RTR ENERGY SOLUTIONS INC

Dynamic Line Rating

Installation on Three PPL Circuits

DLR Project Initiation

PPL requested RTR manage the installation of the Ampacimon devices on the Juniata-Cumberland and Susquehanna-Harwood 1&2 230kV lines.

- Asset Owner
- Project Owner
- IT and PJM Integration
- NERC-CIP Compliance

- Determination of Installation Methods
  - Heli Live Line + Ground Crew (for select spans)
- Create and submit tickets to TCC
  - Both Live Line and Outage
- Line Crossings
- Environmental Permitting

- DLR System/Sensor Provider
- Line Capacity Modeling
- DLR Configuration
- IT Integration with PPL

- Regional Operator
- Accept 1-Day ahead DLR ratings

Ampacimon
Smart solutions for a dynamic grid

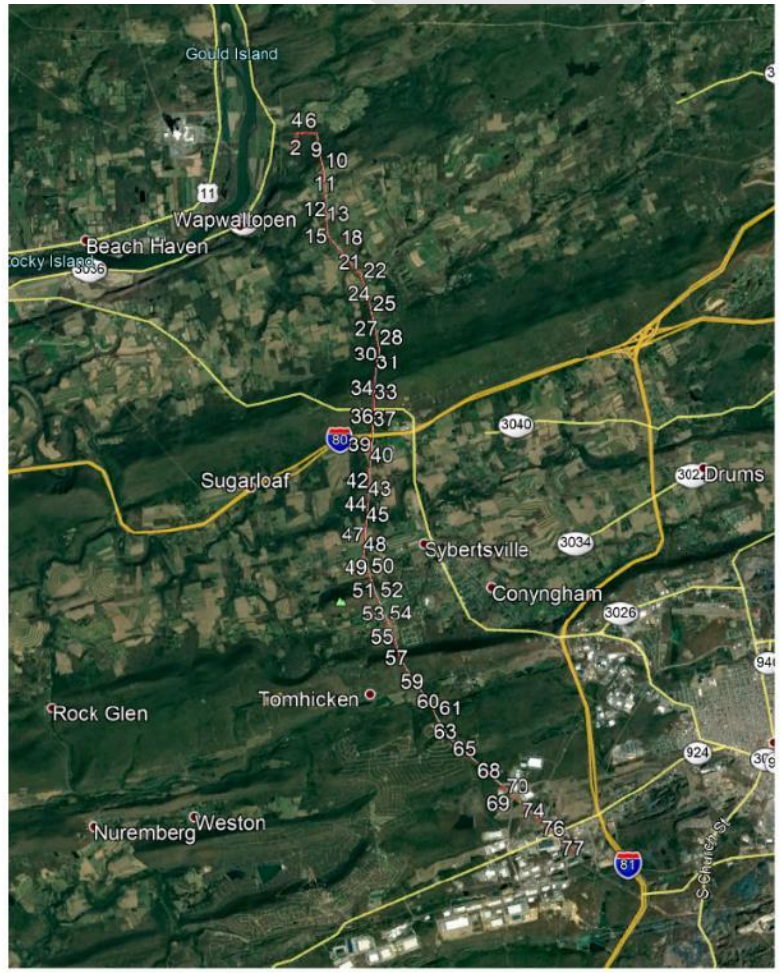
Background

High congestion costs projected in 2025

Harwood to Susquehanna | 230 kV | ACSS | 2040A Static Rating

Juniata to Cumberland | 230 kV | ACSR | 1240A Static Rating

2020/21 RTEP Market Efficiency Window Eligible Energy Market Congestion Drivers* (Posted 03-05-2021)				ME Base Case (Annual Congestion $million)		ME Base Case (Hours Binding)	
FG#	Constraint	FROM AREA	TO AREA	2025 Simulated Year	2028 Simulated Year	2025 Simulated Year	2028 Simulated Year
ME-1	Kammer North to Natrium 138 kV	AEP	AEP	$ 2.02	$ 6.56	69	167
ME-3	Junction to French's Mill 138 kV	APS	APS	$ 9.18	$ 11.97	276	301
ME-4	Yukon to AA2-161 Tap 138 kV	APS	APS	$ 4.36	$ 5.16	1742	1958
ME-5	Charlottesville to Proffit Rd Del Pt 230 kV	DOM	DOM	$ 3.76	$ 4.96	121	124
ME-6	Plymouth Meeting to Whitpain 230 kV	PECO	PECO	$ 3.33	$ 4.09	111	101
ME-7	Cumberland to Juniata 230 kV***	PLGRP	PLGRP	$ 9.00	$ 6.61	213	179
ME-8	Harwood to Susquehanna 230 kV***	PLGRP	PLGRP	$ 14.49	$ 8.69	830	501



Ampacimon
Smart solutions for a dynamic grid

Solutions Considered

	Reconductor	Double Circuit	Dynamic Line Rating
			
Time to Implement	2 – 3 Years	3 – 5 Years	Months
Downtime	Extended Outages	Extended Outages	No Outages Required
Cost	$0.5 M per mile	$2 - 3 M per mile	< $1 M
Est Capacity Benefit	+ 34%	+ 106%	+10 – 30%

Ampacimon
Smart solutions for a dynamic grid

What is DLR?

System of line sensors installed to measure conductor and real-time environmental data in order to determine the true capacity and forecasted capacity

❑ Static Line Ratings

Assumes

- Wind speed
- Ambient Temp
- Solar Radiation
- 2 Seasons (Planning)

Conservatively Calculates Ratings

No way to measure field conditions, ensure safe operations, or line health

❑ Dynamic Line Ratings

Measures

- Wind Speed
- Ambient Temp
- Conductor Temp
- Conductor Sag

Accurate Real-Time and Forecasted Ratings

Measures Conductor Health

Ampacimon
Smart solutions for a dynamic grid

Perpendicular wind is the key factor to increasing capacity

DLR sensors must accurately measure the actual wind speed that each critical span is experiencing

Wind estimates based on weather station data alone have proven to be inaccurate

U.S. Department of Energy | April 2014

Operating Conditions	Change in Conditions	Impact on Capacity
Ambient temperature	2 °C decrease	+ 2%
	10 °C decrease	+ 11%
Solar radiation	Cloud shadowing	+/- a few percent
	Total eclipse	+ 18%
Wind	3 ft./s increase, 45° angle	+ 35%
	3 ft./s increase, 90° angle	+ 44%

Source: Navigant Consulting, Inc. (Navigant) analysis; data from (7)

Table 1. Impacts of Changing Operating Conditions on Transmission Line Capacity

acimon
Smart solutions for a dynamic grid

Dynamic Line Ratings Process

Weather Measurements

Line Measurements

Forecasted Weather Data

Algorithms Calculate Real Time Ratings

IEEE

Algorithms Calculate Forecasted Ratings

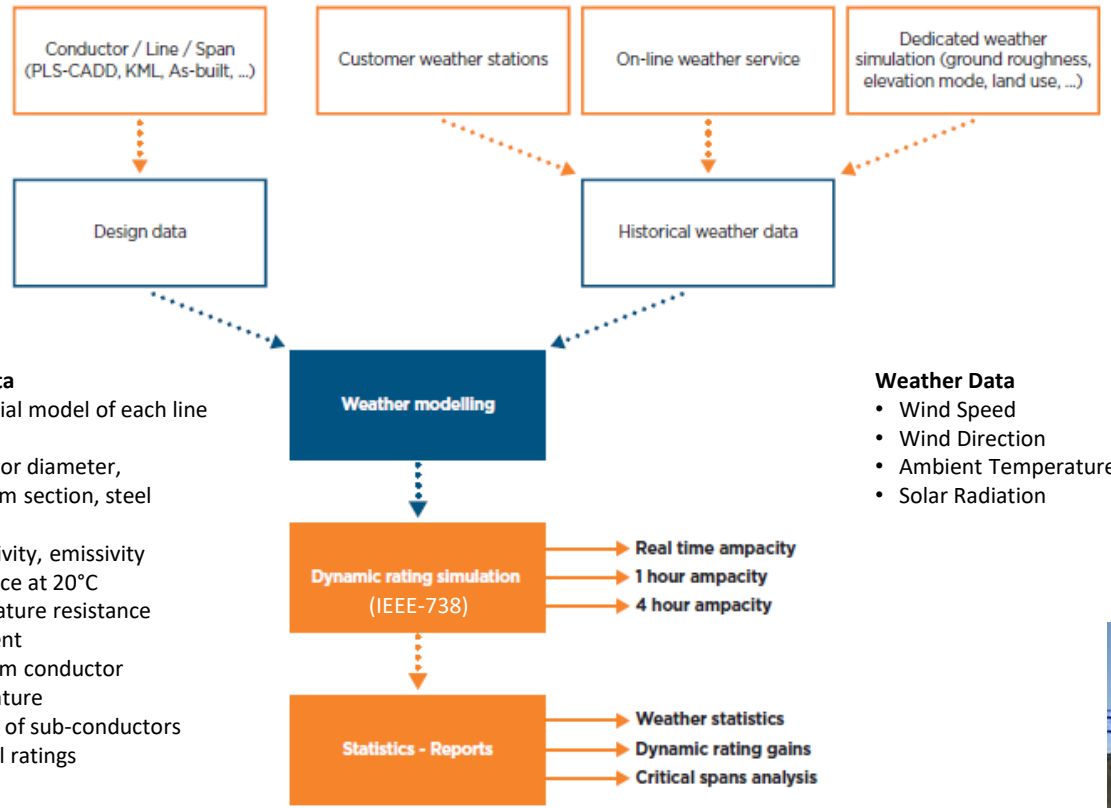
IEEE

TMS operates based on Dynamic Ratings

Machine Learning Feedback Loop

Planning for DLR

Ampacimon DLR Simulations



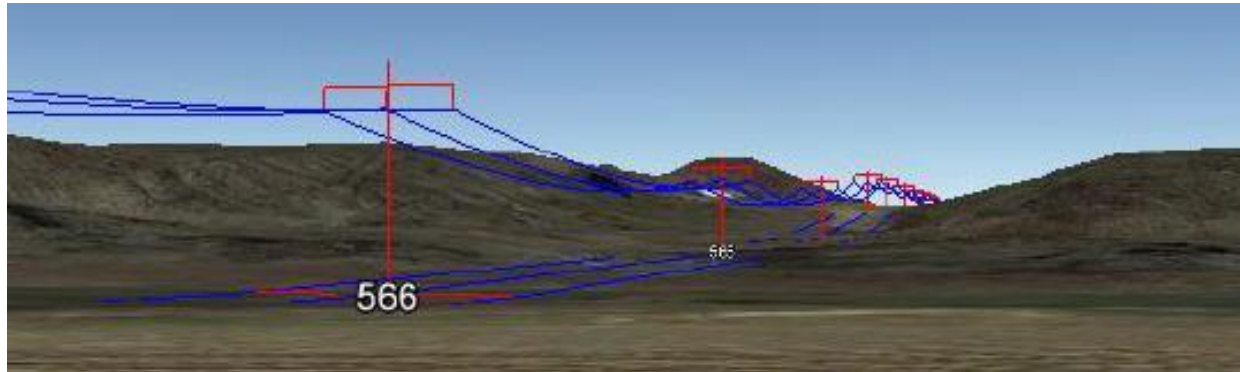
Design Data
- Geospatial model of each line span
- Conductor diameter, aluminum section, steel section
- Absorptivity, emissivity
- Resistance at 20°C
- Temperature resistance coefficient
- Maximum conductor temperature
- Number of sub-conductors
- Seasonal ratings

Weather Data
- Wind Speed
- Wind Direction
- Ambient Temperature
- Solar Radiation

ADR VIEW IN A NUTSHELL

Input data:
- Historic weather data covering surveyed area
- Line design data and existing ratings
- Conductor features
- Span design data

Deliverables:
- ADR View report containing statistics, histograms,
- Time-stamped data in .csv format
- Presentation of results by an Ampacimon expert (face-to-face or conference call)

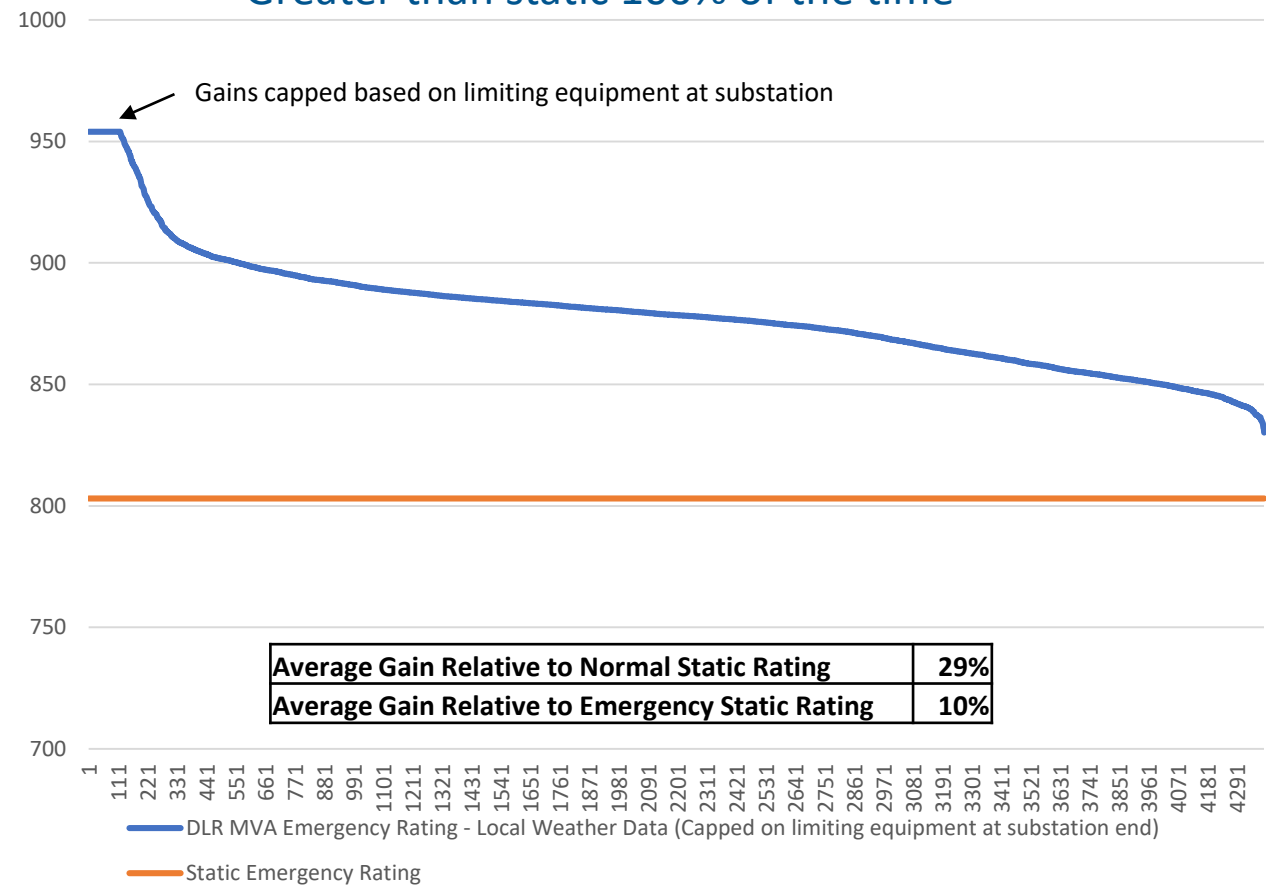


DLR Simulation Results

Steady-state DLR at emergency rating temperature

SUSQ-HARW Summer Emergency Rating (MVA)
(April-September)

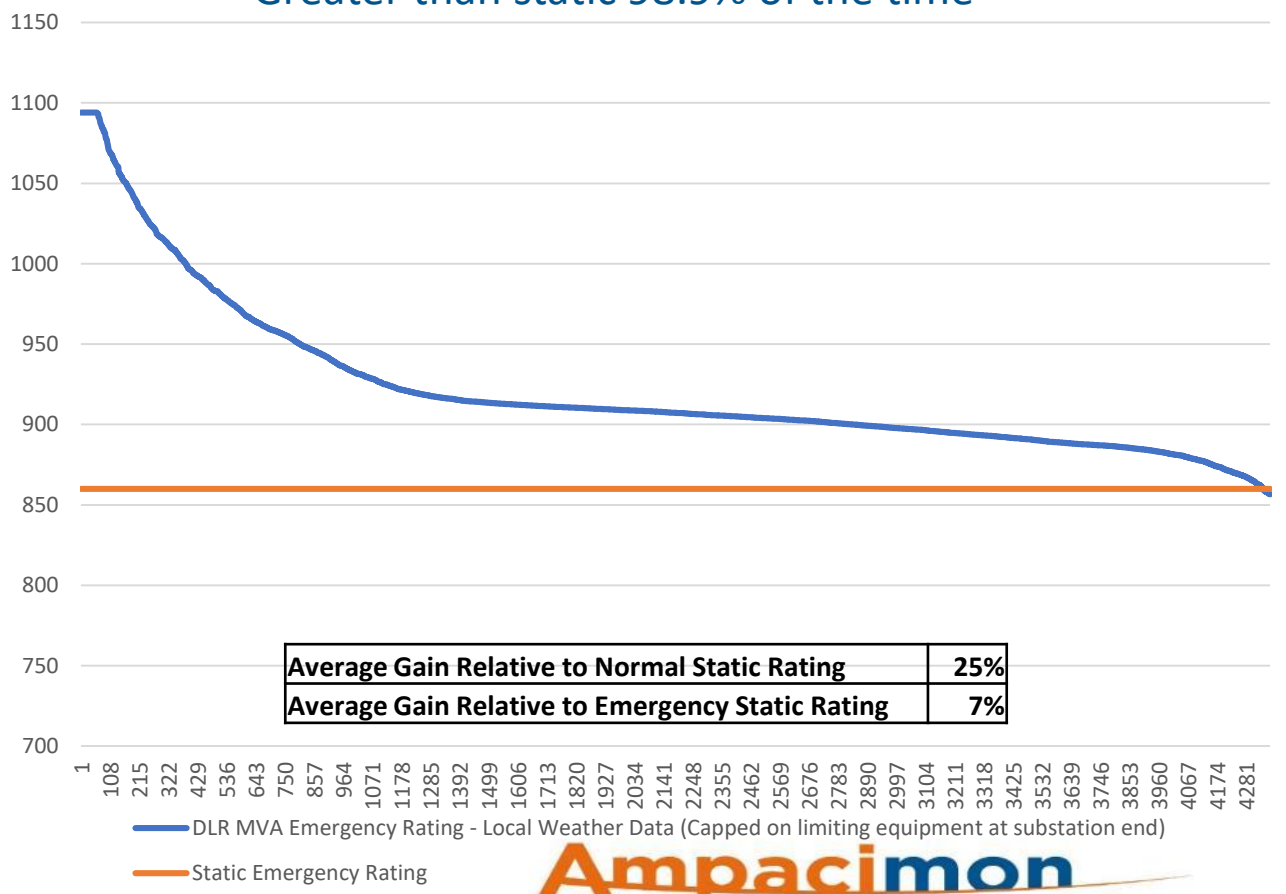
Greater than static 100% of the time



Average Gain Relative to Normal Static Rating	**29%**
Average Gain Relative to Emergency Static Rating	**10%**

SUSQ-HARW Winter Emergency Rating (MVA)
(October-March)

Greater than static 98.9% of the time

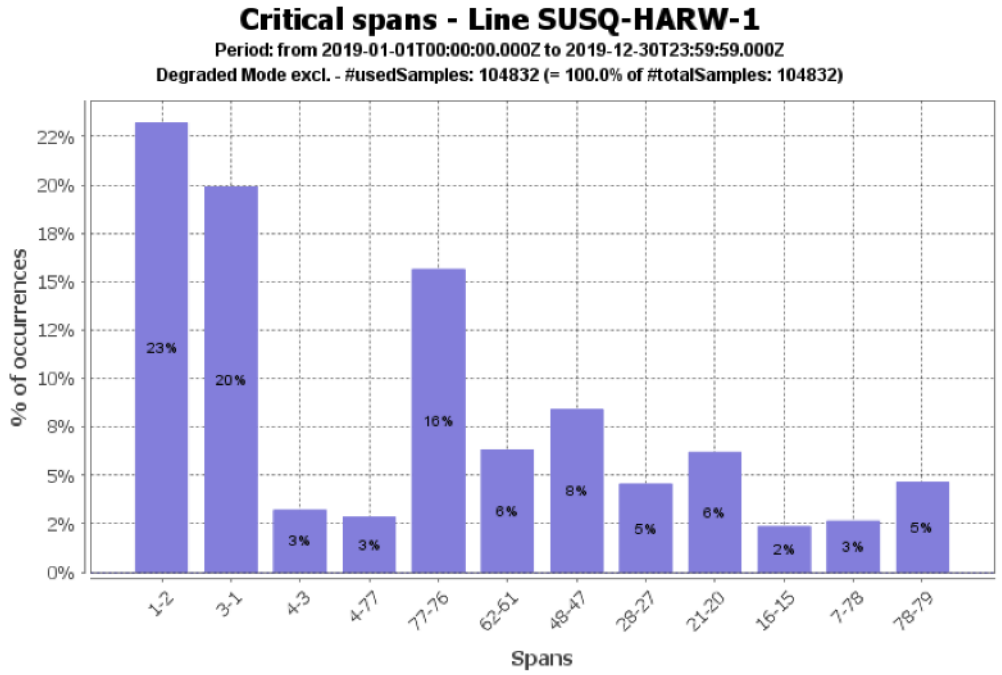


Average Gain Relative to Normal Static Rating	**25%**
Average Gain Relative to Emergency Static Rating	**7%**

Ampacimon
Smart solutions for a dynamic grid

Target Span Identification

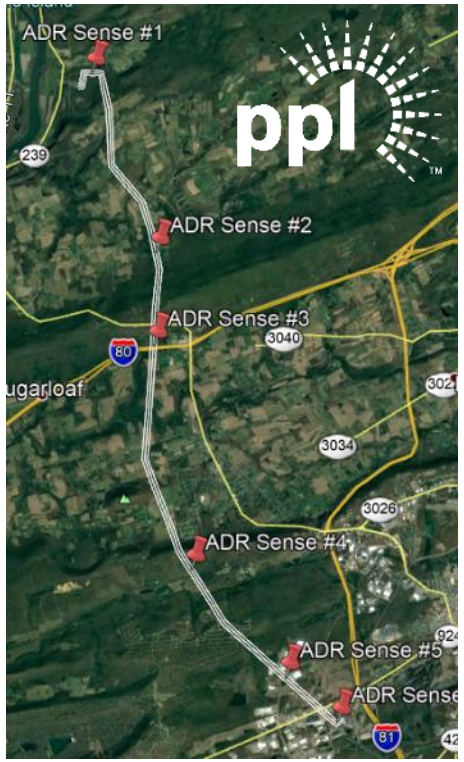
1 Critical Span Distribution From DLR Simulation



2 Required Span Selection Rules

- Orientation between spans changes more than 15°
- Distance is greater than 10 km
- Conductor or number of sub-conductor change
- Span safety concerns
- Utility span data identifies high risk span(s)

3 Final Span Selection



Ampacimon
Smart solutions for a dynamic grid

Preparing for Installation

Susquehanna – Harwood | 2 Circuits | 12 Sensors

Juniata - Cumberland| 1 Circuit | 6 Sensors

- Assembled Crewing Required
- Conducted Crew Training on Sensor Mounting Procedure
- Practiced Mounting Procedures
- Shepherded outage tickets through the PL ticket process
- Energized Sensors Prior to Install to Ensure Functionality and Connectivity
- Physical Install Challenges:
    - Heavy Snowfall and Wind
    - Existing Environment Permits in the Area
    - Needed ground installation for some spans due to adverse weather conditions -> Took advantage of existing outage window for ground installation

RTR ENERGY SOLUTIONS INC ®

Sensor Deployment

Susquehanna – Harwood | 2 Circuits | 12 Sensors

Juniata - Cumberland| 1 Circuit | 6 Sensors

- Installed December 2020
- One phase per identified span
- Sensor mounted 5 – 10% of the total span length from either tower
- Live Line Installation Via Helicopter
    - Select spans installed from ground
- Mounting procedure is 5 - 10 minutes per sensor

Upcoming Work for PPL

- Definition of formal ratings procedure being developed by PPL in partnership with PJM
- Integration of ratings into PJM 1-day ahead operations and market to clear congestion violations
- Finalize IT System with NERC-CIP Compliance

Ampacimon
Smart solutions for a dynamic grid

Ryan Robinson
Owner
RTR Energy Solutions
RRobinson@rtrenergysolutions.com
Cell: 724-550-5010

Horst Lehmann
Senior Engineer
HJLehmann@pplweb.com
Work: 610-774-3168

Joey Alexander
Director, Business Development
Ampacimon
Joey.Alexander@Ampacimon.com
Cell: 678-231-9473

Bill Skumanich
Program Manager
RTR Energy Solutions
BillS@rtrenergysolutions.com
Cell: 484-627-4405