IS OPEN VRAN POWER EFFICIENT?

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TABLE OF CONTENTS

5G MARKET OVERVIEW 1
- MARKET TRENDS..1
- NETWORK INFRASTRUCTURE TRENDS 2

DRAN, VRAN AND OPEN VRAN 3
- DRAN...3
- OPEN VRAN 4

MODELING BASEBAND POWER CONSUMPTION......................... 6
- 5G SUBSCRIBER AND TRAFFIC PROFILES 7
- 5G BASE STATIONS AND SECTORS.....................7
- BASEBAND PROCESSING DIMENSIONING 8
- POWER CONSUMPTION RESULTS 9
- MODELING 32T32R MMIMO 11

QUALITATIVE ANALYSIS OF FURTHER ENERGY SAVINGS.................. 12

OPEN RAN ARCHITECTURE.................... 13
- OPEN RAN AND RIC SUPPORT FOR POWER-EFFICIENT IMPLEMENTATIONS 13

CONCLUSIONS AND RECOMMENDATIONS.......................... 17

5G MARKET OVERVIEW

The past few years have had mixed results in the telecoms world, with geopolitics, COVID-19, and 5G deployment challenges, but at the same time, proving that fixed and mobile telco networks are critical components of national infrastructure. This has created a new wave of investments for telco networks, including a renewed focus on 5G, 5G-Advanced, and 6G.

At the same time, several market developments are proving that the telecoms domain is ripe for innovation and, in fact, needs it. Geopolitical concerns are restricting the number of vendors certain operators can deploy 4G and 5G with, while several mobile operators now state that the established vendor lock-in is restricting innovation and does not allow more favorable horizontal market conditions. As of the end of 2022 and the beginning of 2023, several market trends indicate that a fresh approach is necessary for deploying 5G networks, due to both internal and external factors.

MARKET TRENDS

Telecoms markets in the developed world are now saturated and governed by fierce competition and a growing need to address enterprise applications. 5G network operators have had to deploy their networks during a challenging macroeconomic period, with COVID-19, geopolitical and supply chain constraints, and increased inflation. Nevertheless, 5G networks are starting to be deployed throughout the developed world and providing a significant upgrade in user experience compared to previous generations. These 5G networks are also providing a lower cost/bit compared to 4G, meaning that despite the markets being very competitive, mobile operators are still profitable and will remain so in the future. Their business is not as lucrative as it was in the past, but it is certainly profitable, and it will remain so in the future.

On the other hand, supply chain constraints became a much bigger problem during the recent COVID-19 and geopolitical crisis, which restricted the vendor options for mobile operators. The market has now adapted to these conditions with the emergence of Open Radio Access Network (RAN), which aims to open radio network interfaces and, ultimately, allow operators much more flexibility in terms of choosing suppliers. Moreover, virtualized RAN (vRAN) will disaggregate hardware from software, allowing network elements to run on commoditized hardware. Open vRAN is the combination of the two, enabled by open interfaces and common hardware, and is considered the future of mobile networks.

A most recent challenge for all mobile operators is energy costs, particularly in Europe, where the Ukraine war has caused energy costs to skyrocket. This has caused network energy Operational Expenditure (OPEX) to become a major issue in many European markets, where some mobile operators have even resorted to extreme measures, such as switching off 5G radios during the night, when usage is low. At the same time, mobile operators continuously seek to optimize their network, which, in some cases, means retrofitting new infrastructure or completely replacing existing base stations and network equipment.

NETWORK INFRASTRUCTURE TRENDS

The replacement of network infrastructure typically takes place to optimize network performance, cost, or power consumption. 5G networks are now entering this phase of optimization, after large-scale deployments have taken place using first generations of network infrastructure. This is normal in nationwide rollouts, which are accelerated to meet coverage demands without considering network or energy performance as key drivers for the deployments. First generations of 5G radio networks are now being optimized, while many mobile operators are even switching to newer units that consume less power, have better performance, and offer capabilities that will shape the future of the network.

Baseband modems supporting both 2G and 3G connectivity see use across a wider range of devices than single-mode 2G modems

One of the most important capabilities is the use of AI and ML, which have started entering the mobile network in the upper layers of the network stack, mainly in BSSs that handle subscriber, marketing, and commercial data. The BSS has been a relatively straightforward domain for AI/ML because it deals with large amounts of data and is running on common Information Technology (IT) platforms. However, AI/ML is now expanding well beyond this domain to all areas of the network, reaching as far as the radio domain where network optimization has traditionally been vertically integrated in a closed and well-guarded field due to the complexity of network operations. Many initiatives are now addressing multiple areas of the network, including the Radio Intelligent Controller (RIC), the Service, Management, and Orchestration (SMO) element, network orchestration, and many others. It is important to note that RIC has been designed to address Open RAN deployments and not traditional RAN networks, because it is principally designed for open interfaces. RIC also offers significant advantages over Self Optimizing Networks (SONs), which target traditional RAN deployments, including the capability to perform user-based optimization.

Finally, the telecoms market is now working toward 5G-Advanced and 6G, doing research in the next wave of mobile network technology, while trying to build the platforms for future generations. This is now filtering to current market developments, which are focusing on the deployment of horizontal platforms, rather than vertical architectures that were the mainstream choice in previous years. This is certainly the case in radio networks as well.

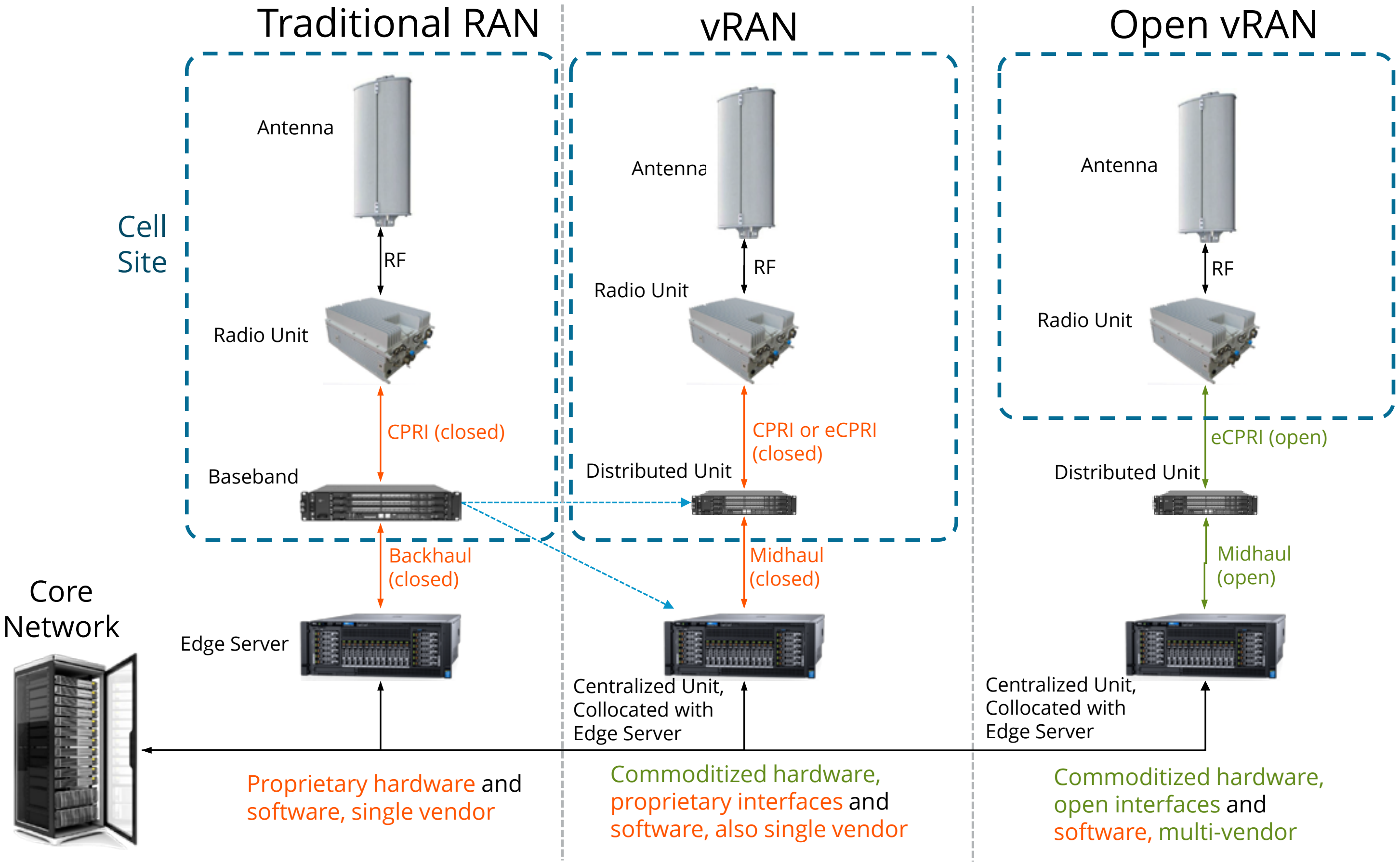
DRAN, VRAN AND OPEN VRAN

Cellular networks are distributed processing environments, where base stations are deployed throughout a country to connect users to the network. This is even more so with 5G networks, which have been designed for massive data communications, the IoT, and low-latency communications, compared to previous generations that were partly designed for voice and Short Messaging Service (SMS). The design and implementation of cellular networks have evolved significantly over the past few years, leading to much more efficient and scalable architectures.

Figure 1 illustrates the transition from traditional RAN, also named Distributed RAN (DRAN) to vRAN and finally, Open vRAN.

Figure 1: Traditional to Open vRAN Evolution

(Source: ABI Research)



DRAN

Traditional, or DRAN, has been the mode of deployment since the early days of cellular networks several decades ago. Early DRAN systems were created to deploy cellular networks as easily as possible, given the available technologies at the time. In short, the evolution of DRAN has followed these phases:

1) The first DRAN networks relied on integrated units that combined baseband and radio processing in one unit, typically deployed at the ground level at a cell site. The signal was transmitted using Radio Frequency (RF) cables from this integrated unit to the antenna at the top of the mast.

2) Second-generation DRAN systems disaggregated the baseband processing from the radio, and replaced expensive and lossy RF cables with optical connections from the baseband unit to the radio. In this phase, every generation was powered by its own unit, meaning that there were multiple radios deployed on a cell site to support 2G, 3G, and 4G.

3) The final generation—and what is being used currently—is SingleRAN, which is a single baseband processing unit and a single radio for 2G, 3G, and 4G. 5G deployed in mid-band frequencies (e.g., 3.5 Gigahertz (GHz)) requires its own radio because it relies on Massive Multiple Input, Multiple Output (mMIMO), which cannot be integrated with previous generations. In many cases, baseband processing is also separate, requiring multiple different Baseband Units (BBUs) at a cell site.

A major consideration for DRAN is that all aspects of the infrastructure rely typically on proprietary, custom hardware that has been tailored for a single application. For example, incumbent infrastructure vendors have developed their own custom silicon and their proprietary platforms on which their DRAN equipment is built. The first evolution of Centralized RAN (C-RAN) is virtualizing the baseband processing, which allows the centralization of the baseband processing, allowing benefits that are typically associated with cloud computing, such as pooling and elasticity.

OPEN VRAN

The closed nature of DRAN has created a gap in the market for open interfaces to allow more vendors in the supply chain, while making infrastructure and network elements more efficient in terms of performance, cost, and power consumption. This trend has led to the creation of Open RAN and vRAN.

OPEN RAN

Open RAN networks open the interface between the processing and radio units in a base station, allowing network operators to theoretically mix and match and select best-of-breed components for either of these. Open vRAN further upgrades Open RAN by disaggregating hardware and software, and building RAN processing functions on Custom Off-the-Shelf (COTS) servers. Moreover, the functional split between the Centralized Unit (CU), Distributed Unit (DU), and Radio Unit (RU) presents a natural environment for open interfaces. The O-RAN Alliance and the broader industry have settled on what is called Option 7.2, which splits physical layer processing between the DU and the RU, and reduces the capacity needed for the connection between these two elements, often referred to as fronthaul. This option allows the centralization of the DU, as well as the opportunity to introduce more vendors in the supply chain.

VRAN

vRAN networks decouple software from hardware and run RAN processing functions on COTS servers. In general, vRAN is about the centralized management of radio resource processing and allows network operators to modularize network functions on COTS servers. All current vendors are pursuing vRAN strategies to help operators minimize costs, but hardware implementations differ; some vendors choose commoditized hardware, whereas others choose proprietary hardware platforms. The value proposition of vRAN is to centralize some of RAN functions, including the BBU, and upper layers of the Radio Remote Unit (RRU). By doing so, operators will be able to save significant OPEX by reducing site rental and the overall power consumptions otherwise needed to power many end-to-end access sites. The standard industry implementation of vRAN is to decouple the BBU into two units:

1) **Centralized Unit (CU):** This unit provides support for the higher layers of the protocol stack and is typically deployed at a central location, either in a core network data center or in a central office location in an urban environment.

2) **Distributed Unit (DU):** This unit supports the lower layers of baseband processing, which also includes the physical layer. This is typically deployed at an aggregation point or at the cell site.

This baseband processing is performed by commoditized IT servers that are interchangeable and easily replaced if necessary. Unlike custom silicon-based BBUs, COTS servers can reduce RAN equipment costs, allow flexible and automatic radio resource allocation, and accelerate network deployment.

COMPARING OPEN VRAN WITH VRAN

The telecoms market is currently considering virtualization for several network domains, but not all implementations are equal. In fact, vRAN itself is not necessarily a new topic in the industry, as the centralization (e.g., C-RAN) of certain network elements has been discussed in the industry for many years. In the RAN domain, vRAN is not the same as Open vRAN. The latter can provide significant cost savings and openness that augments the benefits of virtualization and centralization. The following sections present a few important unique benefits that Open vRAN introduces.

MIDHAUL AND BACKHAUL FLEXIBILITY AND COST SAVINGS

vRAN typically requires CPRI and the physical layer (Layer 1) is processed at the cell site. This places a stringent requirement on fronthaul, which translates to dark fiber needed throughout the network. This increases the deployment cost for vRAN, as dark fiber either has to be introduced, leased, or fiber capacity borrowed from other parts of the network. Certain hybrid operators reported that vRAN trials have resulted in potential degradation of fixed broadband services due to the high fronthaul requirements and the additional strain to their fiber network.

On the other hand, Open vRAN allows for the physical layer to be split between the cell site and the aggregation point, thus reducing both processing requirements at the cell site and the midhaul link capacity. Option 7.2 minimizes the impact on transport bandwidth and standardizes interfaces between DU and RU, so that these two elements can easily interoperate between different vendors, while improving performance of the whole system without ideal backhaul or fronthaul.

RIC

An even more important benefit of Open RAN is the capability to interface with third-party developers and new types of applications, and introduce new functionality that can optimize multiple parts of the network. With vRAN, this is only possible in tightly integrated, single-vendor environments, whereas in Open vRAN, RIC can allow for xApps and rApps from multiple vendors. More information about RIC is discussed in Section 4.

MODELING BASEBAND POWER CONSUMPTION

Apart from performance and cost comparison for any new deployment, energy consumption is becoming a key indicator when considering a new deployment. Thus, ABI Research has created a network model to assess how the power consumption of Open vRAN compares to DRAN, in a real-life network scenario. ABI Research has selected a developed Western European market for several reasons: 5G is well deployed in this region; there is healthy traffic demand from both consumers and enterprises; and the energy crisis is pushing network operators to optimize their power consumption profiles throughout the network. It should be noted that this model is fully applicable to other markets as well, including Asia-Pacific and India. In fact, the model assumptions in this Western European case are arguably stringent, as the network parameters below are very high-end. In developing markets and in cases where capacity demands are lower, 5G networks will be more suitable for centralization of the DU, translating to even further cost and energy savings.

Table 1 summarizes key network parameters and assumptions.

Table 1: Network Model Parameters for Both DRAN and Open vRAN

(Source: ABI Research)

5G Network Parameter	Value
mMIMO configuration	64T64R
Frequency and bandwidth	90 MHz at 3.5 GHz
Environments modeled	Dense urban and urban
Sectorization	80% of sites have 3 sectors 10% have 6 sectors 10% have 9 sectors
Average monthly traffic per 5G user	20 GB in 2020 50 GB in 2027
Effective sector spectral efficiency	25 bps/Hz
Effective sector capacity	2.5 Gbps
Busy hour dimensioning window	12 hours/day
Network elements considered	BBU and DU/CU

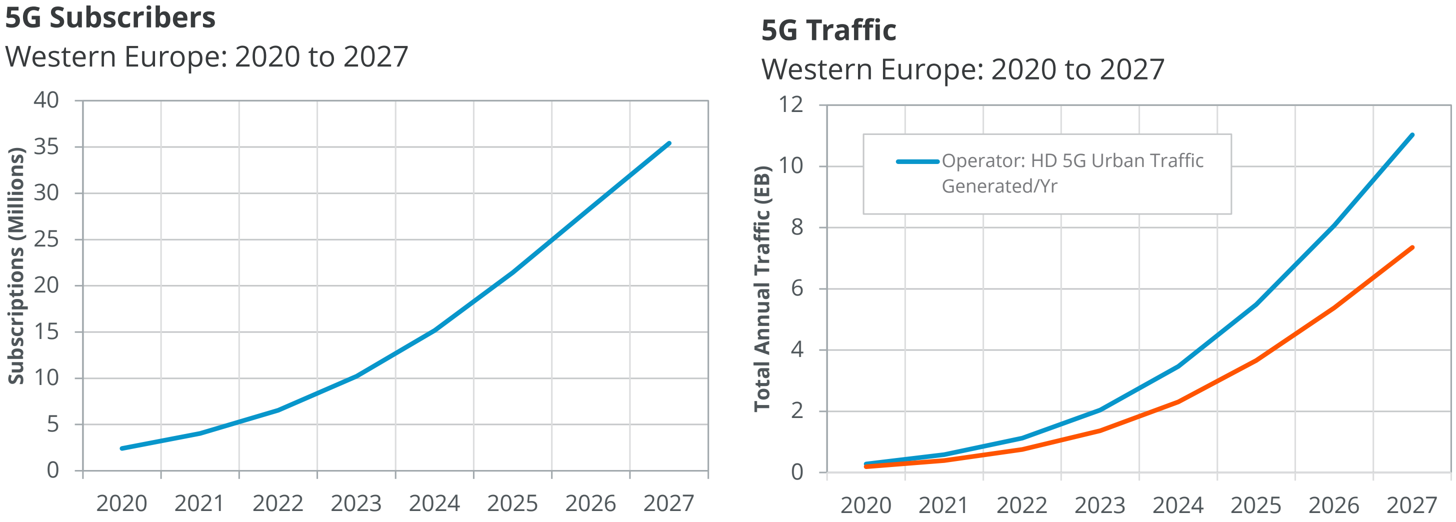
ABI Research has selected this scenario due to its aggressive traffic nature and the demanding user behavior in Western Europe, and in dense urban and urban environments. It is also these environments that are likely to consume most of the energy throughout a country, because suburban and rural sites are likely to generate less traffic and consume a lower amount of energy per day. On the other hand, dense urban and urban sites are likely active throughout the day, hence the choice of 12 busy hours per day, which signals that the network is well utilized throughout most of the day. This means that there are no significant traffic spikes at any time of the day and that traffic throughout the day remains at a very high level. The following sections summarize key network performance characteristics before defining power consumption for baseband processing.

5G SUBSCRIBER AND TRAFFIC PROFILES

The market used in this study is one of the biggest and most advanced in Western Europe, one of the early markets to launch 5G and home to one of the biggest multinational operators in the world. Figure 2 illustrates historical data and ABI Research's projections for the number of 5G subscribers in the market, as well as the total amount of 5G traffic these subscribers are expected to generate throughout the forecast period.

Figure 2: Western Market Subscription and Traffic Forecasts

(Source: ABI Research)



Although traffic has been split between high-density and low-density urban areas, these are treated in the same way in the network model, especially when dimensioning the RUs and BBUs. It is also necessary to note that the network modeling and dimensioning process has been performed using average values throughout the network, i.e., the traffic is assumed to be spatially spread throughout the network uniformly. This has been assumed to make the deployment process easier, rather than treat each individual area in a different manner. In a real network, each area and even each site needs to be treated separately, but this is not possible in a network modeling or simulation exercise.

5G BASE STATIONS AND SECTORS

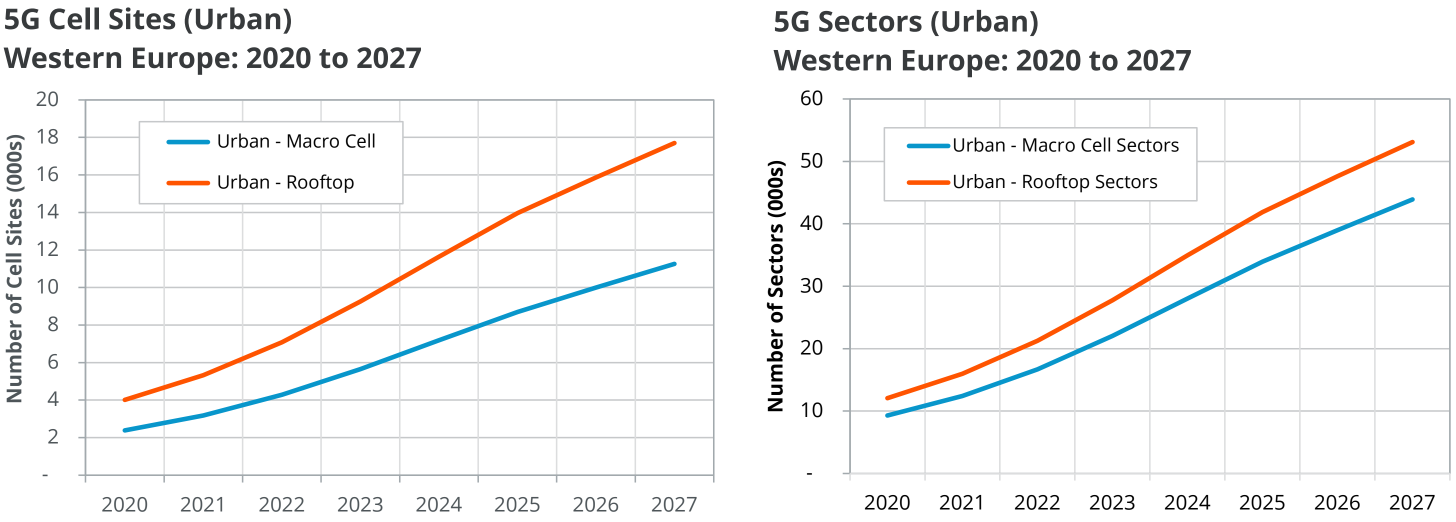
The above parameters allow the deployment of a 5G radio network, including numbers and forecasts for cell sites, sectors, Active Antenna Units (AAUs), and basebands. Figure 3 represents the parameters used for this urban and dense urban 5G network throughout this developed market. It should be noted that cell sites have been split between two main categories:

- **Macro Cells:** These are typically deployed in masts or large poles that cover large areas. These sites are typically high-power, high-capacity sites and consist of 3, 6, or 9 sectors to improve capacity. Given that the Western European market ABI Research is modeling is in the relatively early stages of 5G rollout—when deployment is driven by coverage needs, not capacity—most sites are 3-sector. This is because mMIMO—64T64R is assumed in this modeling scenario—also provides a significant capacity boost compared to previous generations, something that end users will take years to adapt to and ultimately congest.
- **Rooftop Cells:** These cells are deployed on top of buildings to cover dense urban areas. These sites are typically 3- or 4-sector and are not considered for cell splitting in ABI Research's model. These are typically sites that are deployed on low-rise buildings to cover busy street areas and not considered for additional capacity upgrades, given that the current deployment model for 5G in this market is coverage-driven.

Given the above assumptions, the results in Figure 3 illustrate the number of cell sites and sectors in ABI Research's model.

Figure 3: Cell Site and Sector Forecasts

(Source: ABI Research)



Macro cells typically represent a smaller fraction of cell sites in this market—and most developed markets—but the percentage of macro sectors is higher due to 6- and 9-sector macro sites. It should be noted that historical population, subscription, traffic, cell site, and sector numbers for 2020 and 2021 have been validated with the mobile operator this model is approximating. Moreover, the coverage targets assumed in this model approximate what this operator has announced and are in line with Western European 5G coverage targets.

The numbers for cell sites and sectors allow the deployment of BBUs or CUs/DUs to approximate the deployment of DRAN or Open vRAN.

BASEBAND PROCESSING DIMENSIONING

Table 2 illustrates parameters that were used in the model for DRAN and Open vRAN, respectively, to be able to dimension and deploy baseband processing throughout the network.

Table 2: Baseband Processing Modeling Parameters for DRAN and vRAN

(Source: ABI Research)

Baseband Processing Parameter	DRAN Value—BBU	Open vRAN Value—CU/DU
Single unit capacity	BBU: 7 Gbps	CU: 12 Gbps DU: 9 Gbps
Over-dimensioning	20%	20%
Idle power consumption	DRAN vendor 1: 247 W DRAN vendor 2: 310 W DRAN vendor 3: 300 W	CU: 402 W DU: 222 W
Max power consumption	DRAN vendor 1: 379 W DRAN vendor 2: 340 W DRAN vendor 3: 500 W	CU: 596 W DU: 299 W
Baseband processing distribution	100% at cell site	CU: 100% centralized DU: Variable, from 0% to 90%

Note: for VRAN, 1 CU typically contains multiple vCU instances

The above assumption led to the number of BBUs or CUs/DUs deployed throughout the network, which is nearly identical if the same dimensioning parameters are assumed.

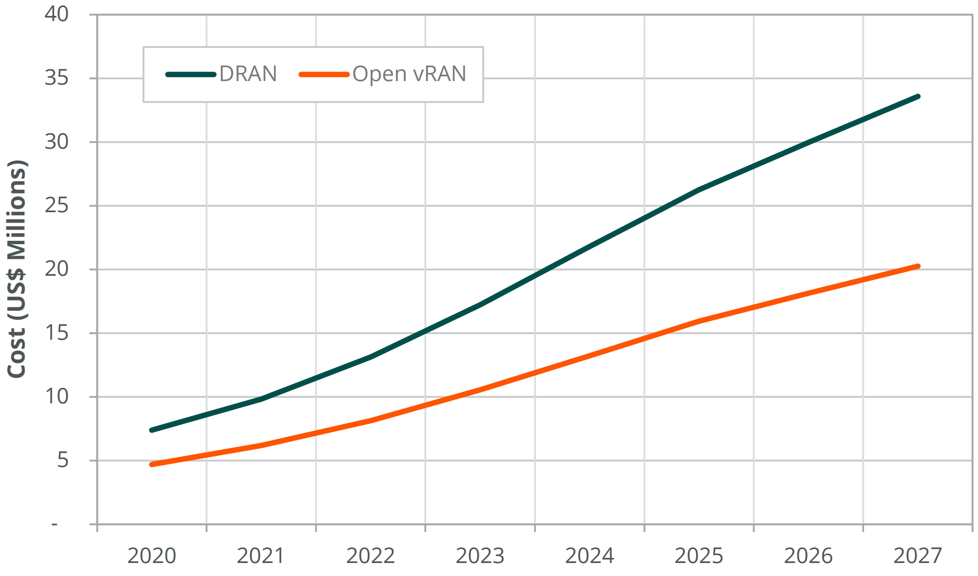
The power ratings used throughout this study have been collected from public, formal data sheets from DRAN vendors. The DRAN BBUs used in this study are also the most popular BBU units used for 5G throughout the world.

POWER CONSUMPTION RESULTS

The assumptions listed in the previous sections allow the power consumption calculation for the entire network. Figure 4 compares the energy consumed per year for DRAN and Open vRAN, assuming that the wholesale energy price in the market ABI Research is considering costs US$400/Megawatt Hour (MWh).

Figure 4: ***DRAN versus Open vRAN Annual Energy OPEX Forecasts Assumptions: Open vRAN 40% Centralized DU and DRAN Vendor 1 BBU***

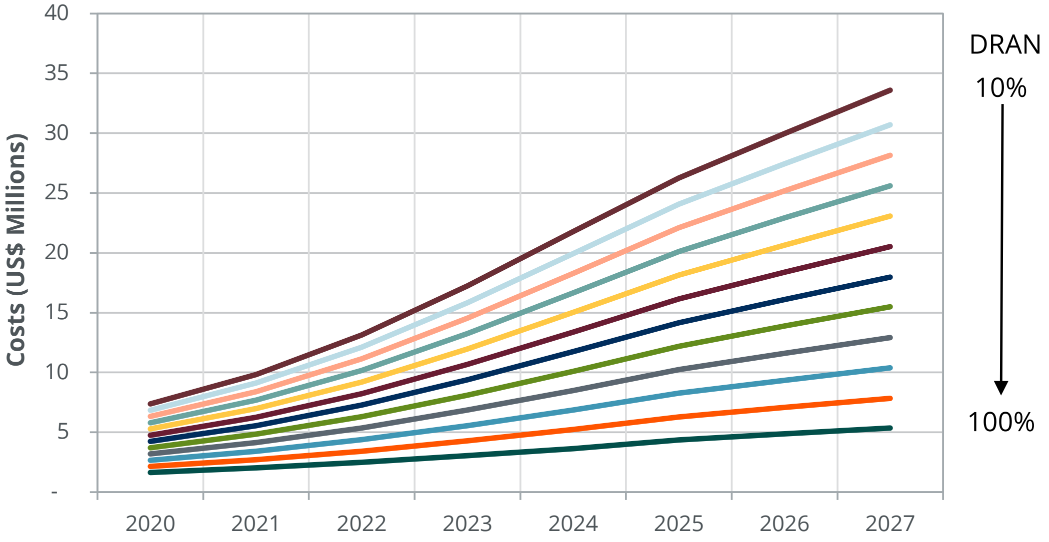
(Source: ABI Research)



The difference in power consumption between two different deployment options appears due to elements of the BBU being split into CU and DU, and the CU being centralized in core locations. This means that even when DU is fully distributed at cell sites, a percentage of this "distributed" energy is centralized and pooled to a central location, and consumed by fewer, more powerful units. This leads to nominal energy savings, which is accentuated when parts of the DU are centralized to a central office or aggregation point. Figure 5 illustrates energy savings with respect to DU centralization.

Figure 5: DRAN versus Open vRAN Annual Energy OPEX Forecasts versus DU Centralization (%)
Assumption: DRAN vendor 1 BBU

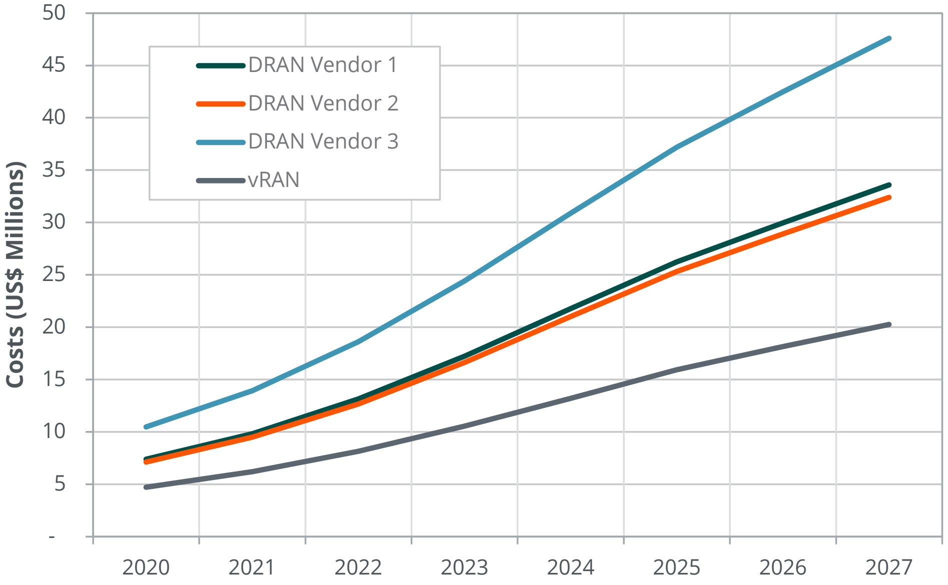
(Source: ABI Research)



Centralizing the DU has a significant effect on power consumption, which reduces to a fraction of the DRAN value. In many cases, centralizing the DU completely may not be possible due to backhaul/fronthaul or other constraints, but ABI Research's model indicates that there are significant savings to be achieved with vRAN, even when considering the baseband processing alone. Figure 6 illustrates the results for multiple DRAN vendors, according to their public data sheets and power consumption details.

Figure 6: Multiple DRAN Vendor versus Open vRAN Energy OPEX
Assumption: 40% DU Centralized

(Source: ABI Research)



It is also possible to model other countries, including the United States and India. In ABI Research's model, the average cost of MWh is as high as US$1,000 in the US,[1] while the average cost for India is US$200, which will be a very conservative estimate if off-grid installations are considered, which often rely on diesel for powering equipment. Figure 7 illustrates the model results for Germany, the United States, and India.

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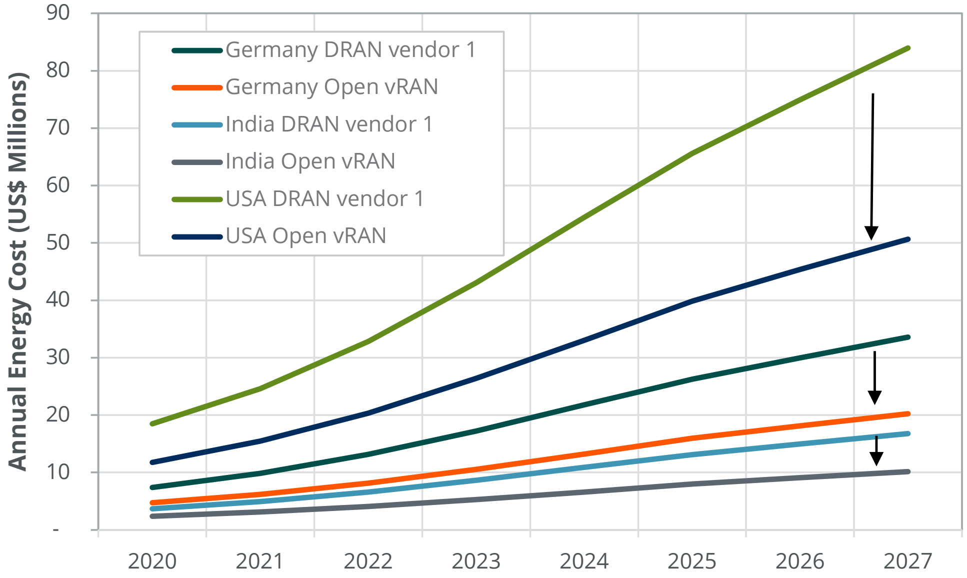
[1] https://www.eia.gov/electricity/monthly/update/wholesale-markets.php

Figure 7: *DRAN versus Open vRAN Annual Energy OPEX Forecasts for Germany, the United States, and India*
Assumptions: Open vRAN 40% Centralized DU and DRAN Vendor 1 BBU

(Source: ABI Research)

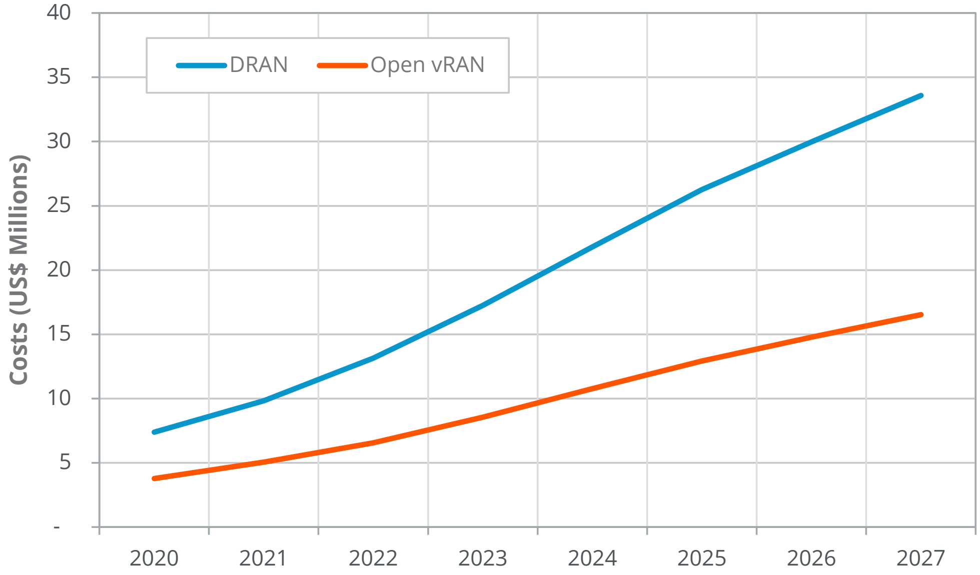


MODELING 32T32R MMIMO

All previous cases have been modeled with 64T64R mMIMO, the highest end for 5G networks today. If we model 32T32R and place lower capacity requirements in the model, then the results are even better for Open vRAN, as shown in Figure 8.

Figure 8: *DRAN versus Open vRAN Annual Energy OPEX Forecasts—32T32R*
Assumptions: Open vRAN 40% Centralized DU and DRAN Vendor 1 BBU

(Source: ABI Research)



The difference in energy usage is wider between DRAN and Open vRAN due to the necessity to have a BBU at every cell site for the DRAN case, but not for Open vRAN, which allows DUs to be centralized. The further centralization—and lower overall DU capacity requirement—presents an even more lucrative use case for Open vRAN. Furthermore, as capacity requirements lower, such as with 8T8R, then Open vRAN benefits continue to increase, as further DU centralization is possible.

QUALITATIVE ANALYSIS OF FURTHER ENERGY SAVINGS

The analysis and modeling presented above illustrates the minimum power saving that can be expected when considering Open vRAN. The scenarios selected above represent the most aggressive capacity and traffic cases, where 64T64R mMIMO radios are considered for dense urban areas. In reality, 5G networks will also consist of 32T32R and even lower MIMO configurations for lower frequencies (e.g., T-Mobile US has deployed 5G at 600 Megahertz (MHz)). In these cases, the benefit of Open vRAN is even higher, because fewer DUs will be necessary at the cell site. Moreover, 32T32R deployments are more relaxed in terms of fronthaul/midhaul, meaning that the centralization of a DU is more favorable, leading to additional cost and energy savings. In cases where coverage is the only driver for the deployment and capacity is a secondary concern, Open vRAN will excel even further.

Furthermore, in DRAN and by default, the RRU consumes more energy compared to vRAN, because physical layer processing, which is computationally intensive and power-hungry, is implemented in these units. On the other hand, Open vRAN splits this functionality and the high parts of the physical layer (High-PHY) and even parts of the lower physical layer (Low-PHY) are implemented in a DU and even pooled. This creates a significant energy saving, which scales further with centralization of the DU.

Nevertheless, the promise of Open vRAN is much more than the scenario ABI Research has modeled, especially when considering the application of RIC and SMO. All Tier One infrastructure vendors offer similar functionality, in the form of centralized or distributed SON capabilities, but RIC promises to open this innovation to third parties and attract interest, talent, and developers previously not reachable in the telco domain.

This is an important consideration because 75% to 80% of power consumption takes place in the radio network, namely the RRU. The importance of RIC and Open vRAN is even higher, because xApps and rApps can optimize the radio even further, as illustrated by use cases in Section 5.

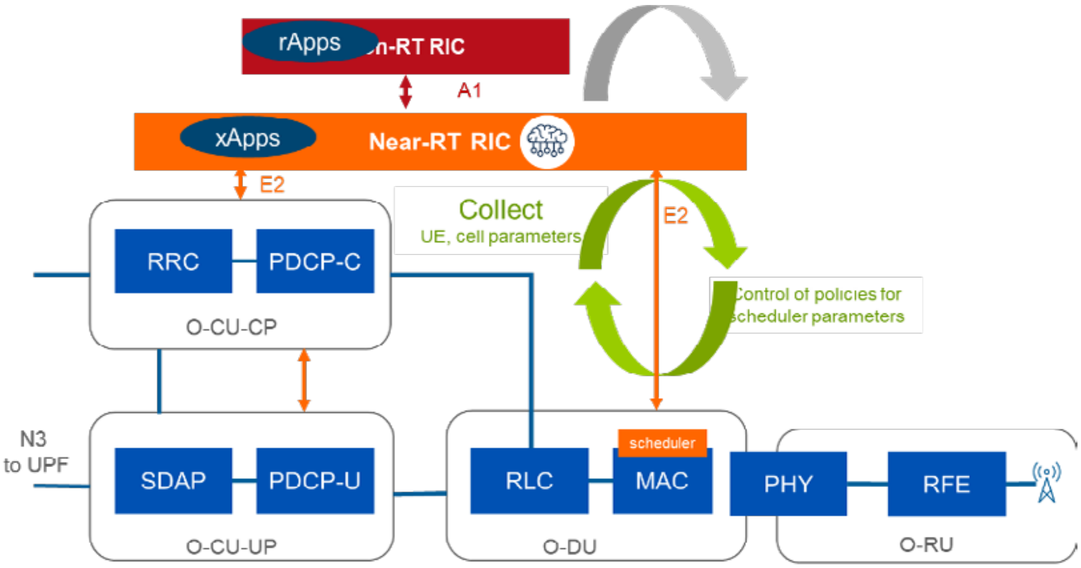
Energy savings have, in fact, become the most important driver for RIC the past year, driven by the energy crisis and the ongoing sustainability drive that many mobile operators are now prioritizing. The following section presents more information about the Open vRAN architecture and how RIC can lead to superior network performance and lower energy consumption.

OPEN RAN ARCHITECTURE

The O-RAN Alliance defines the RAN architecture with a focus on open interfaces between the logical nodes and physical partitions of the RAN functions. The Open RAN architecture, shown in Figure 9, supports two RICs that perform management and control of the network at near-Real Time (RT), response time to control loop actions is >10 Millisecond (ms) and <1 Second (sec)), and non-RT response time to control loop actions is >1 sec) time scales. These entities house xApps and rApps, respectively, that permit closed-loop optimization based on operator-driven intent, and data collected from the network. The 3rd Generation Partnership Project (3GPP) and the O-RAN Alliance are defining advanced energy efficiency measures that are expected to make Open RAN products even more energy efficient.

Figure 9: Open RAN Architecture with RIC Platforms

(Source: ABI Research)



OPEN RAN AND RIC SUPPORT FOR POWER-EFFICIENT IMPLEMENTATIONS

RICs in an Open RAN system can help optimize energy efficiency and performance across the entire operator network. The xApps and rApps executing in the near-RT RIC and non-RT RIC, respectively, leverage AI/ML techniques to implement energy savings use cases. Application telemetry for many of these use cases include dynamic resource and network performance information from the RAN stack, including L1. The Key Performance Indicators (KPIs) and resource information may be at the antenna level, cell level, or user level.

Minimizing 5G energy consumption is an end-to-end network problem, which highly depends on complex base station and User Equipment (UE) distributions, varying traffic demands, and wireless channels, as well as hidden network trade-offs. Therefore, understanding and predicting UE behavior and service requirements over time are critical to optimizing the network operation and configuration of mMIMO, RF carriers, sleep modes, etc. The current trend is to replace rule-based heuristics and associated thresholds with optimal parameters configured through the knowledge acquired by ML models, for example.

Given the dynamic nature of wireless networks, and lack of network measurements for all network procedures in all possible configurations, Reinforcement Learning (RL) is being widely explored to optimize

5G network performance and energy efficiency. Shutting down network elements is a combinatorial problem with several variables. RL agents may be used to let the network interact with the environment and learn optimum resource shutdown policies to minimize the total network energy consumption.

> *Recent trials in live networks have shown that a non-RT RIC rApp for switching radios on and off can provide as high as 15% to 20% in non-ideal conditions, even when the interface between radios, RIC, and other parts of the network is not ideal. In the future, multiple energy-saving applications may be running on RICs, meaning that significant energy savings are to be expected.*

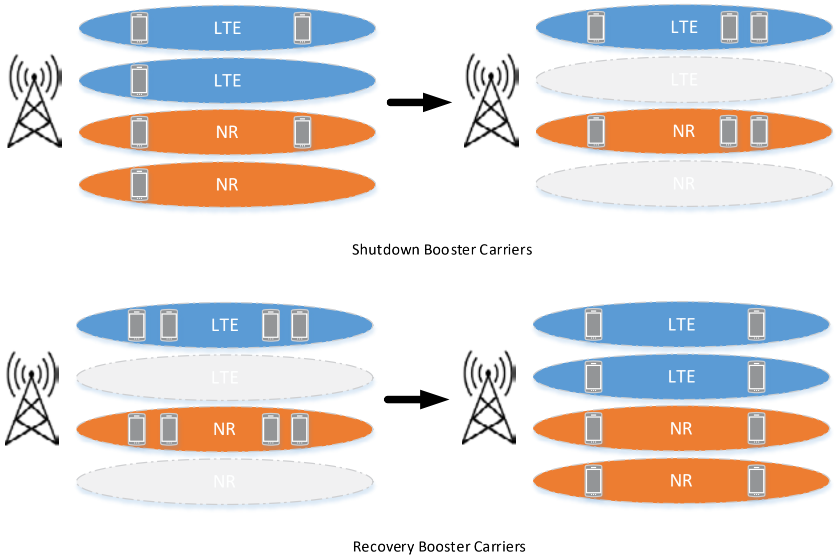
The application of RIC to optimize energy and exploit energy savings opportunities are addressed next.

CARRIER MANAGEMENT (RF CARRIER ACTIVATION/DEACTIVATION) AND CELL ZOOMING

To improve system-level energy efficiency with a multi-carrier system, the number of active RF carriers must be dynamically managed. When the load of the entire base station is low during off-peak hours, the BS energy consumption can be reduced by moving UE from lightly loaded cells onto other cells with similar coverage. These cells can absorb the slight increase in traffic without impacting user experience, and the offloaded cells can be shut down as indicated in Figure 10. Likewise, as congestion in a cell grows due to a sudden surge in traffic, new cells can be powered on, and traffic can be load-balanced across all the cells to help improve user experience across all the cells.

Figure 10: RF Carrier Shutdown

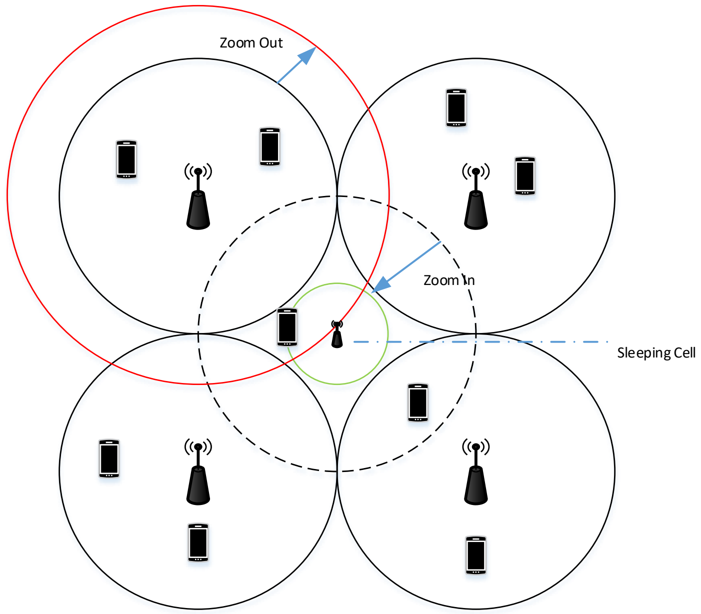
(Source: ABI Research)



A different approach to inter-BS energy savings is cell zooming. It adapts the transmission power by reducing the cell coverage of lightly loaded cells, while simultaneously increasing the area covered by neighboring cells, shown in Figure 11. When using this mechanism, the network topology changes should be carefully handled to avoid service outage. A data-driven approach may be used to optimize the cell zooming mechanism.

Figure 11: Cell Zooming Procedure

(Source: ABI Research)



The RF carrier shutdown feature (typically hosted by the SMO and non-RT RIC in an Open RAN architecture) periodically checks the service load of multiple carriers, and if the service load is below a specified threshold, the capacity-layers are shut off, as shown in Figure 11. The UE served by those carriers can camp on or access the services from the carrier providing basic coverage. When the load of the carrier providing basic coverage is higher than a specified threshold, the base station turns on the carriers that have been shut down for service provisioning. When shutting down a carrier, it is important to ensure that basic coverage is maintained.

RF carriers can be shut down by non-RT RIC rApps more intelligently using information from telemetry data from an E2 interface with Open RAN, as shown in Figure 9. The information from the E2 is available by default with Open RAN systems and would not typically be made available in a SON/non-RT RIC deployment. Additional information from these data may permit more opportunities for shutdowns, and over more granular time scales with minimal impact to the user experience.

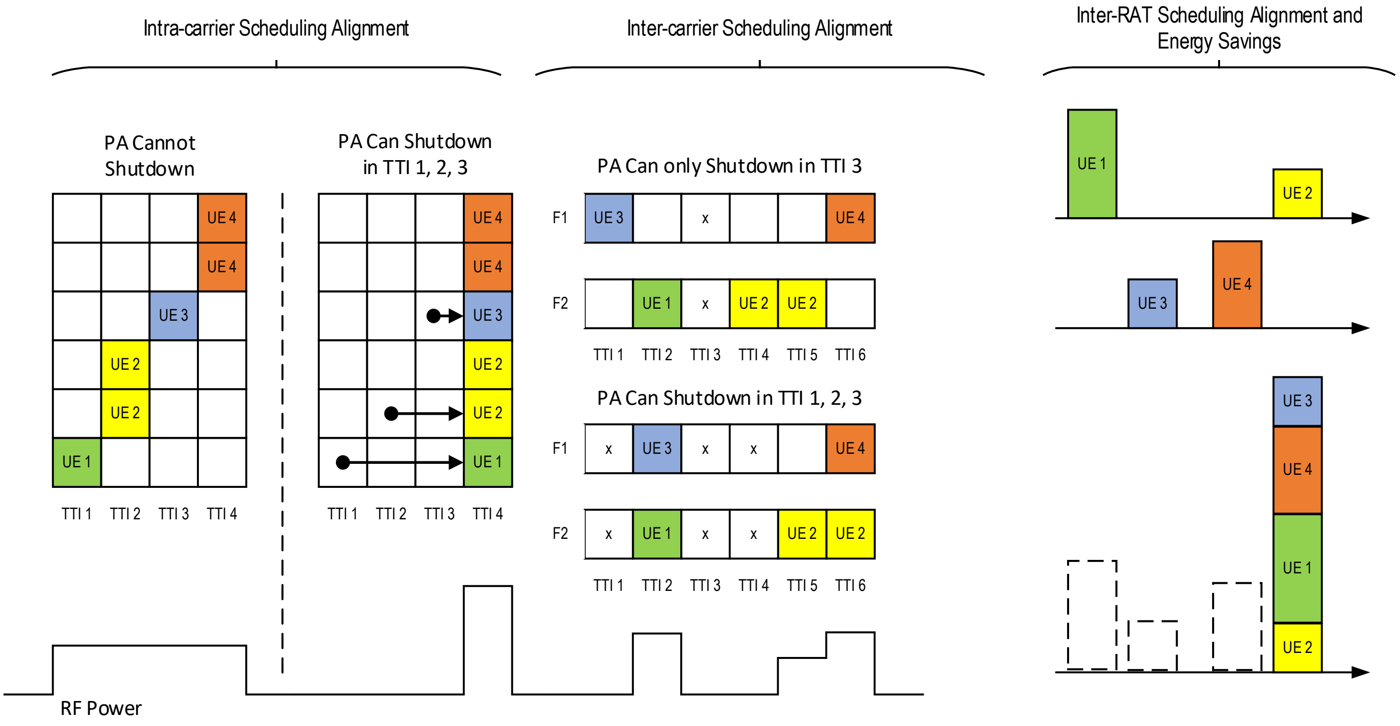
Additionally, Open RAN can provide more differentiation versus non-Open RAN through access to additional data that provide valuable insights about the RAN and the UE performance.

INTELLIGENT SCHEDULING OF UE

To ensure that the RU Power Amplifiers (PAs) can shut down in low-load conditions, the DU scheduler must take certain considerations into account when scheduling the active UE in a cell. To prolong the PA shutdown duration, the UE should be grouped and scheduled intelligently to allow more consecutive blank Transition Time Intervals (TTIs).

Figure 12: Intelligent Scheduling to Allow Longer PA Shutdown

(Source: ABI Research)



With Open RAN, AI/ML-based scheduling algorithms may be trained and adopted to optimize radio resource allocation and power saving in a DU based on instantaneous or statistical network conditions. Furthermore, near-RT RIC can provide energy savings guidance to- the DU based on an overall view of the radio network to optimize resource utilization and power consumption.

Open RAN xApps can further optimize energy efficiency on the DU compared to non-Open RAN solutions using AI/ML-based scheduling algorithms that use RAN data from a single DU and from across a cluster of DUs, and use those data to make predictions of different variables. This permits more opportunities for power savings.

CONCLUSIONS AND RECOMMENDATIONS

The study and modeling performed in this project have illustrated that not only is Open vRAN more power efficient in the baseband processing domain, but it can really save on energy costs for operators with dense mMIMO deployments, which are the pinnacle deployment technology now in the cellular industry. In addition to the energy savings presented in this paper, Open vRAN will introduce further improvements and new types of innovation that will also contribute to energy savings and better performing networks in the long term.

The energy savings presented in this paper are mainly achieved through two main areas:

1) Centralization of the CU and the DU removes significant power requirements at the cell site. In this study, only the CU/DU power consumption was modeled, but other parameters will also contribute to energy savings, including the need for fewer appliances at the cell site. Moreover, real estate costs may also decrease, due to the same reason. Centralization of the DU has resulted in major cost savings in the model compiled for this study, which may further improve if renewable energy or other means to improve carbon efficiency are used at the centralized location. This is in addition to creating an infrastructure that actually meets the 5G low latency requirements, with densification of sites and maintaining a cost profile probably much more accessible to operators.

2) Open vRAN uses IT servers, which have been used also in this study. These servers have been optimized in terms of performance, power consumption, and many other factors through several iterations in the IT domain. This translates to energy savings, even if assuming 0% centralization of the DU. Moreover, mobile operators that choose to deploy vRAN will have more choice in terms of CU/DU servers, meaning that additional savings can be possible through further optimization.

ABI Research recommends that mobile operators consider Open vRAN for their 5G network rollouts, especially for new sites that have yet to receive 5G upgrades. Our modelling exercise illustrates that, even developed markets in Western Europe still have years of deployment until 5G is deployed nationwide, even for urban areas. This is where Open vRAN can excel and create significant power savings, with the promise of further improvements and benefits when RIC is introduced.

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