IRRP Modeling Inputs and Assumptions

Demand Forecast

1a

Load Forecast Reports Reviewed

Objective:	
	• Understand methodologies and assumptions used
	• Identify commonalities and differences
	• Understand benefits and challenges with each model
	• Identify any geographical breakout of demand

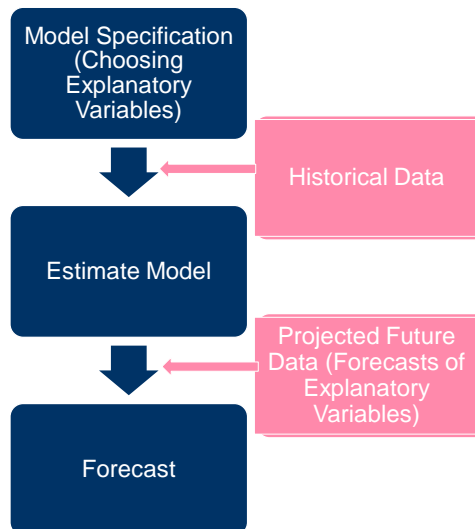| Outlook:	
	• Develop updated demand forecasts building on existing work
	• Review LEAP modelling assumptions/results with the EC
	• Build consensus around updated reference forecast
	• Review of forecasts will be an ongoing process

2

USAID FROM THE AMERICAN PEOPLE
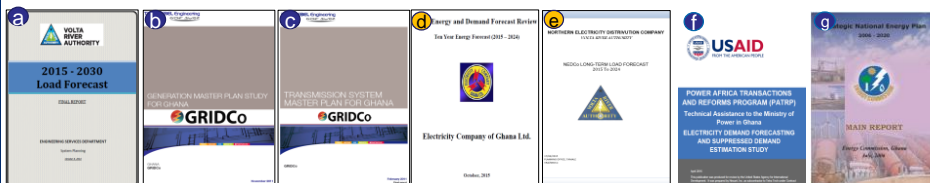
IRRP PROJECT -- NOT FOR DISTRIBUTION

ICF

Econometric Methods

- Used by ECG, NEDCo, VRA, GRIDCo
- Combines economic theory and statistical techniques
  - Estimates relationship between electricity consumption and the factors influencing consumption
  - Different equations for different customer classes and regions (ECG, NEDCo, VRA)
- Electricity consumption is modeled as a function of variables describing the major influences on load
  - Population growth, economic growth, energy prices
  - Presence of major end uses, locational factors, weather
- Should provide information on future levels of load, including why load is changing, and what factors have the most influence

Model Specification (Choosing Explanatory Variables)

→ Historical Data

Estimate Model

→ Projected Future Data (Forecasts of Explanatory Variables)

Forecast

3

USAID FROM THE AMERICAN PEOPLE

ICF

Summary of Key Assumptions

Report	Variables Used		
	GDP	Population	Price
VRA	• GDP forecasts from IMF Report (in USD at 2006 constant prices) • ECG and NEDCO sales regressed on GDP • Forecast ends in 2019. Moving average used to extrapolate from 2020 to 2030 based on 2013 to 2019	Not used	Not used
Generation Master Plan	• Domestic consumption regressed on GDP and GDP per capita • GDP forecasts from IMF from 2011 to 2015. • Rate of 5.8% used for 2016 to 2026 based on trend between 2010 to 2015 • Economic parameters expressed in GHS at 2000 constant prices	• Population forecasts from IMF from 2011 to 2015; trend from 2010 to 2015 used to forecast for the remaining period	Not used
Transmission Master Plan	• GDP forecasts from 2010 to 2014 was obtained from IMF. • Rate of 6.1% used for 2014 to 2020 based on trend between 2010 to 2014 • Real GDP growth rates in constant GHS prices	Not used	Not used
ECG	• Total GDP in 2006 constant GHS was used for NSLT whiles Non-Agric GDP was used for SLT • Growth rate assumptions beyond IMF projections was based on a trending method	• Population figures for NSLT and SLT was used • Basis for growth rate assumptions stated in report	• Real average NSLT prices was used for NSLT model
NEDCo	• Real GDP per capita growth rates used for 2015 to 2019 (in constant [year] GHS) was based on IMF Country Data 2014 report. • That of year 2020 onwards was estimated at 4.7%	• 6.5% growth rate was used based on historical trend	• Rate of 7% was used to forecast price
USAID/Nexant	• Assumed base case growth rates based on IMF and World Bank projections: 2015-2018: 7.2%; 2019-2024: 6.2%; 2025-2030: 5.5%	• Variables included Ghana pop, average household size, residential customers, non-residential customers, SLT Customers • Growth rates assumptions based on historical trend	• Used average end-use price from EC Report • Assumed base case growth rates based on historical trend

Current Regression Approaches

- ECG's 2015/2016 forecasts for ECG Subregions
  - ECG makes specific forecasts for SLT and NSLT customer categories
  - ECG regresses NSLT sales using log-log linear regression with explanatory variables of GDP, customer population, and average price (but variables are correlated)
  - SLT forecast is auto-regressive using log-log linear regression, but it also has other correlated variables (population and GDP)
  - ECG converts sales to purchases based on forecast of distribution loss %
- NEDCO 2015/2017 forecasts
  - NEDCo regresses sales using linear regression, with explanatory variables of GDP per capita, customer population, and average price
  - Regression tests show some variables are not significant, and variables are correlated
- VRA
  - VRA focused on purchases from various customers (ECG, NEDCo, Mines, ODCs)
  - VRA regresses only on GDP – 2 for ECG and GDP for NEDCo using linear regression
  - Mines and ODCs are based on surveys
- GRIDCO TMP regresses domestic consumption using linear regression with only GDP; whereas GMP linearly regresses on GDP+1, GDP per capita, population

5

End-use Methods (e.g., EC's LEAP modeling)

- EC uses LEAP model to estimate energy demand by using information on end users, technologies and consumption patterns
  - Relies on surveys of customer electricity-consuming equipment and operations
  - Forecasts are made by projecting equipment quantity, energy use per device, and expected intensity and time of use
  - $Example$: $AC\ Electric\ Consumption\ (KWh) = Customers * \left(\frac{Units\ of\ AC}{Customer}\right) * \left(\frac{KWh}{AC\ Unit}\right)$
- LEAP demand forecasts (for now) do not consider supply and infrastructure constraints; short term forecasts may not reflect current conditions
- LEAP results could be used for assessing suppressed demand in the short-term
- End-use methods can be used to evaluate how specific policies that impact demand forecasts (e.g., time-of-use tariffs, energy efficiency goals, demand side management supported by smart meters)
- Both LEAP demand forecasts vs. regression methods have their limitations, but they can also complement each other
- LEAP's optimization functionality could be used to compare against IPM results

6

USAID FROM THE AMERICAN PEOPLE

ICF

Proposed IRRP Reference Case Energy Forecasts

- IMF (Sep 2016) GDP projections till 2021, with 5-year moving average afterwards

- **ECG**: log-log linear regression of ECG sales with <u>only</u> on GDP (in 2006 GHC)
  - **<u>Half</u>** of the measured losses is assumed to be potential sales
  - R^2: 0.9922; Elasticity: 0.37 (10% GDP increase → 3.7% ECG sales increase)
  - Sales converted to ECG purchases based on loss factor
  - Measured loss decrease from 23% in recent years to 14% by 2030 (Reasonable?)
  - "Technical" losses decrease from 11.5% in recent years to 7% by 2030 (Reasonable?)
  - Zonal splits based on zonal demand ratios from ECG 2016 load forecast

- **NEDCo**: log-log linear regression of NEDCo sales with <u>only</u> on GDP
  - Including potential sales did not improve regression (but <u>additional analysis necessary</u>)
  - R^2: 0.9914; Elasticity: 0.59 (10% GDP increase → 5.9% NEDCo sales increase)
  - Measured loss decrease from 21% in recent years to 13% by 2030

- Bulk Customer forecasts by <u>each zone</u> based on GRIDCo 2014 Supply Plan, and additional updates from GRIDCO

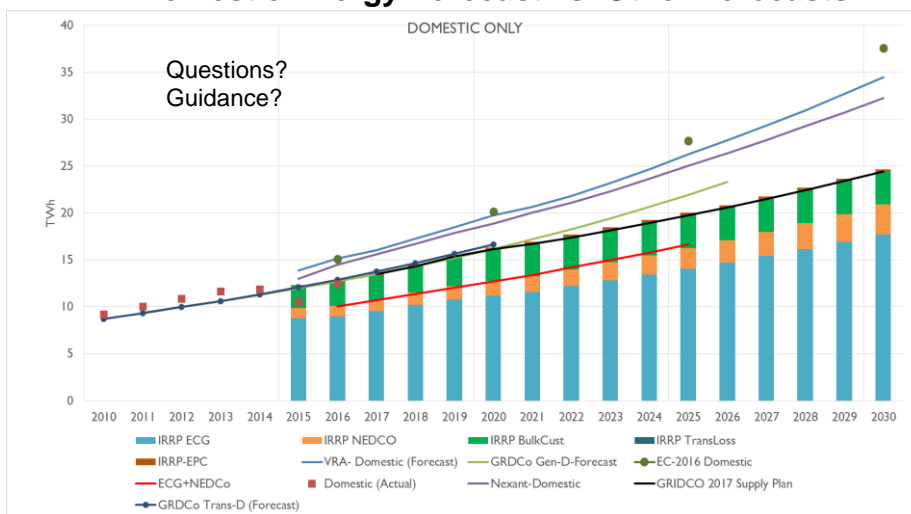- Transmission losses included as "demand" for each zone

7

USAID FROM THE AMERICAN PEOPLE

ICF

IRRP Domestic Energy Forecast vs. Other Forecasts

8

IRRP Reference Case: VALCO and Exports

- VALCO Peak Demand and Energy forecasts are based on one potline in 2017, two potlines in 2018, and four potlines in 2019 and beyond – based on discussions with Technical Committee
- Exports to Burkina Group were estimated based on discussions with GRIDCo
- Exports to Cote D'Ivoire
  - Energy Forecast are based on VRA 2015 load forecast
  - Peak Forecast for are based on GRIDCo 2016 Annual Forecast
- Exports to Togo
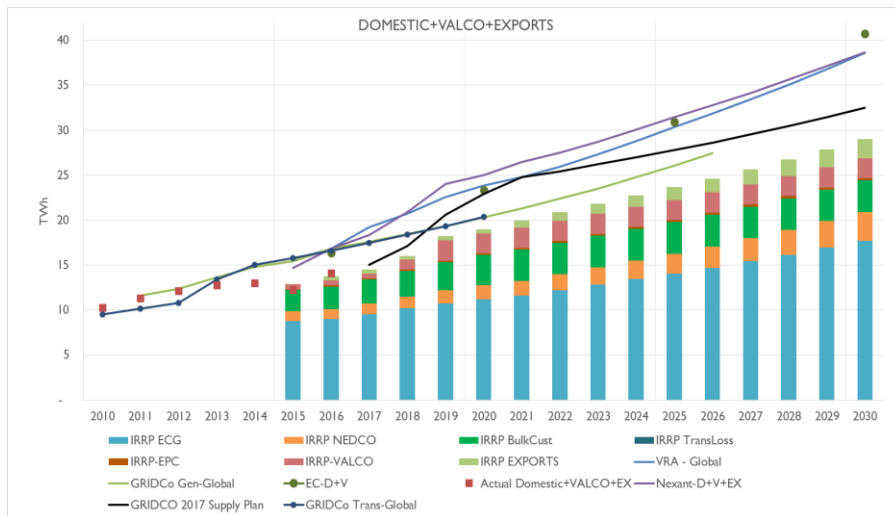 - Estimates were made for Energy and Peak forecasts based on GMP and discussions with GRIDCo

9

IRRP Global Energy Forecast vs. Other Forecasts

10

USAID
FROM THE AMERICAN PEOPLE

ICF

IRRP Peak Load Forecast

- Historical peak load data is strongly affected by supply challenges
- Measured peak load is correlated with GDP, but with limitations
- More granular analysis is needed to better forecast peak demand (vs. consumption), and determine the explanatory variables
- IRRP used the average ratio of ECG/NEDCo purchases to measured peak loads (about 70%) to convert energy into peak demand
- Peak demand from Bulk Customers and EPC based on GRIDCo 2014 supply plan and EPC inputs
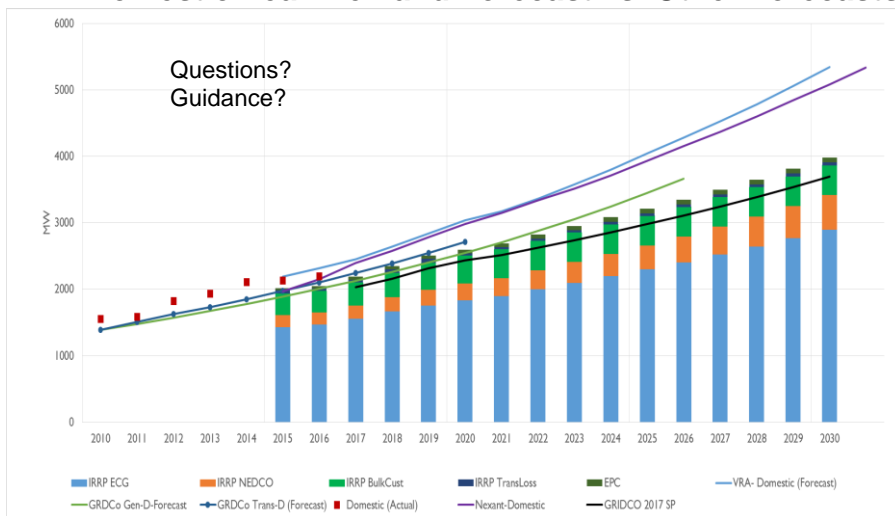- IRRP Peak demand is slightly lower compared to 2017 GRIDCo Supply Plan, but additional review is needed

11

USAID
FROM THE AMERICAN PEOPLE

ICF

IRRP Domestic Peak Demand Forecast vs. Other Forecasts

12

IRRP Global Peak Demand Forecast vs. Other Forecasts

13

Questions?
Discussion…

14a