ELECTRICITY TARIFF IMPLICATIONS OF INCREASING ADOPTION OF BEHIND THE METER TECHNOLOGIES IN AN AFRICAN CONTEXT

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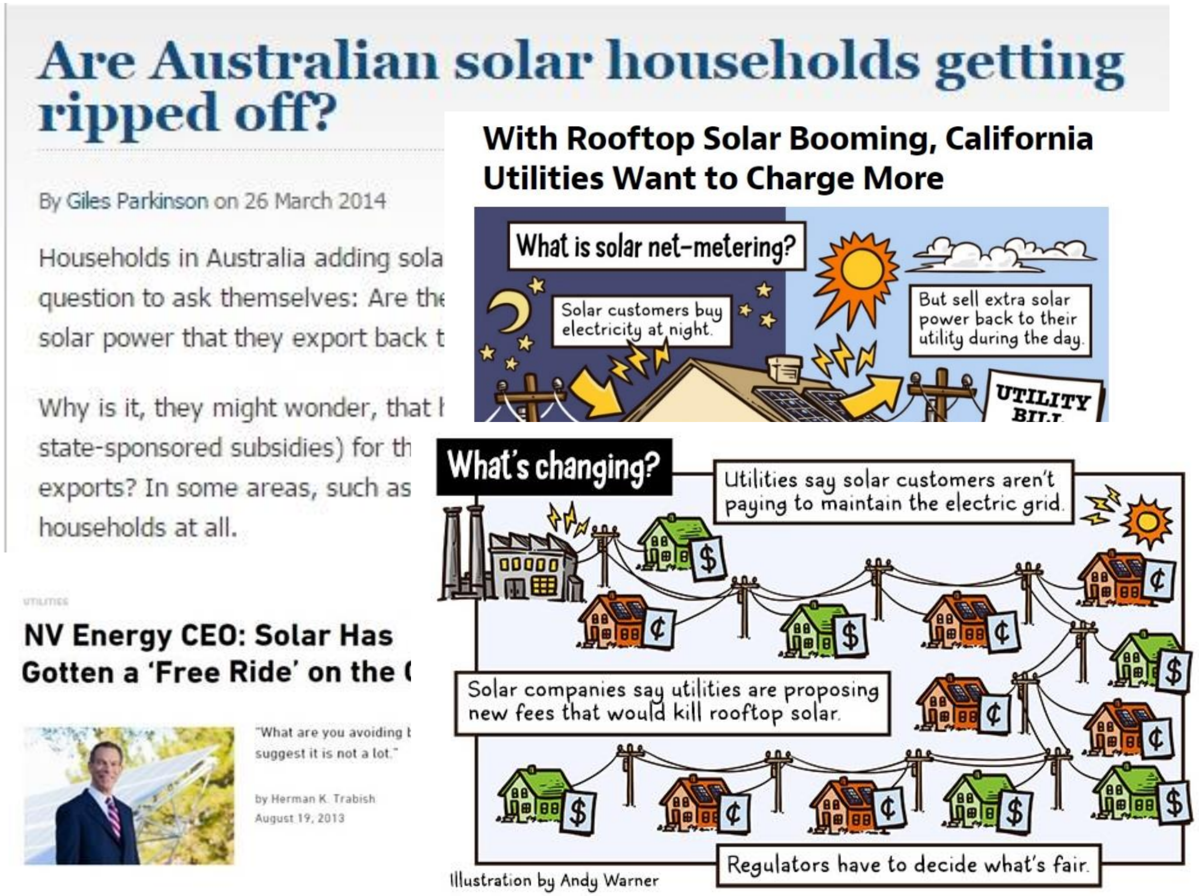
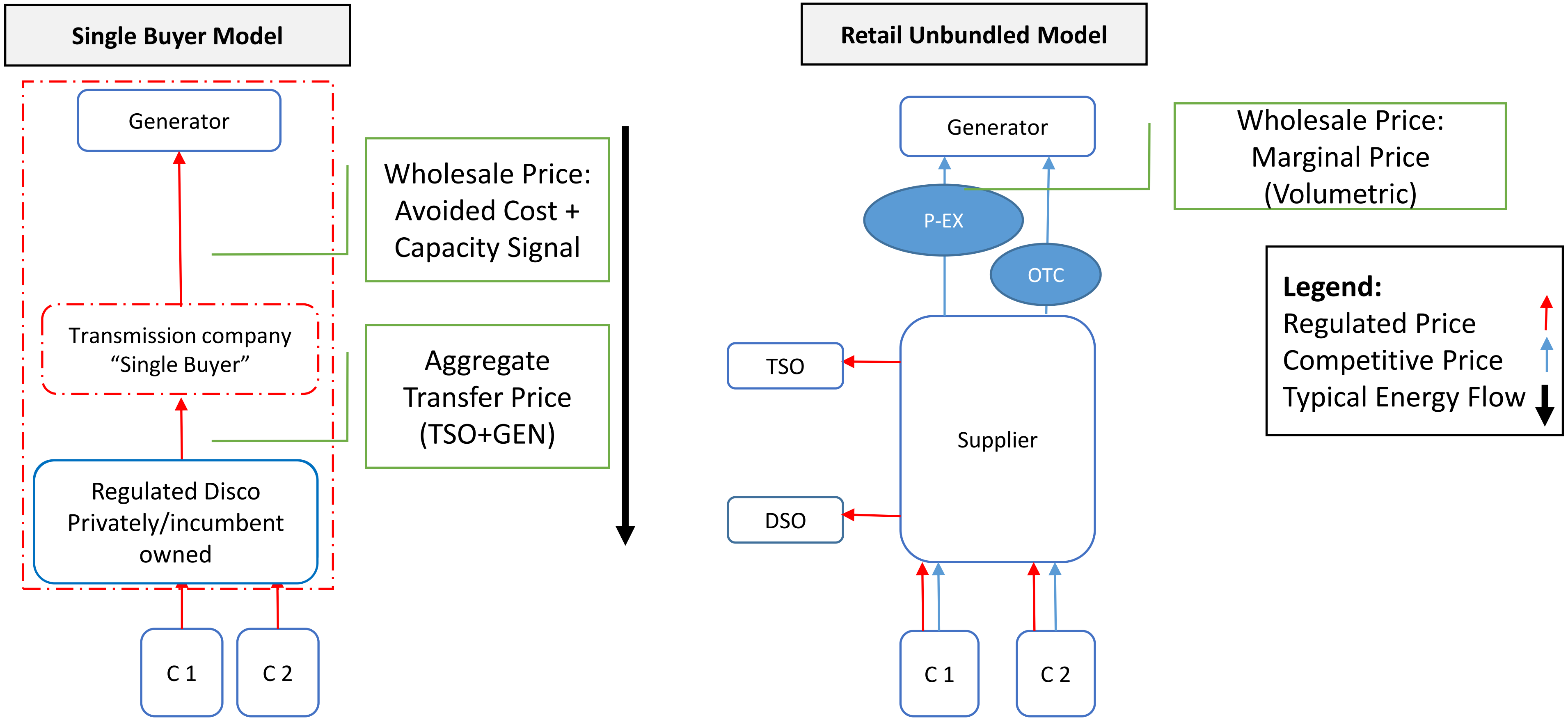
Introduction

- Significant BTM namely small scale PV adoption was driven by **subsidy schemes** Inderberg et al. (2018).
- Currently, BTM investments can be **profitable depending merely on retail rates** and solar irradiation (Candas et al., 2019; Young et al., 2019).
- Despite being **a societal & governmental objective**, we need to be careful not to jeopardise regulatory objectives.
- BTM **challenges cost recovery** of utility regulated investment, since reduced revenues are not proportional to reduced costs.
- **Africa is not an exception;** we can see the increasing adoption of solar PV by grid-connected households from behind the meter (BTM).



Market Structure

- **What are the regulatory implications of the adoption of BTM technologies, under Single Buyer Model?**
- **Can we mitigate those implications through a better design of retail rate?**



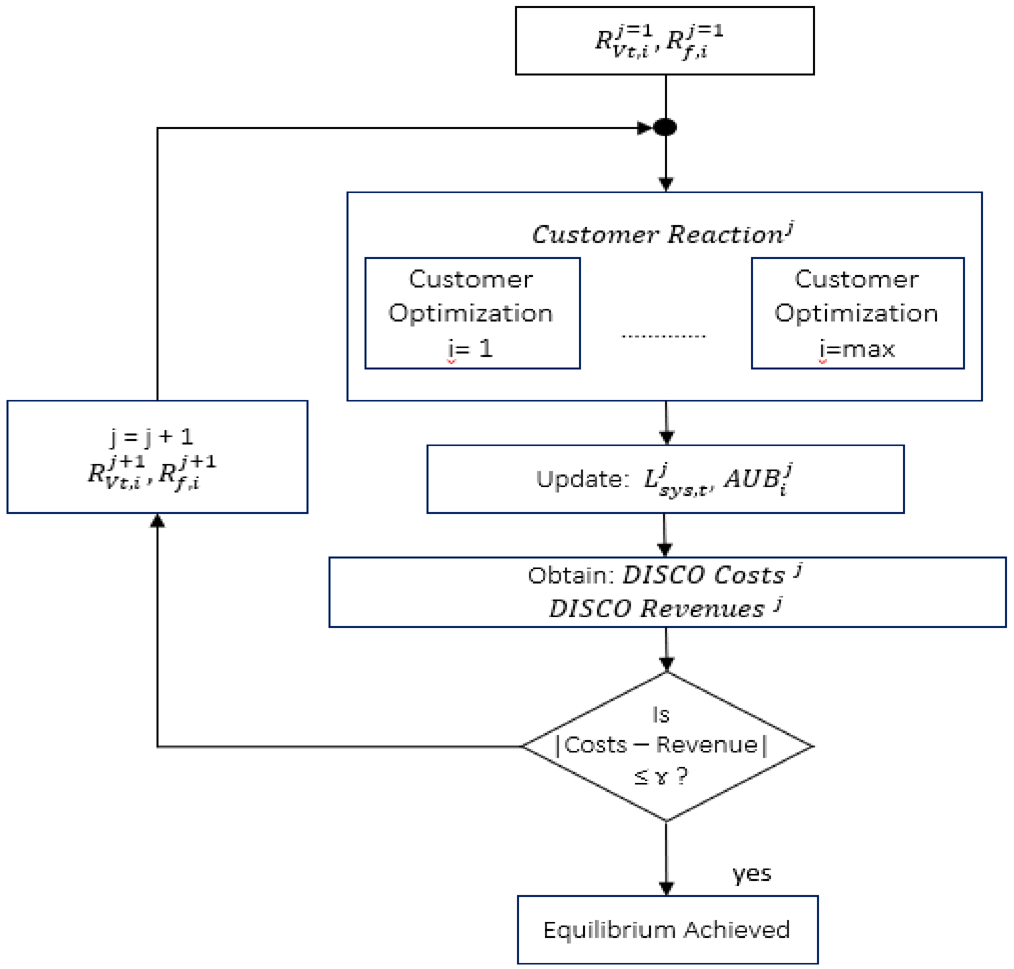
Sources: (Eberhard et al., 2019) (EE Law, 2015) (Directive EU 944, 2019)

Previous Work: Implications of BTM Technologies

Publication	Journal	Structure	Focus	Customer Decision	Approach	Case studies
Eid et.al (2014)	Energy Policy	EU/ Liberalized	NM Cost Recovery + Cross subsidy	Exogenous	Financial Model + Excel	Volumetric /Capacity /Fixed **DSO** charges
Abdelmotteleb et al (2017)	Applied Energy	EU/ Liberalized	DSO Cost Recovery + System Cost	Endogenous	Simulation + Optimization + Matlab	Volumetric / PCNC + Fixed
Schittekatte et.al (2018)	Energy Economics	EU/ Liberalized	Regulatory Proxies: Efficiency & Fairness	Endogenous	Game theoretic + GAMS	NM (bi-d) Volumetric Or Capacity
Satchwell et al. (2015a)	Energy Policy	US / VIU/ Single buyer	Average rates & Shareholder earnings / NM	Exogenous	Proforma Financial Model	ROE + Avg. Rates
Satchwell et al. (2015b)	Energy Policy	US / VIU/ Single buyer	Average rates & Shareholder earnings / NM	Exogenous	Proforma Financial Model	Recommendations on revenue loss: (U. Incentives, rate readjustment, ownership)
Sergici et al. (2019)	The Electricity Journal	US / VIU/ Single buyer	Cross subsidy / NM	Actual - 16 utility	Cost of service Model	Diff Utility Circumstances: PV penetration levels + and locations + Utility sizes

Methodology

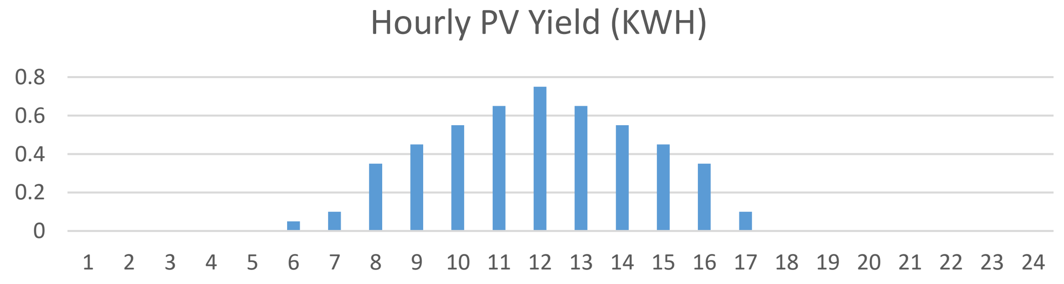
- **Modelling**:
  - **Regulatory Cost Recovery Constraint** (Iteratively maintained in MATLAB)
  - **Prosumer**: Optimisation of Annual Energy Costs (in GAMS)
- **BTM Cost Scenarios**: High & Low
- **Rate Designs**: IBT & DFC
- **Regulatory Metrics**:
  - **Equity (Fairness)**: the degree that certain consumer categories namely low-income consumers are protected against negative redistributional impact of a new rate design (Battle et al, 2020).
  - **Economic Efficiency**: the degree that economic signals such as tariffs and prices align the interest of private consumers with that of the system (Schweppe, 1988).
  - **Cost Recovery of the single Buyer**: the recovered percentage of the single buyer investment.
  - **Cost Recovery of the DISCO**: the recovered percentage of the DISCO investment.

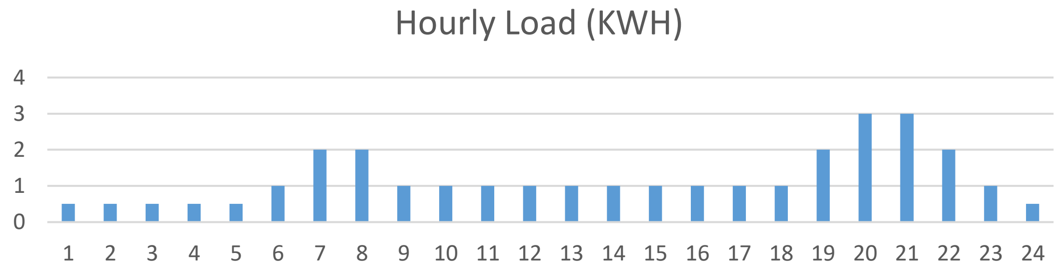


Case Study

Indicator	Unit	Consumer Segment		
		"S1" Lowest-Consumption	"S2" Medium-Consumption	"S3" Higher-Consumption
Consumption Span	(KWh/Month)	0 – 100	101 – 650	Above 650
Consumer Share	(%)	26.4	71.17	2.43
Number of Consumers	Metering point	4603	12409	424
Representative consumption	KWh/Month	50	550	1050
	KWh/Year	600	6600	12600
Volumetric Charges	(EGP/KwH)	0.71	(0- 200): 0.97 (201- 350): 1.23 (351- 550): 1.36	1.45
Volumetric Obligation	(EGP/Month)	35.5	650.5	1522.5
Fixed Charge	(EGP/Month)	1	15	40
Monthly Bill	(EGP/Month)	36.5	665.5	1562.5

Item	Value
Transfer Price - Volumetric component @ 66 kV	1.1 EGP/KWh
Transfer Price – Capacity component @ 66 kV	50 EGP/KW per Month
Weighted Average System Generation Cost	0.714 EGP/KWh
Weighted Average Retail Rate	1.213 EGP/KWh





Sources: (EgyptERA website, 2020; EEHC, 2020)

Results 1 – Status Quo IBT

- Under historical assumptions about consumers' inelasticity, IBT is maintaining regulatory confidence.
- Under a low cost BTM scenario:
  - positive efficiency outcome with a reduction of 6.2% in total system costs
  - IBT rate design will fail in maintaining cost recovery of the single buyer
  - revisiting the transfer price design

Parameter / Variable / Regulatory Metric		High Cost	Low Cost
Volumetric Rate Component (EGP/kWh)	High – Consumption	1.48	1.52
	Medium - Consumption	1.20	1.24
	Low – Consumption	0.72	0.74
Fixed-Rate Component (EGP/Month)	High – Consumption	40	40
	Medium - consumption	15	15
	Low - Consumption	1	1
Efficiency Concerns (%)		3.0%	-6.2%
Equity Concerns (%)		1.8%	4.6%
Cost Recovery Concerns of DISCO (%)		0%	0%
Cost Recovery Concerns of Single Buyer (%)		4.9%	23.9%

Results 2 – Revisiting Transfer Prices

<u>Adjustments:</u>

- **Volumetric component of the transfer price** is the marginal cost while remaining sunk cost as a fixed charge
- Consumers remain seeing the **IBT end-user charge**

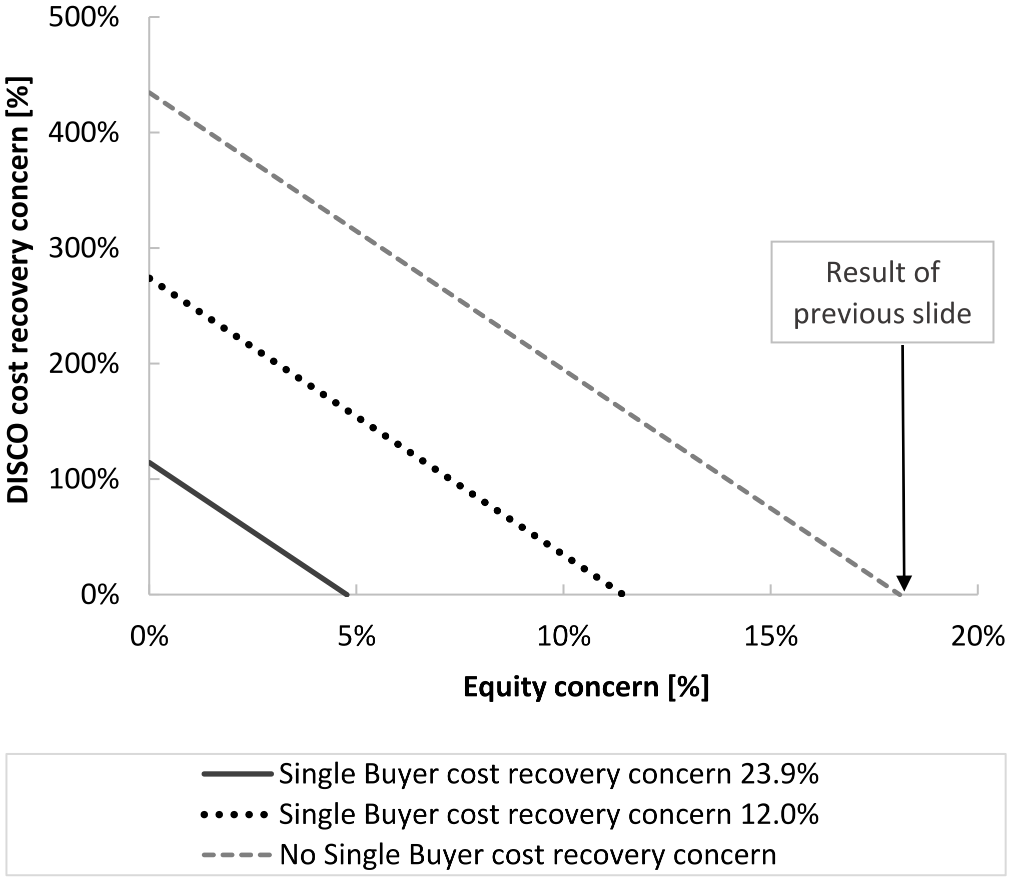
<u>Results:</u>

- Increased equity concerns
- Load defection of both segments high and Medium consumption

Parameter / Variable / Regulatory Metric		Low Cost
Volumetric Rate Component (EGP/kWh)	High-consumption	1.71
	Medium-consumption	1.40
	Low-consumption	0.84
Fixed-Rate Component (EGP/Month)	High-consumption	40
	Medium-consumption	15
	Low-consumption	1
Transfer Price Components	Volumetric (EGP/kWh)	0.714
	Fixed (M EGP/Month)	3.473
Efficiency Concerns (%)		-6.2%
Equity Concerns (%)		18.1%
Cost Recovery Concerns of DISCO (%)		0%
Cost Recovery Concerns of Single Buyer (%)		0%

Results 2 – Revisiting Transfer Prices

- A regulatory trilemma arises
- The sandwiched DISCOs.
  - Given a recorded financial deficit of more than 100% in the unbundled model
  - Additional supply obligations compared to the unbundled DSOs
  - An accelerated death spiral since highest consumer class is contributing to consumers in the lowest consumer class.
  - Analogy to the situation in California 2000-1 crisis
- The only way out is to move away from fully volumetric end-user charges



Results 3 – Differentiated Fixed Charges

<u>Adjustments:</u>

- Economic theory suggests reflecting only marginal cost in a volumetric format
- Fixed charge differentiated based on historical cost drivers

<u>Results:</u>

- Overall, the DFC methodology shows robustness in achieving cost recovery, unlike IBT methodology.
- Such regulated system of prices will allow BTM growth efficiently with the least regulatory concerns & interventions.

<u>Design Considerations:</u>

  - Based on unchangeable historical load profiles
  - Proxy is done once
  - Avoid grid defection with Exit fees

Parameter / Variable / Regulatory Metric		High Cost	Low Cost
Volumetric Rate Component (EGP/kWh)	High-consumption	0.714	0.714
	Medium-consumption	0.714	0.714
	Low-consumption	0.714	0.714
Fixed-Rate Component (EGP/Month)	High-consumption	812.8	812.8
	Medium-consumption	272.8	272.8
	Low-consumption	0.8	0.8
Transfer Price Components	Volumetric (EGP/kWh)	0.714	
	Fixed (M EGP/Month)	3.473	
Efficiency Concerns (%)		0%	-6.2%
Equity Concerns (%)		0%	0%
Cost Recovery Concerns of DISCO (%)		0%	0%
Cost Recovery Concerns of Single Buyer (%)		0%	0%

Regulatory Takeaways!

- Under a low cost BTM scenario, the IBT rate design **cannot maintain cost recovery** of regulated entities specially that of **the sandwiched DISCO**.
- It is not just about rate design. To maintain cost recovery of the SB under low cost BTM scenario there is a need to reconsider the **design of the transfer price.**
- BTM adoption is an additional argument for implementing of short term markets in order to allow for a better signals and the recuperation of the sunk generation costs
- The DFC methodology can achieve equity, efficiency and cost recovery, provided that:
  - **Backward cost causation**: non-distortive allocation; done once and left for 10 or 20 years
  - **Exit Fees**
- Implementation**:**
  - **When: Better to start moving today to be ready tomorrow!**
  - **How:** Gradually move towards DFC design to be ready at the time when BTM knocks on the door.

Thank You!

For further inquiries:

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