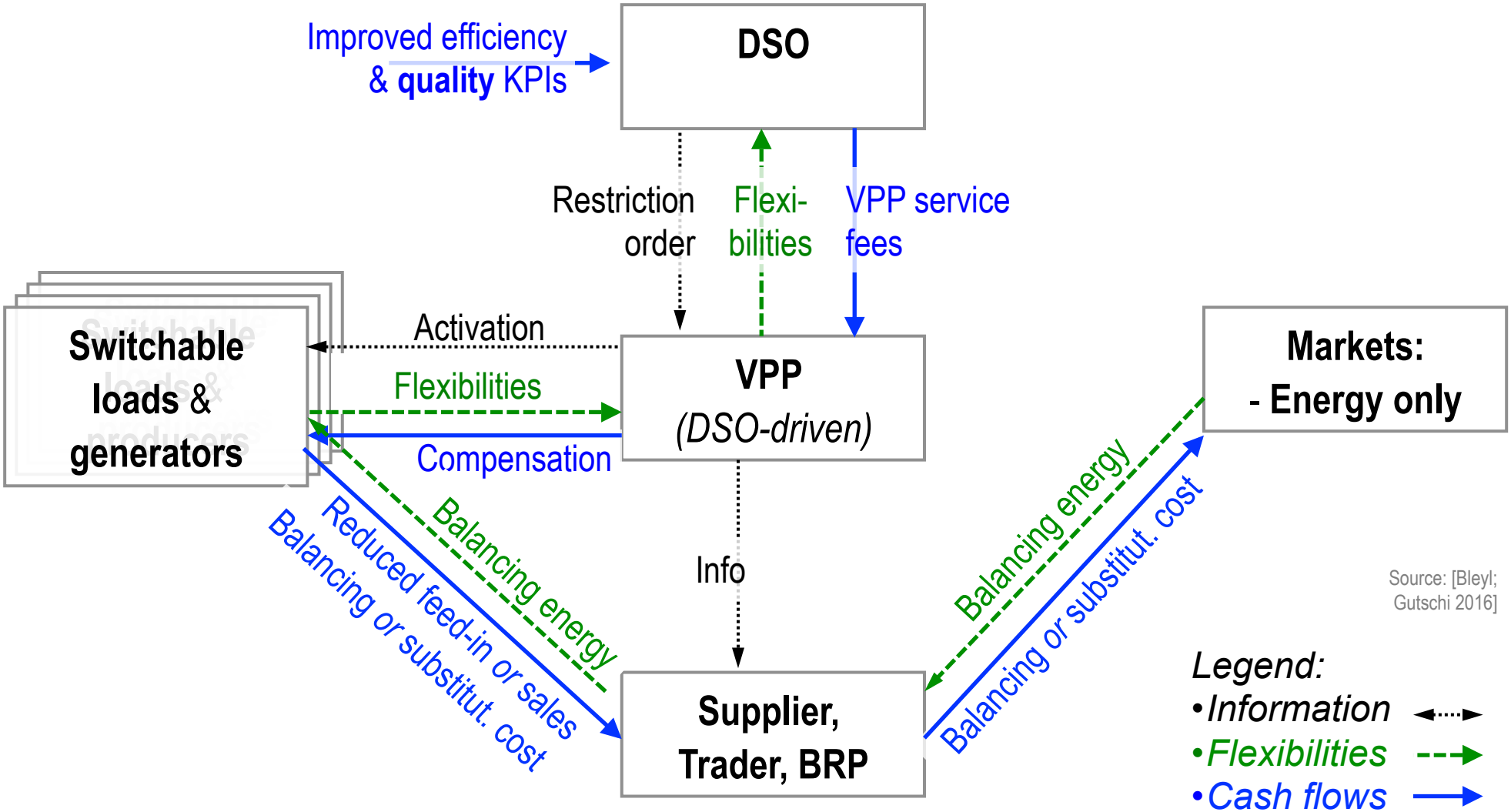
	Generator or consumer	*hybrid*-VPP	DSO	Supplier, Trader, BRP	Markets	*Explanations and remarks*
Revenues / Benefits	Additional income from VPP	Additional income from DSO	Avoided investment (reduced CAPEX)	Balancing energy (from customer)	Balancing energy	
	-	-	-	-	-	
Cost	Balancing cost	Operation cost	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)	
Other benefits or risks		+ Access to new flexibilities	+ Add. network operation data + Customer relation	- Minor administr. efforts - Forecast more complex		

++	clearly positiv
+	slightly positiv
0	mainly neutral
-	slightly negativ
- -	clearly negativ

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

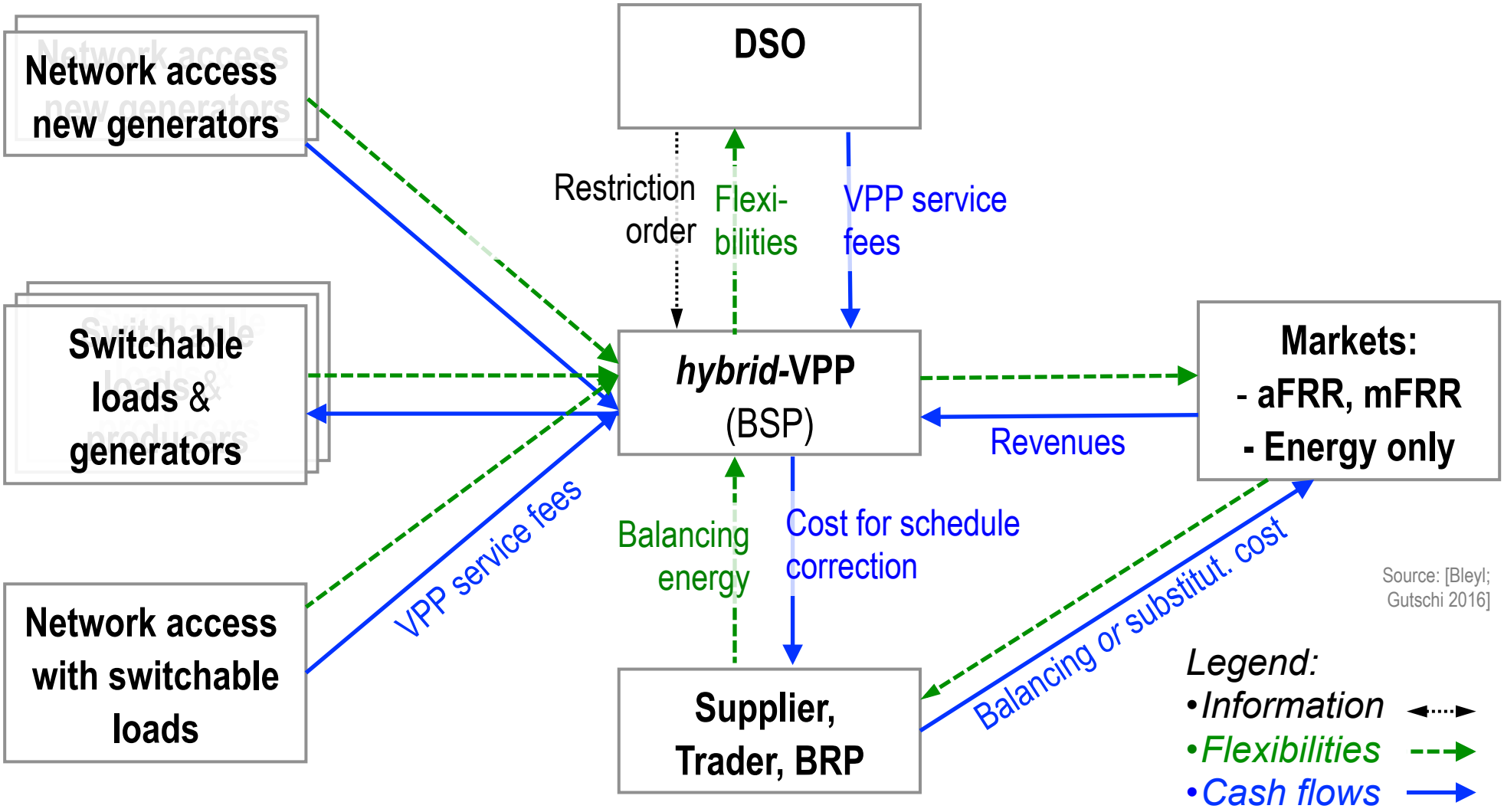


3c. VPP to support grid operation with quality regulation regime



Ausblick: *hybrid*-VPP
= Case 1 + Case 2 + (Case 3)

*1.-3. **hybrid**-VPP: Market-, Network access-* & **DSO- driven** => *Mix of use cases*



hybrid-VPP4DSO: Stakeholder Workshop

Thank you very much for your attention!
Your feedback is appreciated

Christoph Gutschi (Cybergrid)

Jan W. Bleyl (Energetic Solutions)

Vienna, 14. December 2016