IRRP Modeling Inputs and Assumptions

Demand Forecast

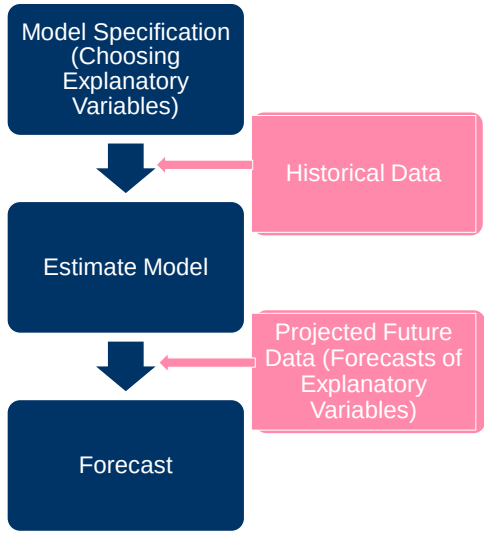
Load Forecast Reports Reviewed

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

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



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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

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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

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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 only on GDP (in 2006 GHC)
  - **Half** 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 only on GDP
  - Including potential sales did not improve regression (but additional analysis necessary)
  - 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 each zone based on GRIDCo 2014 Supply Plan, and additional updates from GRIDCO
- Transmission losses included as "demand" for each zone

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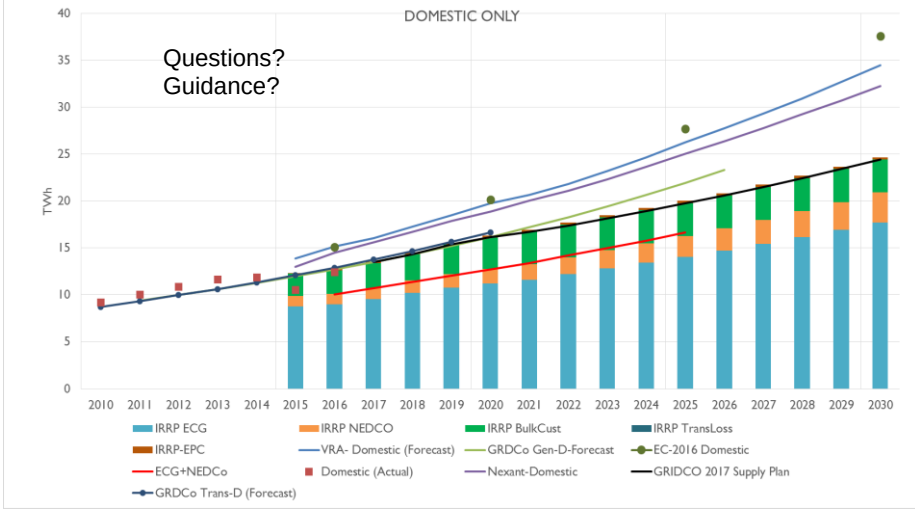
IRRP Domestic Energy Forecast vs. Other Forecasts



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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

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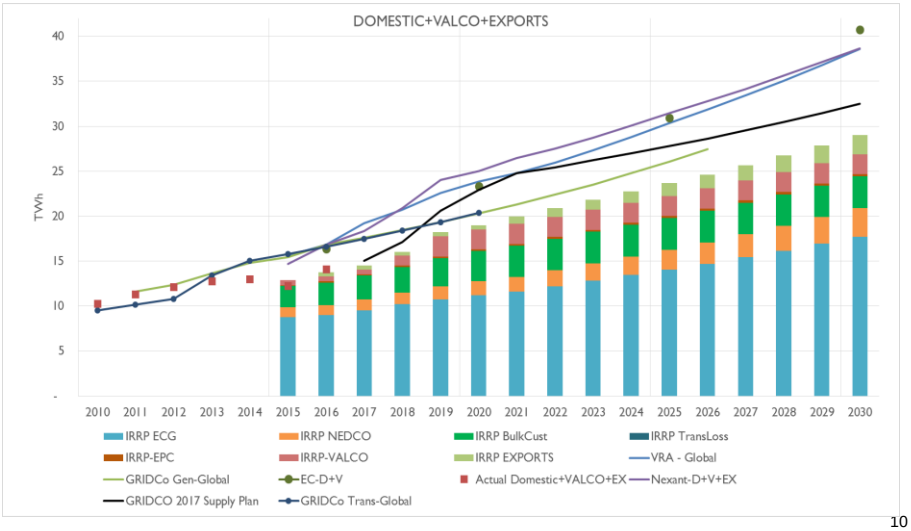
IRRP Global Energy Forecast vs. Other Forecasts



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

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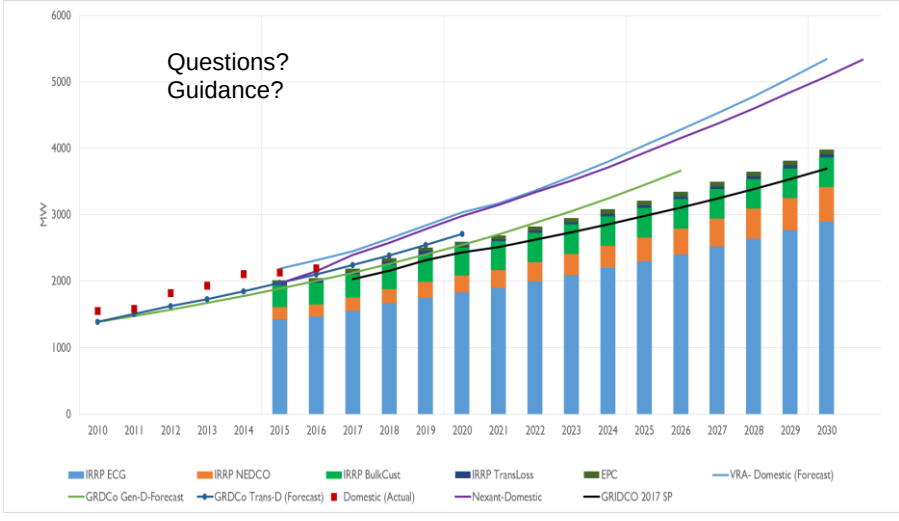
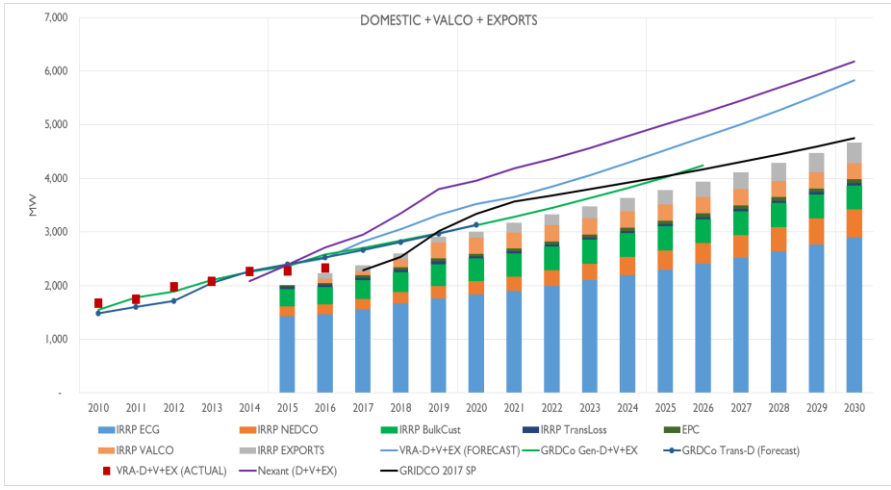
IRRP Domestic Peak Demand Forecast vs. Other Forecasts



IRRP Global Peak Demand Forecast vs. Other Forecasts



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Questions? Discussion…

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