Donor contracting conditions and public procurement: Causal evidence from Kenyan electrification

Catherine Wolfram,[1] Edward Miguel,[2]
Eric Hsu,[3] and Susanna Berkouwer[4]
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[1]Harvard University, Kennedy School (on leave from UC Berkeley)
[2]University of California Berkeley, Department of Economics
[3]Yale University, MacMillan Center
[4]University of Pennsylvania, The Wharton School

Power Sector Roundtable:
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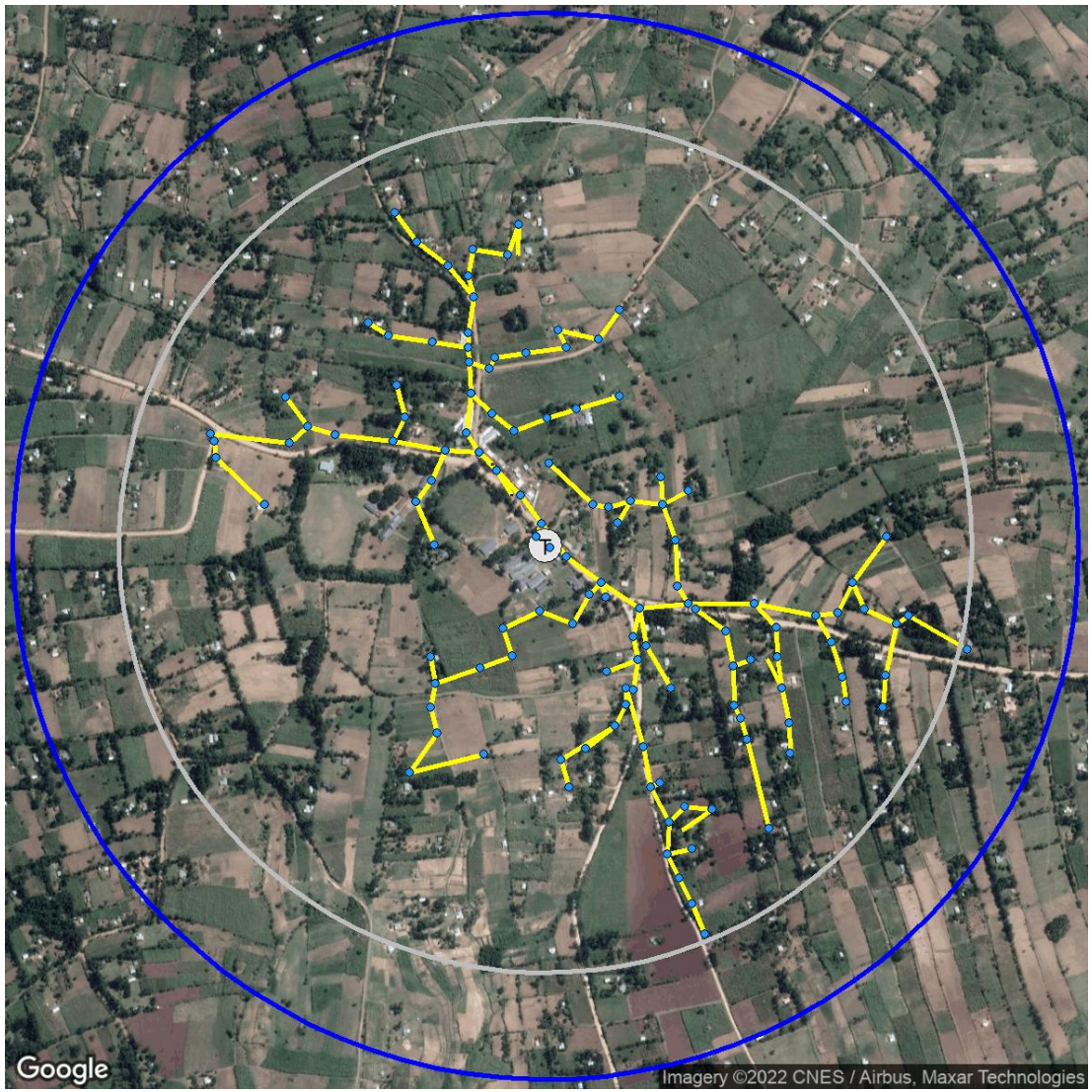
ⓡ The order of authors' names has been randomized

Understanding public procurement regulations

- Governments spend 12% of global GDP on public procurement, which is often heavily regulated
- **Multilateral agencies:** in 2000–2022 the World Bank financed **311,000 private sector contracts** to procure $185bn in works, goods, services across >21,000 projects
- Context: Kenya's Last Mile Connectivity Project (LMCP)
  - Announced in 2015
  - **Goal:** connect all Kenyan households to electricity by 2022

Example of an LMCP Site



Pole

Wiring

This Paper

Research question:

What are the **costs** (financial, delays) and the **benefits** (quality) associated with two key procurement procedures: **ex ante contract unbundling** and **ex post monitoring**?

Unusual context: A national electrification program in Kenya

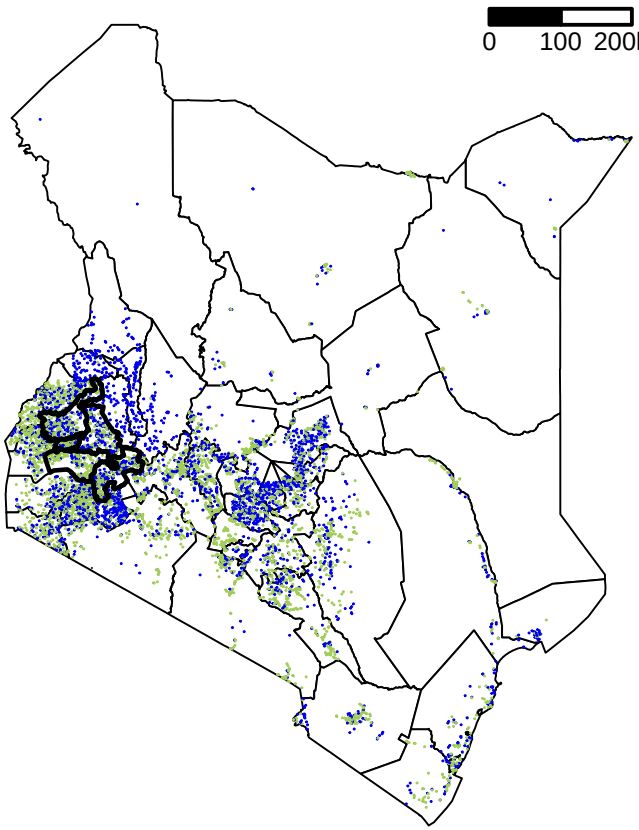
- Ad hoc assignment of sites with neighboring villages often subject to **distinct procurement regulations**
- **World Bank (WB)** financed 4,200 sites
- **African Development Bank (AfDB)** financed 5,320 sites

Data:

- Original field data of construction quality, reliability; admin records; RCT; interviews with managers; contract text

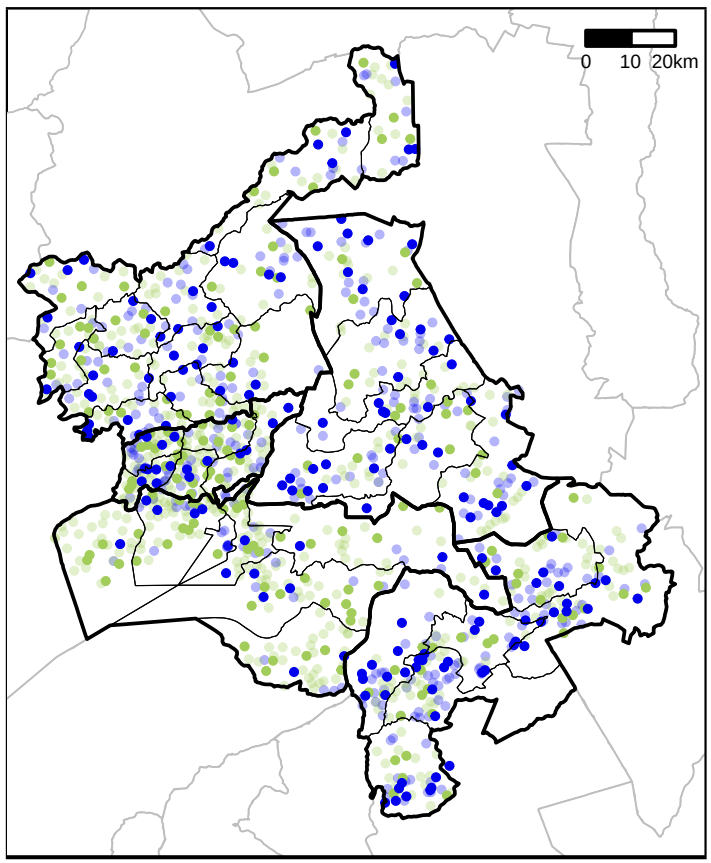
LMCP sites by funder

All Phase I LMCP sites:



We focus on 190 WB & 190 AfDB sites

(Kakamega, Kericho, Kisumu, Nandi, Vihiga)



African Development Bank

World Bank

This talk

Introduction

Procurement procedures

Research design

Data and measurement

Results

Assessing costs and benefits

Discussion

Public procurement by Kenya Power for the LMCP

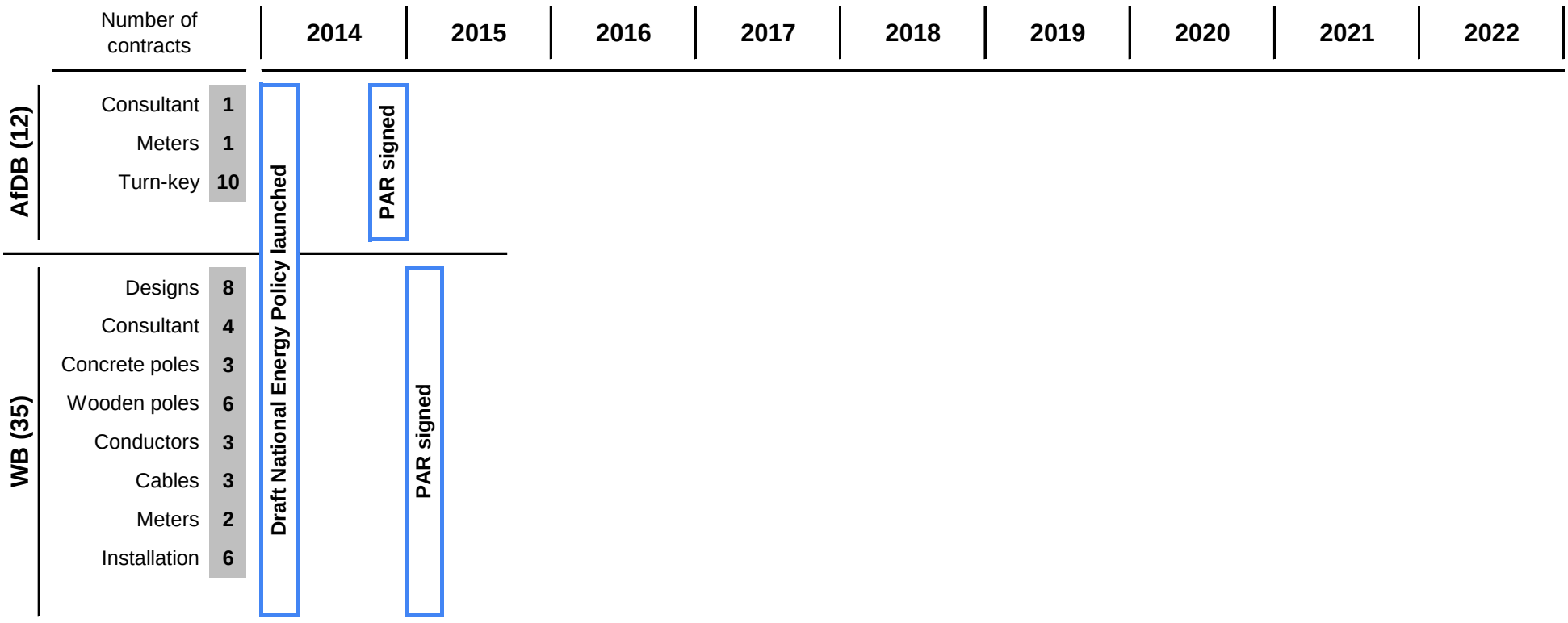
Single, nationwide program with universal technical specifications:

- Subject to Kenya Power network standards & regulations
- Each **contract** covers specific tasks across several counties: e.g. **designing sites, procuring materials, construction**
- Private **contractors** (Kenyan, Indian, Chinese, Spanish, etc. firms) can bid in lowest-cost auction
- Kenya Power and contractor jointly visit site & issue **Joint Measurement Certificate** (JMC) prior to handover
- **Kenya Power** conducts auctions, awards and administers contracts, oversees implementation

Kenya Power used two different procurement procedures

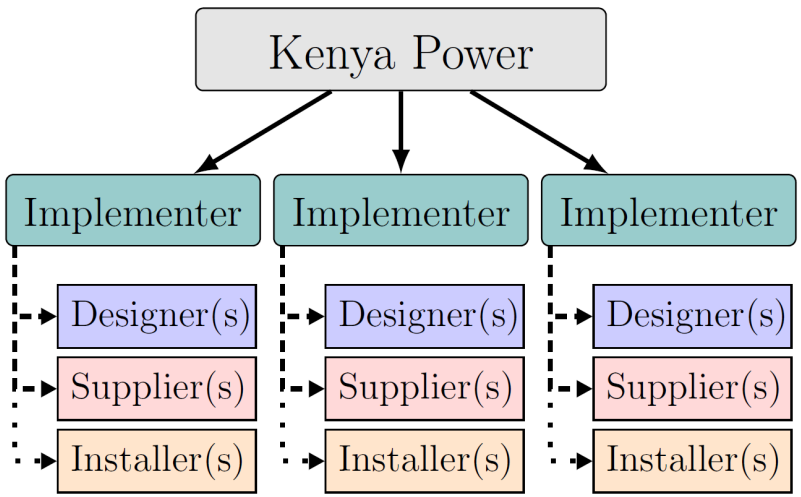
- **Bundled** contracting (used at sites funded by the AfDB)
  - 10 turn-key contracts: each contract comprehensively covers all sites in a specific region (3-5 counties)
- **Unbundled** contracting (used at sites funded by the WB)
  - 8 contracts for designs
  - 3 contracts for concrete poles
  - 6 contracts for wooden poles
  - 3 contracts for conductors
  - 3 contracts for cables
  - 6 contracts for installation (by region)

Differences in contracting and procurement timeline

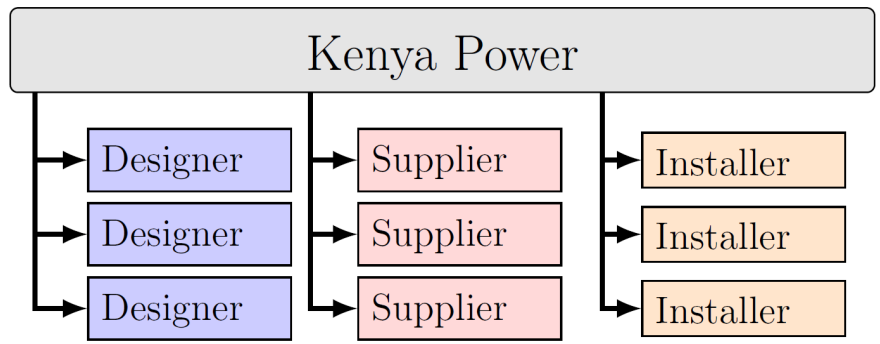


Stylized framework for contract bundling

A) Bundled contracts (AfDB)



B) Unbundled contracts (WB)



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Two key differences between AfDB and WB procedures

1) **Ex-ante contracting**

- **Bundled** contracting (at AfDB-funded sites)
- **Unbundled** contracting (at WB-funded sites)

2) **Ex-post audits**

- Kenya Power implemented additional **Inspection Reports** prior to JMC and handover (e.g. "*pole caps are poorly installed*" and "*the strut pole bolt is not secured with nut and washers*")
  $\Rightarrow$ **Only at WB-funded sites**

$\Rightarrow$ We implement an **Audits RCT** to mimic Inspection Reports

Ex-ante notification of (randomized) ex-post audits

THE WORLD BANK IBRD • IDA

Kenya Power

Contractor XYZ
ADDRESS
P.O. Box YYY-ZZZ
Nairobi, Kenya

June 2017

TO: CONTRACTOR NAME
RE: ENHANCED MONITORING PROGRAM ("EMP") FOR LMCP MAXIMIZATION SITES

Dear Sir/Madame:

Kenya Power aims to provide the highest quality of electricity to all Kenyans. To achieve this goal, an international team of engineers will closely audit the quality of construction at a number of Last Mile Connectivity Project ("LMCP") maximization sites. These independent audits will be performed as part of the Enhanced Monitoring Program ("EMP"), and will target both African Development Bank and World Bank project sites. The results of the EMP audits will be shared with project supervisors, financiers, and international agencies, all of which may impose consequences on future contracting opportunities, as they see fit.

Upon project completion, EMP technicians will extensively measure the quality of various aspects of construction, including:

- Distance between poles
- Line sag
- Quality of connection between transformer and LV wiring
- Blackouts and electricity reliability post-connection

We wish to inform you of the sites that have been awarded to you that have been selected for the EMP. Please find attached a list of these sites.

Sincerely yours,

[redacted] — Senior Energy Specialist, The World Bank
[redacted] — Principal Power Engineer, The African Development Bank
[redacted] — Electrification Project Manager, Kenya Power & Lighting Company

- Delivered to private contractors at in-person meetings
- *"International team of engineers will closely audit the quality of construction"*
- Attached list of sites to be monitored (treatment group only)

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Construction quality data

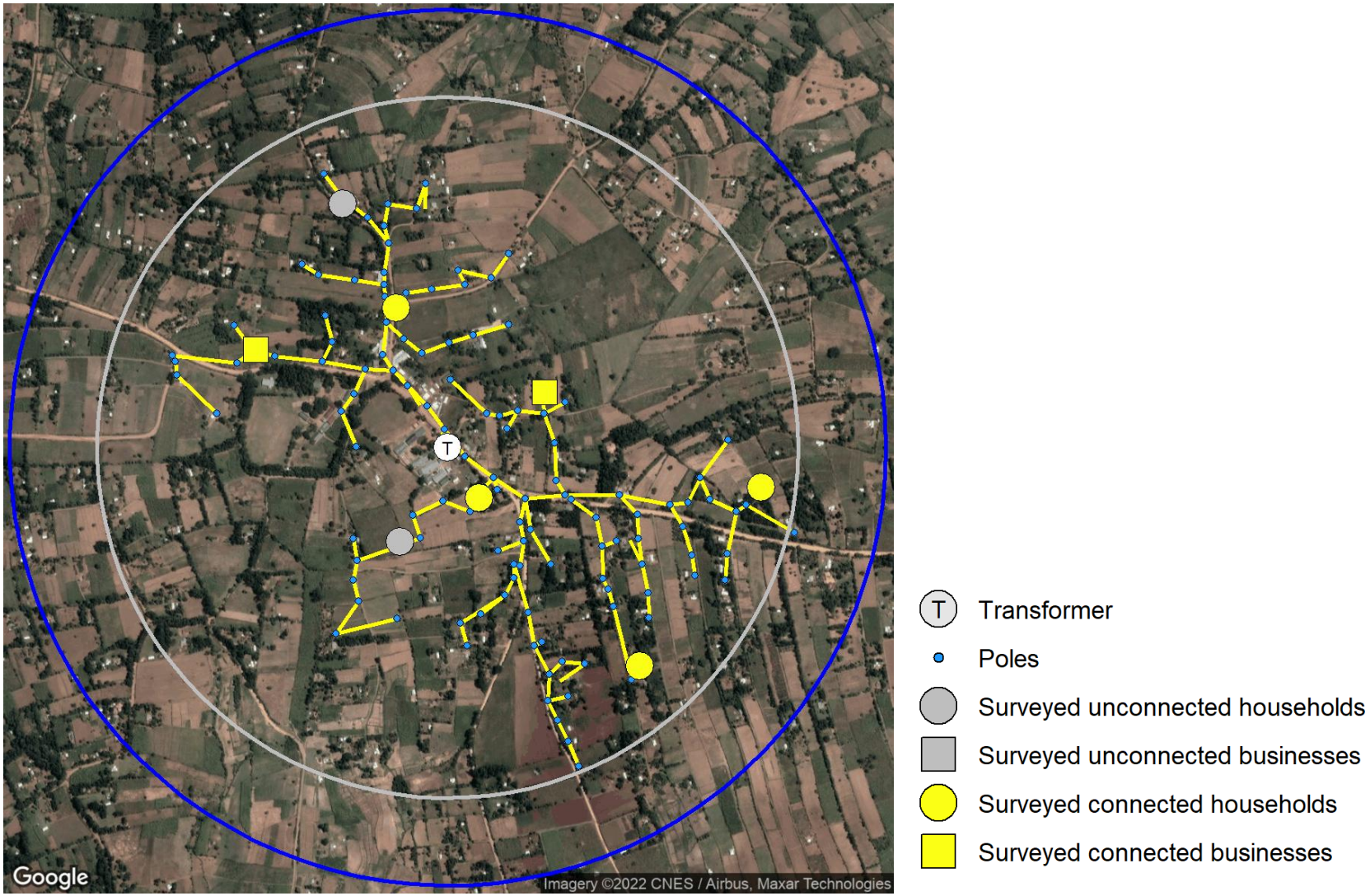
Transformer quality (fuses, poles, etc.)

Construction quality data

Pole angle, sag, grounding wire, struts, stays, etc.

Summary stats

Household & business survey data

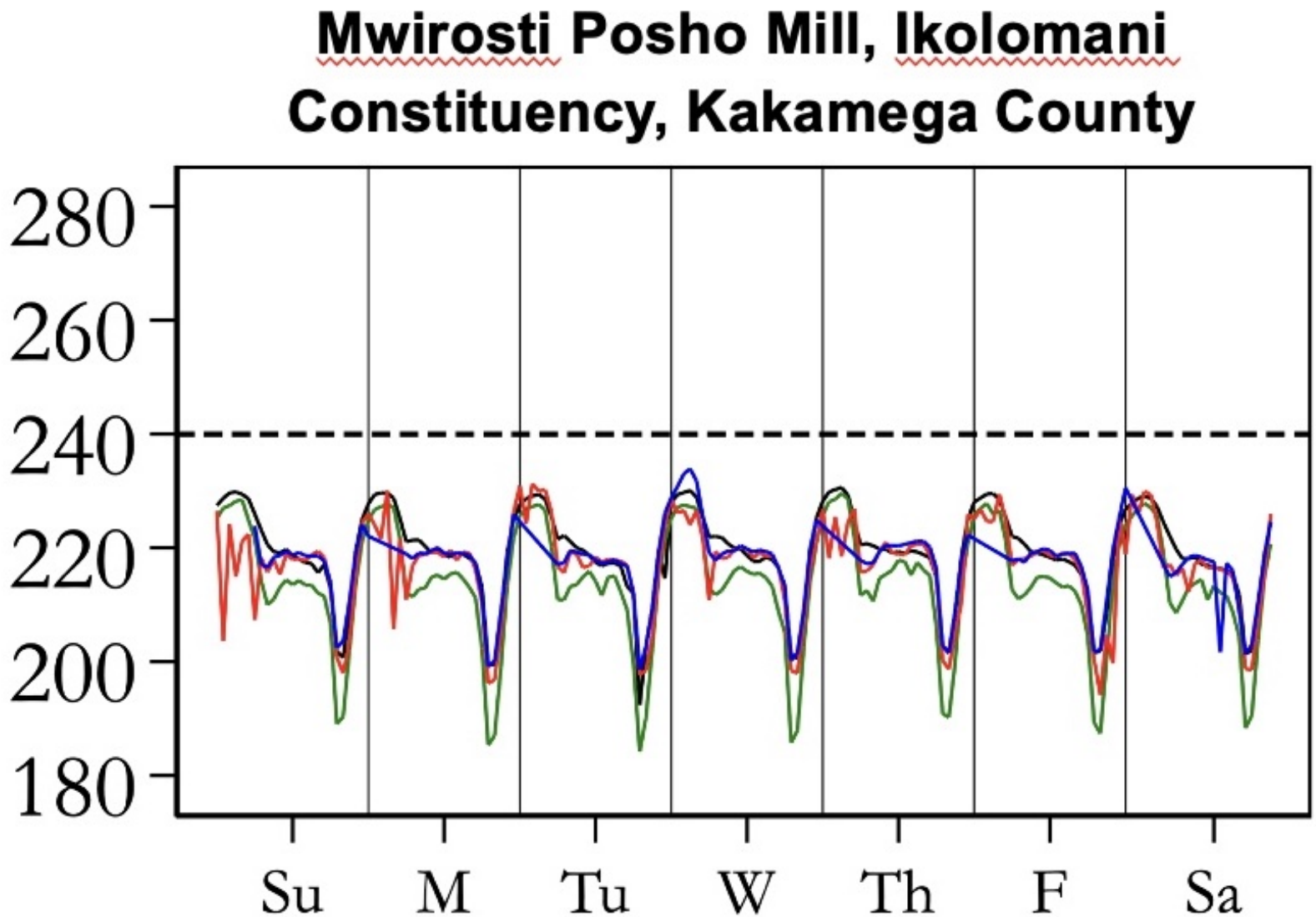


Outage and voltage data for 600 respondents

nLine's GridWatch Technology

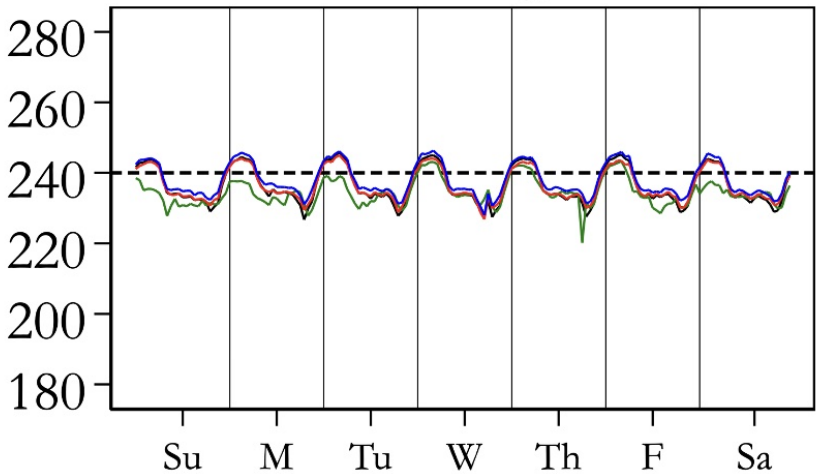
- Plugged in at household outlet for two months

nLine GridWatch Data: Voltage quality

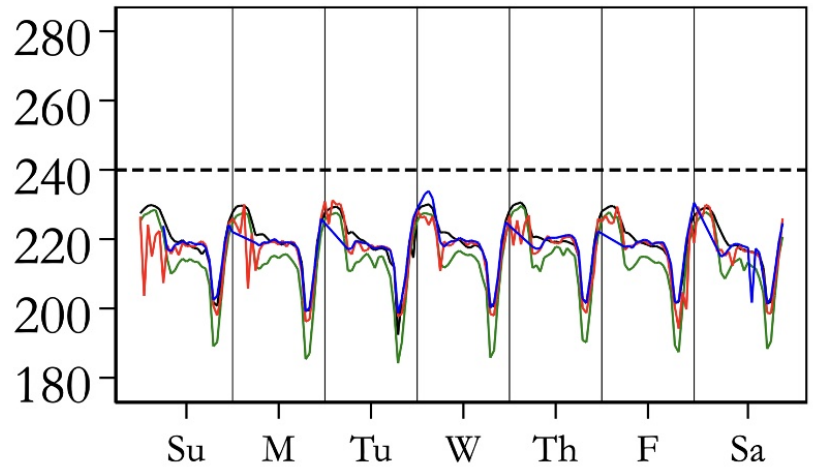


nLine GridWatch Data: Voltage quality varies by village

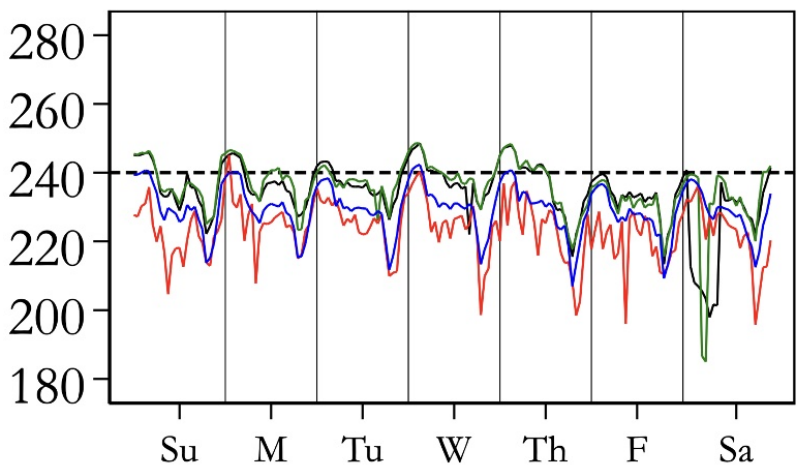
Tieng're Primary School Transformer, Seme Constituency, Kisumu



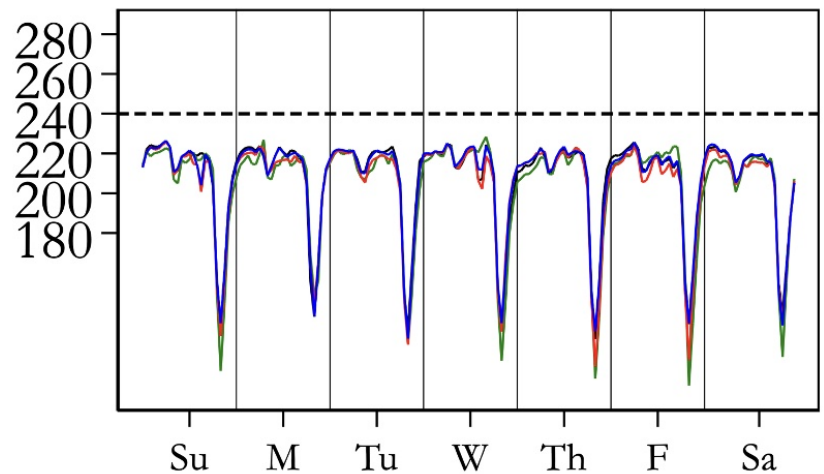
Mwirosti Posho Mill, Ikolomani Constituency, Kakamega County



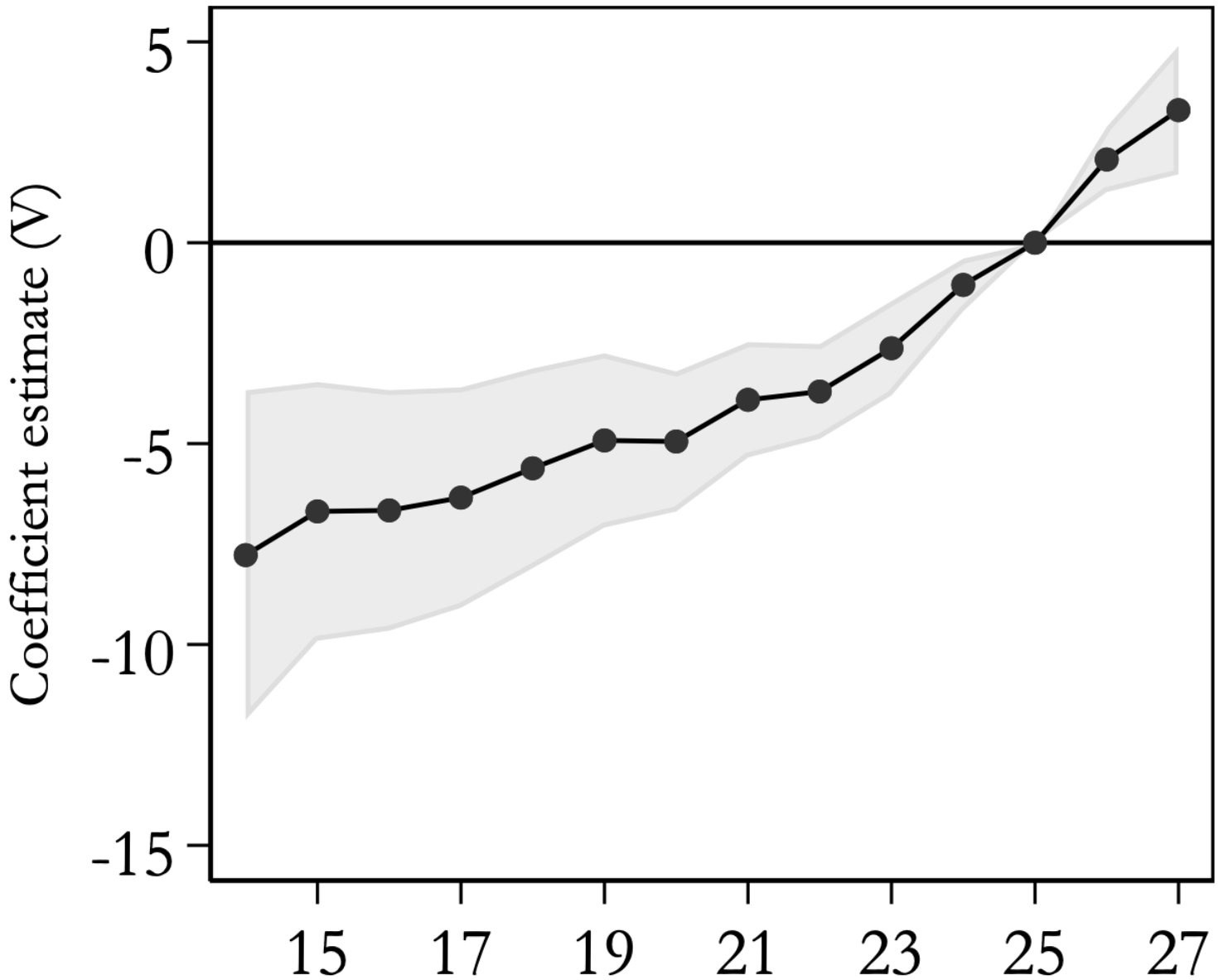
Esibeye Primary School Transformer, Luanda Constituency, Vihiga



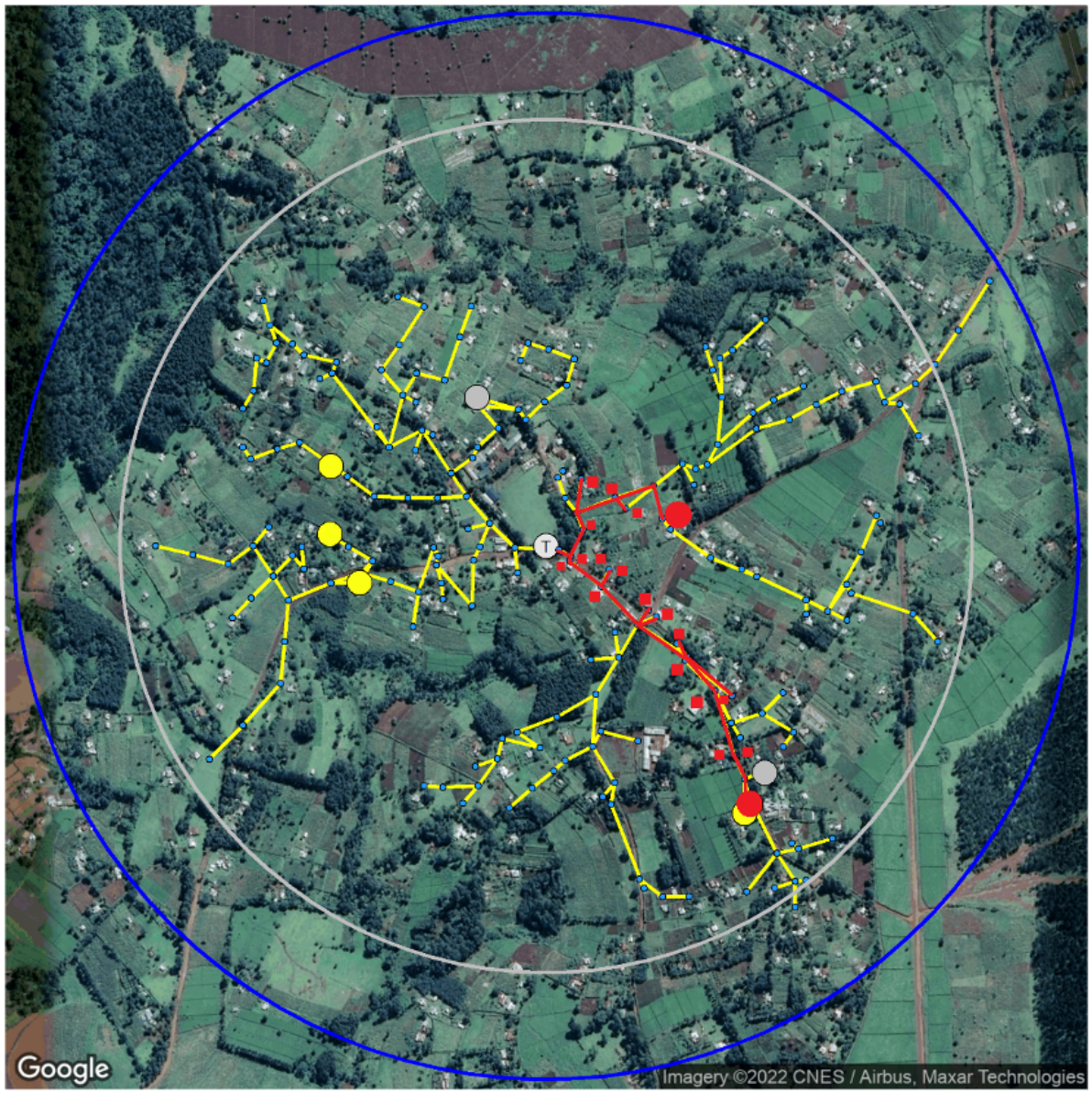
Mukavakava Transformer, Malava Constituency, Kakamega



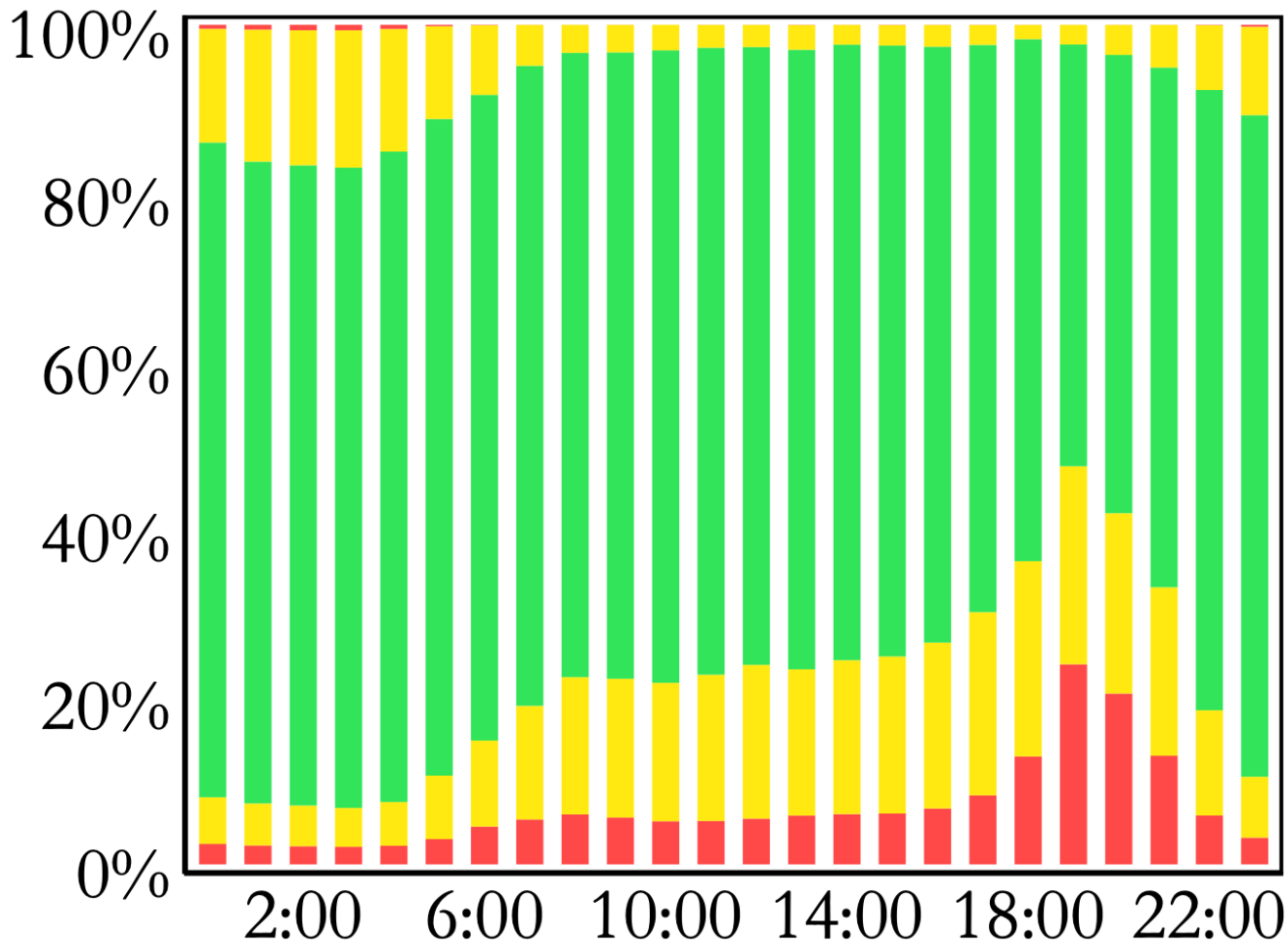
nLine GridWatch Data: Voltage varies by temperature



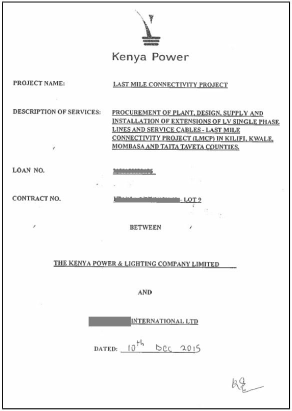
nLine GridWatch Data: 5V drop every 10 customers



nLine GridWatch Data: Voltage quality varies by hours



Primary contract data



Kenya Power

PROJECT NAME: LAST MILE CONNECTIVITY PROJECT

DESCRIPTION OF SERVICES: PROCUREMENT OF PLANT, DESIGN, SUPPLY AND INSTALLATION OF EXTENSIONS OF LV SINGLE PHASE LINES AND SERVICE CABLES - LAST MILE CONNECTIVITY PROJECT (LMCP) IN KILIFI, KWALE, MOMBASA AND TAITA TAVETA COUNTIES.

LOAN NO. [redacted]

CONTRACT NO. [redacted]-LOT 9

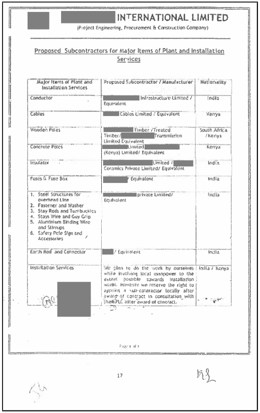
BETWEEN

THE KENYA POWER & LIGHTING COMPANY LIMITED

AND

[redacted] INTERNATIONAL LTD

DATED: 10th Dec 2015



[redacted] INTERNATIONAL LIMITED

(Project Engineering, Procurement & Construction Company)

Proposed Subcontractors for Major Items of Plant and Installation Services

Major Items of Plant and Installation Services	Proposed Subcontractor / Manufacturer	Nationality
Conductor	[redacted] Infrastructure Limited / Equivalent	India
Cables	[redacted] Cables Limited / Equivalent	Kenya
Wooden Poles	[redacted] Timber /Treated Timber/[redacted] Transmission Limited Equivalent	South Africa /Kenya
Concrete Poles	[redacted] Limited/[redacted] (Kenya) Limited/ Equivalent	Kenya
Insulator	[redacted] Limited / [redacted] Ceramics Private Limited/ Equivalent	India
Fuses & Fuse Box	[redacted] / Equivalent	India
1. Steel Structures for overhead Line 2. Fastener and Washer 3. Stay Rods and Turnbuckles 4. Stays Wire and Guy Grip 5. Aluminium Binding Wire and Stirrups 6. Safety Pole Sign and Accessories	[redacted] private Limited/ Equivalent	India
Earth Rod and Connector	[redacted] / Equivalent	India
Installation Services	We plan to do the work by ourselves while involving local manpower to the extent possible towards installation works. However we reserve the right to appoint a sub-contractor locally after award of contract in consultation with the KPLC after award of contract.	India / Kenya

[redacted]

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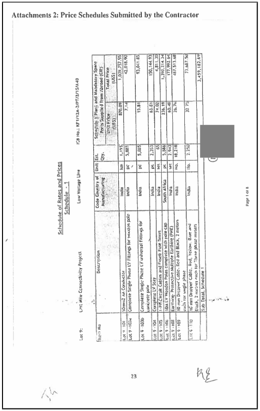

Attachments 2: Price Schedules Submitted by the Contractor

Schedule of Rates and Prices
Schedule - 1

Lot 9: Last Mile Connectivity Project Low Voltage Line ICB No.: KP1/12A-2/PT/2/15/A40

Item No	Description	Code Country of Manufacturing	Unit	Est. Qty.	Schedule 1 Plant and Mandatory Spare Parts Supplied from Abroad (CIP) Unit Price (US$)	Total Price (US$)
Lot 9 - 101	50mm2 AA Conductor	India	km	1,195	870.09	1,039,757.55
Lot 9 - 103a	Complete Single Phase LV Fittings for wooden pole	India	pc	5,885	7.14	42,018.90
Lot 9 - 103b	Complete Single Phase LV universal Fittings for concrete pole	India	pc	5,885	15.81	93,041.85
Lot 9 - 104	Complete LV Stay	India	pc	2,353	63.81	150,144.93
Lot 9 - 105	1-PH Circuit Cables and Fused Fuse Boxes	India	set	65	74.02	4,811.30
Lot 9 - 106	10m LV Wooden Poles complete with pole cap	South Africa	pc	5,886	236.19	1,390,214.34
Lot 9 - 108	Earthing- Protective Multiple Earthing (PME)	India	set	2,943	60.48	177,992.64
Lot 9 - 109	10 mm Dropper Cable- Red and Black, 2 meters each for single phase	India	No.	18,218	26.76	487,513.68
Lot 9 - 110	16 mm Dropper Cable, Red, Yellow, Blue and Black, 2 metres each for Three phase meters	India	No.	2,250	32.75	73,687.50
	Sub Total, Schedule 1					3,459,182.69

[redacted]

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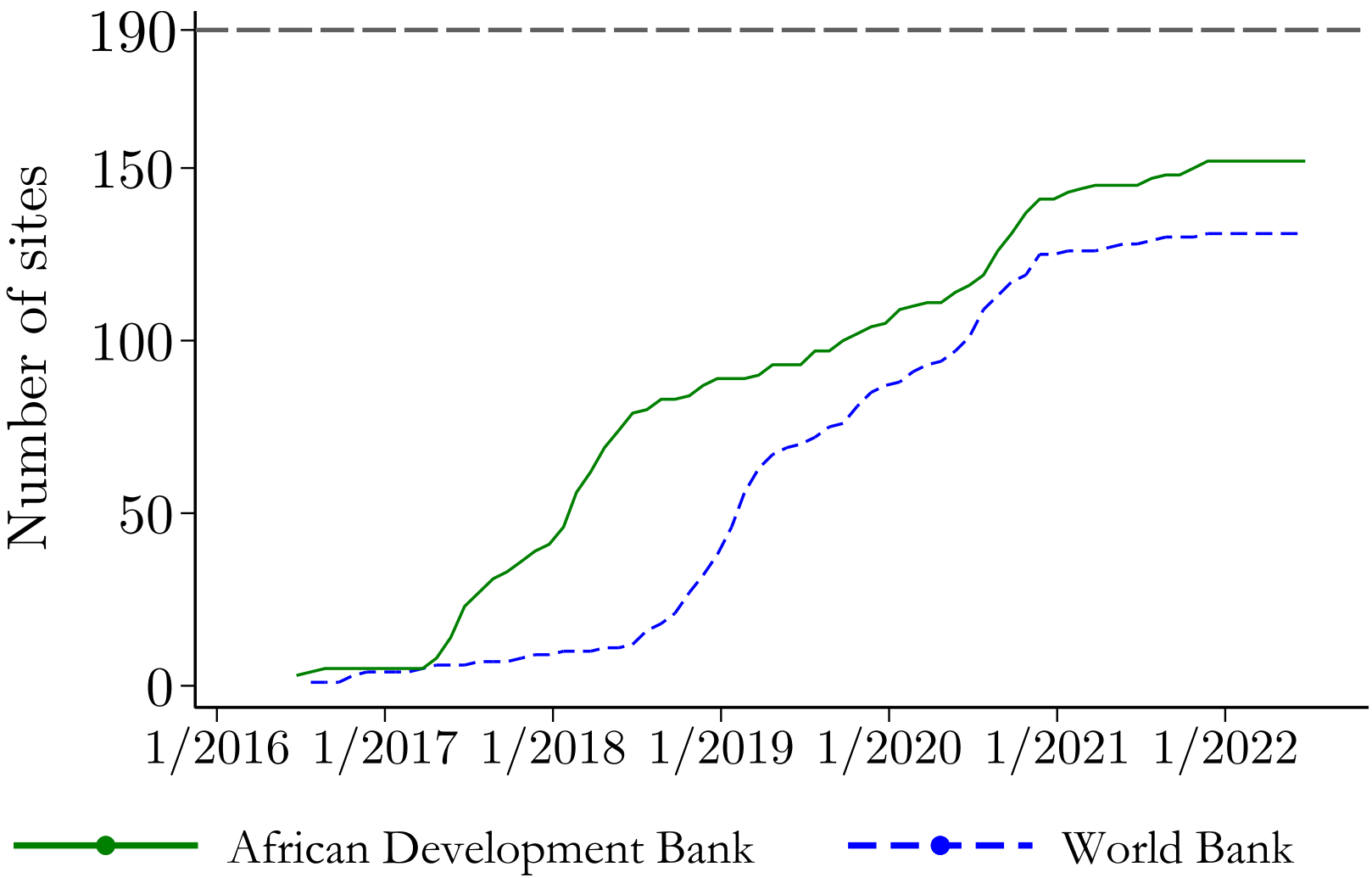
- Combined with dozens of interviews between 2016-2022 with senior management at Kenya Power, WB, AfDB

This talk

Delay: Stringing completed 16 months later at WB sites



This talk

Quantity: Fewer hh connections (-18%) at WB sites

- Audit treatment increases construction **only at AfDB sites**

	Poles		Connections	
	(1)	(2)	(3)	(4)
World Bank (=1)	-11.9**	-2.2	-12.8**	-19.3*
	(5.9)	(10.1)	(6.2)	(10.7)
Treatment (=1)	6.3		4.9	
	(5.8)		(6.1)	
Treatment (WB sites)		-3.3		6.8
		(8.5)		(9.0)
Treatment (AfDB sites)		16.3*		2.8
		(8.3)		(8.8)
Observations	250	250	250	250
Control Mean	92.26	92.26	72.25	72.25

All regressions include constituency FE. SE in parentheses.
$^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

This talk

Higher construction quality at WB sites

(*As specified in pre-analysis plan; indices mean=0, sd=1*)

	World Bank Effect Estimate	
Outcome 1: Construction quality index	0.60***	250
	(0.21)	
Outcome 2: Network size and configuration index	0.01	241
	(0.19)	
Outcome 3: Construction timing index	-0.90***	250
	(0.17)	
Outcome 4: Household installation quality index	0.05	944
	(0.12)	
Outcome 5: Household cost, experience, bribery index	0.13	944
	(0.12)	
Outcome 6: Reliability and safety index	-0.11	944
	(0.13)	
Outcome 7: Knowledge index	0.14	944
	(0.10)	
Outcome 8: Electricity Usage index	0.12	944
	(0.13)	

Increased WB quality could improve **longevity**

	AfDB Mean	World Bank Effect Estimate	
Outcome 1: Construction quality index	0.00 [1.00]	0.60*** (0.21)	250
∗ Transformer does not have bypassed fuse (=1)	0.40 [0.49]	-0.15* (0.08)	250
Pole does not have a crack ≥1cm	0.73 [0.44]	0.06* (0.03)	20282
Pole leaning at ≥85 degrees	0.97 [0.16]	0.01** (0.00)	20483
Line has ≥0.5m horiz clearance	0.93 [0.25]	-0.03*** (0.01)	19068
Pole has cap	0.28 [0.45]	0.33*** (0.04)	17377
Stay/strut properly installed	0.92 [0.28]	0.01 (0.02)	3083
Stay/strut installed when required	0.78 [0.41]	0.17*** (0.04)	9482
Insulator properly installed	0.99 [0.10]	-0.03** (0.01)	2971
Insulator installed when required	0.98 [0.13]	0.01* (0.01)	2996
Pole has grounding wire	0.34 [0.47]	0.03** (0.01)	20483

Audits modestly improved quality – **only at AfDB sites**

	(1) WB Effect Estimate	(2) Audit Treatment Effect, WB Sites
Outcome 1: Construction quality index	0.60***	0.11
	(0.21)	(0.21)
Outcome 2: Network size and configuration index	0.01	0.27
	(0.19)	(0.17)
Outcome 3: Construction timing index	-0.90***	-0.07
	(0.17)	(0.16)
Outcome 4: Household installation quality index	0.05	0.02
	(0.12)	(0.11)
Outcome 5: Household cost, experience, bribery index	0.13	0.05
	(0.12)	(0.11)
Outcome 6: Reliability and safety index	-0.11	0.03
	(0.13)	(0.14)
Outcome 7: Knowledge index	0.14	-0.00
	(0.10)	(0.09)
Outcome 8: Electricity Usage index	0.12	0.11
	(0.13)	(0.10)
Outcome 9: Household socioeconomic outcomes index	0.24*	-0.00
	(0.12)	(0.13)
Outcome 10: Firm Performance Index	0.29	-0.11
	(0.19)	(0.21)
Outcome 11: Political and Social Beliefs index	0.03	0.01
	(0.08)	(0.07)

All indices constructed to have mean 0, standard deviation 1

This talk

Audits modestly improved quality – **only at AfDB sites**

Using GridWatch data:

	Outage			Voltage		
	(1)	(2)	(3)	(4)	(5)	(6)
World Bank (=1)	0.19	0.25	0.31	1.73	1.64	2.86
	(0.21)	(0.21)	(0.22)	(2.34)	(2.40)	(2.72)
Treatment for WB Sites	0.00	-0.01	-0.33*	3.45	3.49	1.39
	(0.24)	(0.23)	(0.17)	(2.22)	(2.18)	(1.77)
Treatment for AfDB Sites	0.15	0.18	-0.10	4.35**	3.81*	4.94*
	(0.18)	(0.17)	(0.18)	(2.01)	(1.96)	(2.59)
Observations	9,906	9,906	9,906	654,541	654,541	645,648
Week of Sample FE	No	Yes	Yes	No	No	No
Day of Sample FE	No	No	No	No	Yes	Yes
Hour of Day FE	No	No	No	No	Yes	Yes
Constituency FE	No	No	Yes	No	No	Yes
All FE Interacted	No	No	Yes	No	No	Yes
Control Mean	0.90	0.90	0.90	232.63	232.63	232.63

Standard errors are clustered by site

This talk

Weighing benefits from longevity against costs of delay

Up-front costs and benefits per perpetual grid connection:

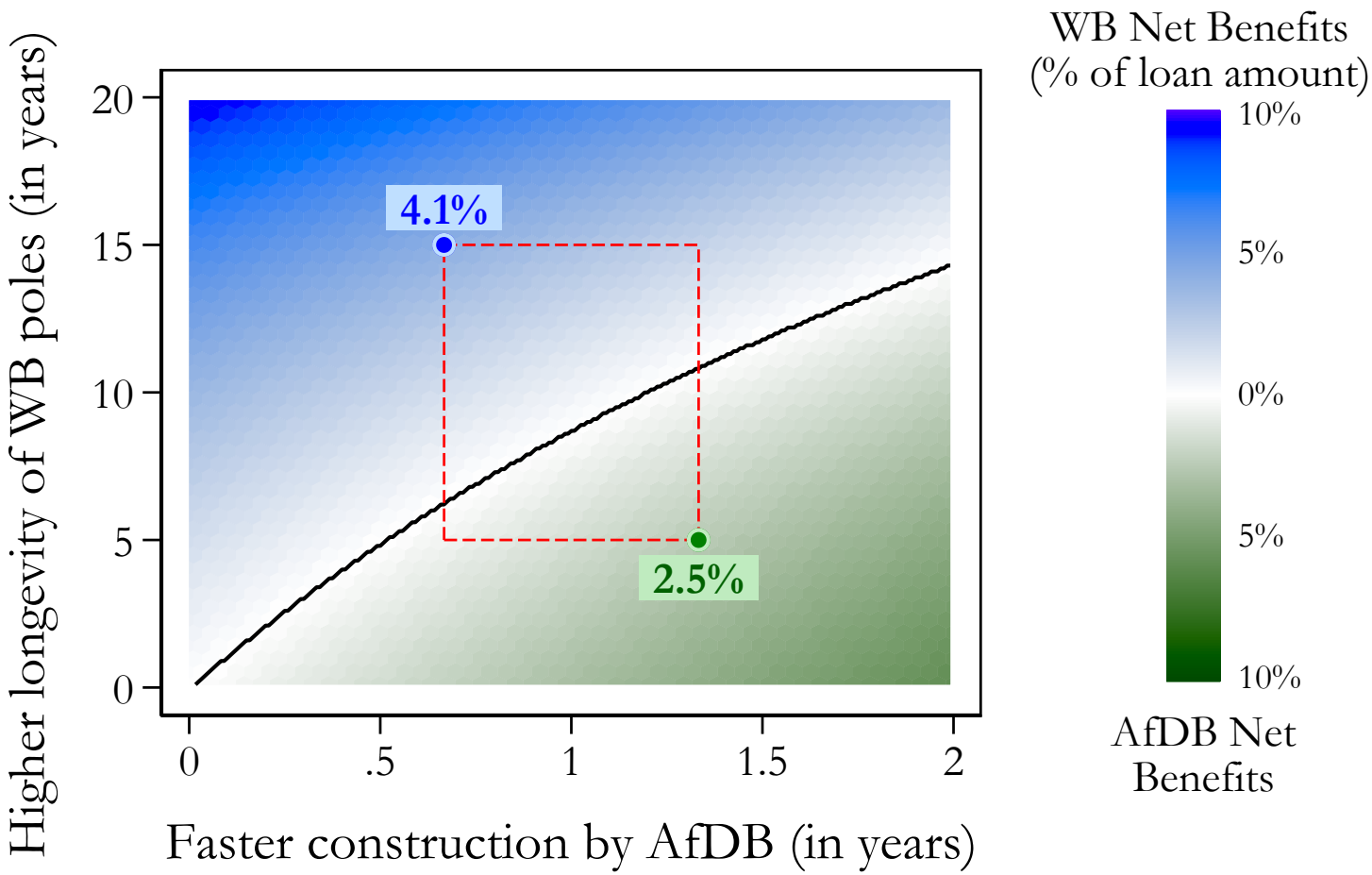
- **Up-front cost:** $563 for AfDB, $728 WB (30% higher)
- **Benefit: $147** (revealed preference) or **$293** (stated preference) (Ken Lee, Ted Miguel, Catherine Wolfram 2020, JPE)

Factoring in:

- Short-term delays: AfDB 8–16 months faster (benefits sooner)
- Long-term cost: WB 0.6 SD higher quality installation
  $\Rightarrow$ Adds 5–15 years to pole longevity, lower maintenance costs
- 20 year horizon
- 5% discount rate

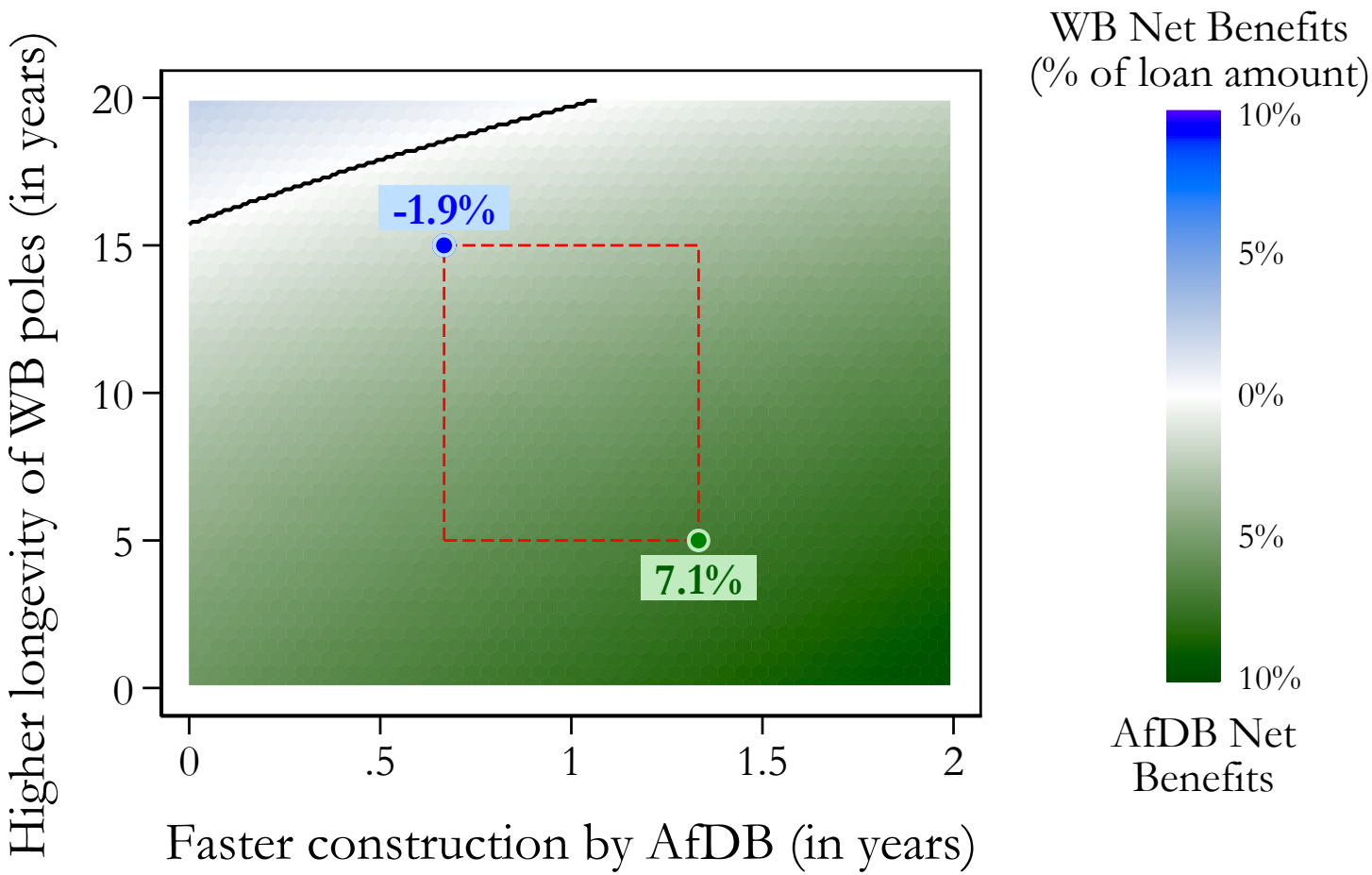
Net benefits of the AfDB vs. WB approaches

- Black line is AfDB-WB "break-even"
- Assuming 80 connections per site for all sites



Net benefits of the AfDB vs. WB approaches

- Black line is AfDB-WB "break-even"
- 72 connections at AfDB sites, 58 at WB sites:



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Policy implications

- Which set of procurement conditions is **"better"**?
  - Trade-off: unbundling causes **higher short-term costs** but **long-term resilience**
  - **Planner might prefer bundling if** they use a shorter time horizon, higher discount rate, or larger household benefits
  - **Planner might prefer unbundling if** they use a longer time horizon, lower discount rate, or care more about long-term grid resilience
- Could procedures be "tweaked" to improve results?
  - Could **up-front contracting** be streamlined to reduce construction delays?
  - Could **ex-post audits** be boosted to improve construction and household outcomes at relatively low cost?

Let's cllaborate:

- What are the constraints to productive enterprise? Information? Financial? Reliability and voltage quality?
- Time of use: shifting demand to when generation cost is lowest
- How do customers respond to fixed vs variable, or postpaid vs. prepaid?
- Tariffs: Balancing revenue vs affordability vs inequality

sberkou@wharton.upenn.edu