Activity 14: Development of Database & Reporting

Activity 14.3: Database design, development, maintenance and reporting for 2023

Document by:

ARM
AIR RESOURCE MANAGEMENT

Final Report

28th March 2024

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TABLE OF CONTENTS

TABLE OF FIGURES

EXECUTIVE SUMMARY

In accordance with the scope of work, for Activity 14: Development for Database Reporting, ARM must establish and maintain a project database for all the air quality and survey information, implementation information that is required to interpret the air quality results (to be provided by the local project management offices), for all the project documentation and reports and any other documentation of relevance to the project.

ARM developed a Management Information System (MIS) to ensure that all project data and data visualisations are centrally warehoused in a secure and highly available environment. The MIS contains the following elements: a front-end User Interface; a Business Intelligence (BI) reporting layer, and a file storage repository for all project-related reports.

This system consists of a front-end application that routes users to a Power BI Dashboard where users can view key project metrics related to 3 sites, namely: Kwazamokuhle, Sharpeville and Ezamokuhle. Additionally, a visualisation function has been included wherein an interactive map shows the status of the Eskom AQO interventions as well as household coal stove use. A cloud-based document repository was created for all project-related documents to be uploaded. The entire MIS solution is cloud-based which provides extensive security and guards against data loss through *force majeure* events. This has the benefit of leveraging the cloud provider's resources in terms of IT security ($1Bn spent on cybersecurity annually) to ensure that the sensitive information stored in the database and displayed on the front-end would not fall prey to cyber-attacks.

Its envisioned that the MIS system will be utilised as the central database & reporting platform for Eskom's upcoming Phase 2 and 3 AQO Offset Projects.

1. BACKGROUND

1.1 Air Quality Offsets Guideline

An environmental offset is an action(s), designed to compensate for a negative environmental impact of resource use, a discharge, emission or other activity. The Department of Forestry, Fisheries and the Environment (DFFE) defines air emissions offsets as an intervention, or interventions, specifically implemented to counterbalance the adverse and residual environmental impact of atmospheric emissions in order to deliver a net ambient air quality benefit within, but not limited to, the affected airshed where ambient air quality standards are being or have the potential to be exceeded and whereby opportunities and need for offsetting exist (Notice 333 of 2016).

1.2 ESKOM'S Approach to Air Quality Offsets

DEFF's Air Quality Offset Guideline has shaped and informed Eskom's Air Quality Offsets Implementation Plan. This Plan has been based on a scientific process of feasibility studies, testing and demonstration, and on consultation with key stakeholders. Figure 1 illustrates the concept schedule for the phased implementation of Eskom's air quality offsets.

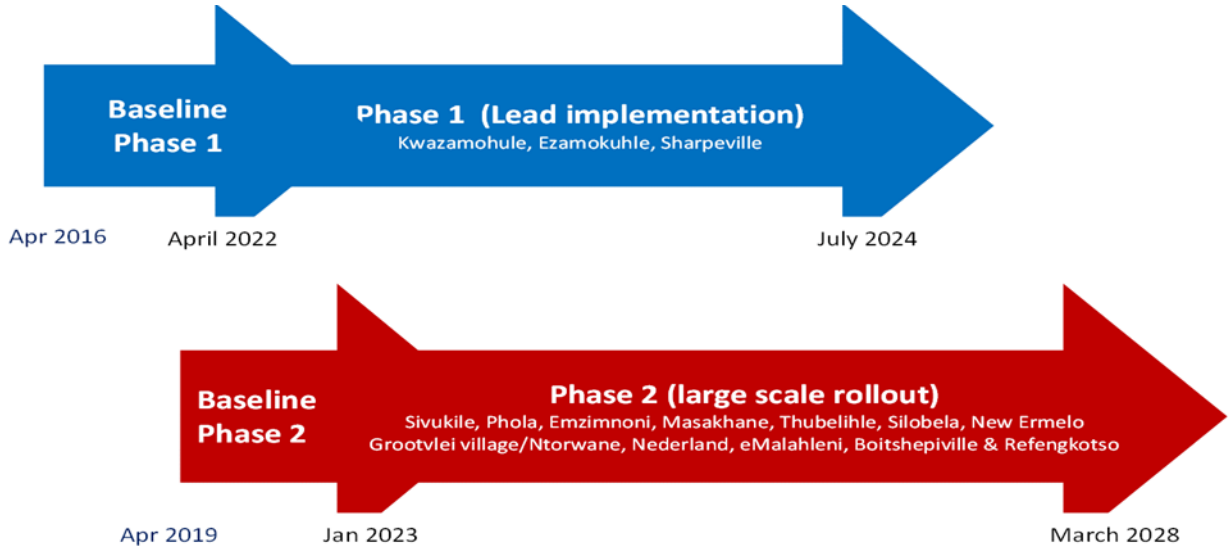
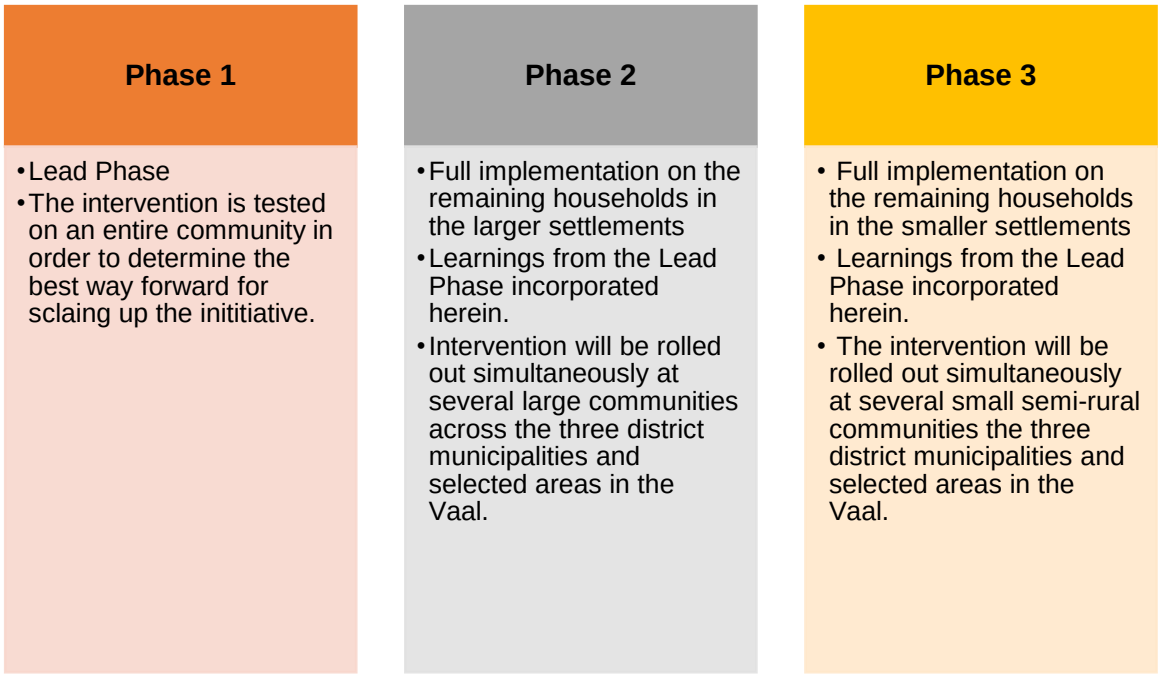


Figure 1: Concept Schedule for the implementation of Eskom's air quality offsets (Matimolane, 2023)

Eskom has adopted the phased approach (Figure 2) herein to increase the probability of success and to ensure that learnings from early phases are incorporated into the large-scale roll-out. (Matimolane, 2020).

Figure 2: Eskom's Phased approach to the rollout of air quality offset interventions (Matimolane, 2020)



Eskom's air quality offsets programme is designed to reduce human exposure to harmful levels of air pollution by reducing emissions from local sources, like domestic coal burning and waste burning. Thus, air quality offsets can improve ambient air quality in low-income communities in the vicinity of Eskom's power stations. Eskom has developed air quality offset (AQO) implementation plans for three district municipalities; Nkangala, Gert Sibande, and Fezile Dabi.

1.3 ESKOM'S PLANNING, MONITORING AND VERIFICATION (PMV) PROJECT

For Eskom's phase one of the PMV Project, interventions to reduce household emissions from domestic coal/wood burning will be rolled out in KwaZamokuhle, Ezamokuhle and Sharpeville in the Mpumalanga Highveld. For formal dwellings the intervention will be a thermal insulation retrofit and an electricity starter pack and installation. The intervention

for informal dwellings still needs to be selected and tested. Waste intervention solutions have been identified and implemented in Sharpeville, Gauteng. Since domestic coal burning is less prevalent in Sharpeville, it is expected that a community-scale intervention, like reducing waste burning, will be more suitable there.

Air Resource Management (ARM) (Pty) Ltd has been appointed by Eskom to support the PMV services in support of the *Phase 1: Lead implementation* at: KwaZamokuhle; Ezamokuhle and Sharpeville. Its ARM (Pty) Ltd understanding that the overall objective *Lead Implementation Phase* is to benefit the specific local communities, minimize implementation risk, increase practical and scientific knowledge, and develop and refine monitoring, reporting and verifications processes. To achieve this, Eskom has included sixteen targeted work package Activities (Table 1) for these respective communities. This report focuses on Activity 14 "*Development of Database Reporting*" for Ezamokuhle, KwaZamokuhle and Sharpeville.

Table 1: Eskom PMV Activity Schedule (Eskom PMV NEC Contract,27082020)

Activities	Kwazamokuhle	Ezamokuhle	Sharpeville
Activity 1: Preliminary air quality assessment		✓	
Activity 2: Gather Area intelligence		✓	
Activity 3: Rapid in situ assessment		✓	
Activity 4: Obtain ethical clearance		✓	
Activity 5: Census	✓	✓	✓
Activity 6: Community source survey		✓	
Activity 7: Fuel source survey		✓	
Activity 8: Household surveys		✓	
Activity 9: Annual (household/community) surveys and monitoring of project effectiveness	✓	✓	✓
Activity 10: Ambient air quality monitoring	✓	✓	✓
Activity 11: Conduct indoor air quality monitoring	✓	✓	
Activity 12: Atmospheric Dispersion Model	✓	✓	✓
Activity 13: Design of Intervention		✓	✓
Activity 14: Development of Database Reporting	✓	✓	✓
Activity 15: Strategic Assistance and offsets methodology	✓	✓	✓
Activity 16: Research and Development	✓	✓	✓

1.4 Scope of Work

In accordance with the scope of work, for Activity 14: Development for Database Reporting, ARM must establish and maintain a project database for all the air quality and survey information, implementation information that is required to interpret the air quality results (to be provided by the local project management offices), for all the project documentation and reports and any other documentation of relevance to the project. Eskom shall be trained on the use of the project database, and the database shall be accessible to Eskom for the duration of the project. The database shall be handed over to Eskom at the end of the contract.

2. METHODOLOGY

2.1 Design and Build

The design approach entailed an extensive requirements-gathering phase in order to define the scope of the project. Once the scope was defined, the team conducted research into the best technology solutions that would ensure that the system was secure, robust and highly available.

Thus, a decision was taken to develop the solution in a cloud-based environment. This has the benefit of leveraging the cloud provider's resources in terms of IT security ($1Bn spent on cybersecurity annually) to ensure that the sensitive information stored in the database and displayed on the front-end would not fall prey to cyber-attacks. Further, cloud providers ensure that data is replicated across several regions – this ensures that if a particular data centre is affected by a *force majeure* event, copies of the data are still kept at other international locations. Thus, a user centric approach was used to design a database & reporting custom-tailored application for Eskom's AQO Project that is both secure and highly available (Figure 3 & Figure 4).

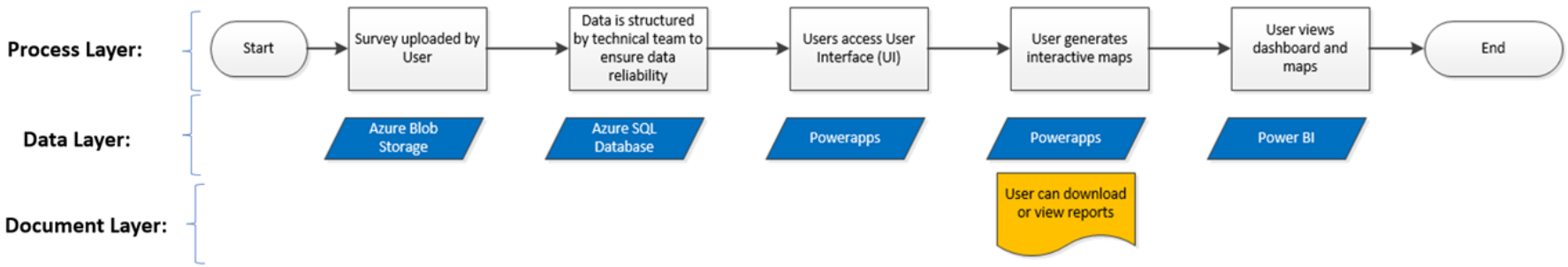


Figure 3: User Interactions with Information System

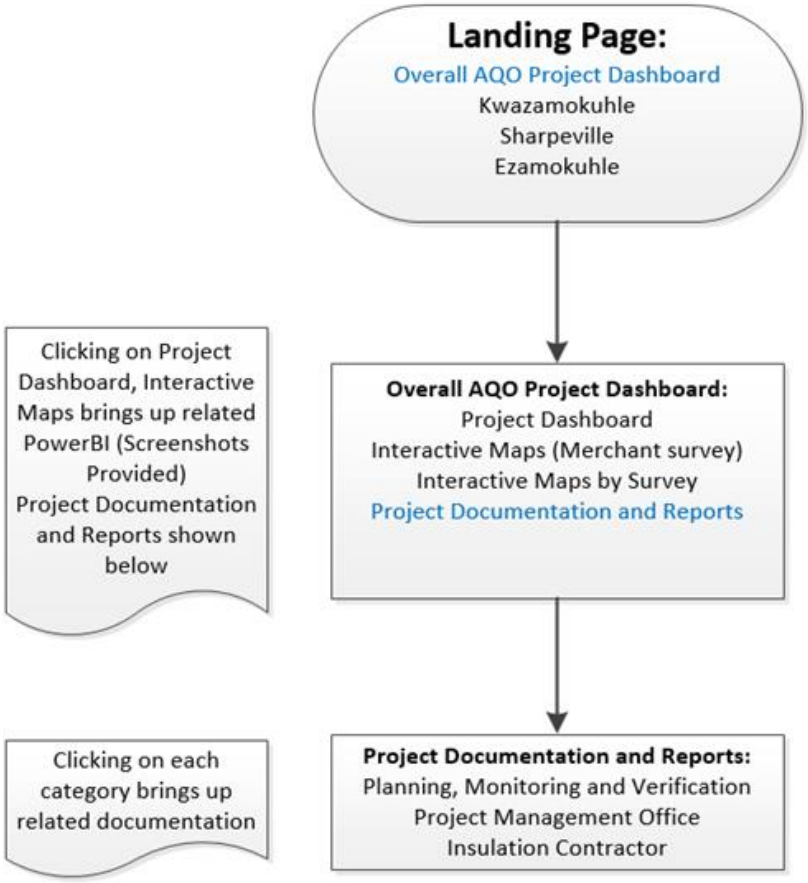


Figure 4: Front End App Design

2.2 AZURE

Azure is Microsoft's cloud computing platform. It provides a broad range of cloud services, including compute, analytics, storage and networking. Users can pick and choose from these services to develop and scale new applications or run existing applications in the public cloud. Further details herein are contained in Annexure 1. The database was developed in Azure.

The ARM subscription was set up in Azure Portal and user roles were added to the subscription (Figure 5). A Resource Group was then created to house all the resources

needed for the project, namely Azure SQL Server, PowerApps and Azure Blob Storage (Figure 6 & Figure 7).

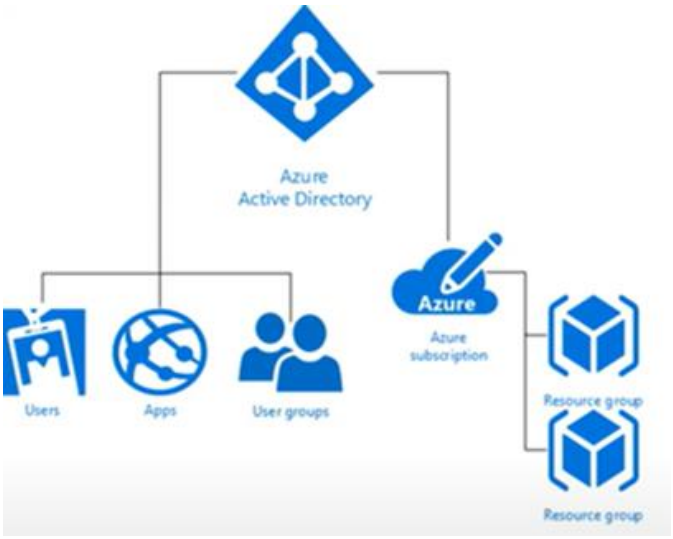


Figure 5: Azure Portal

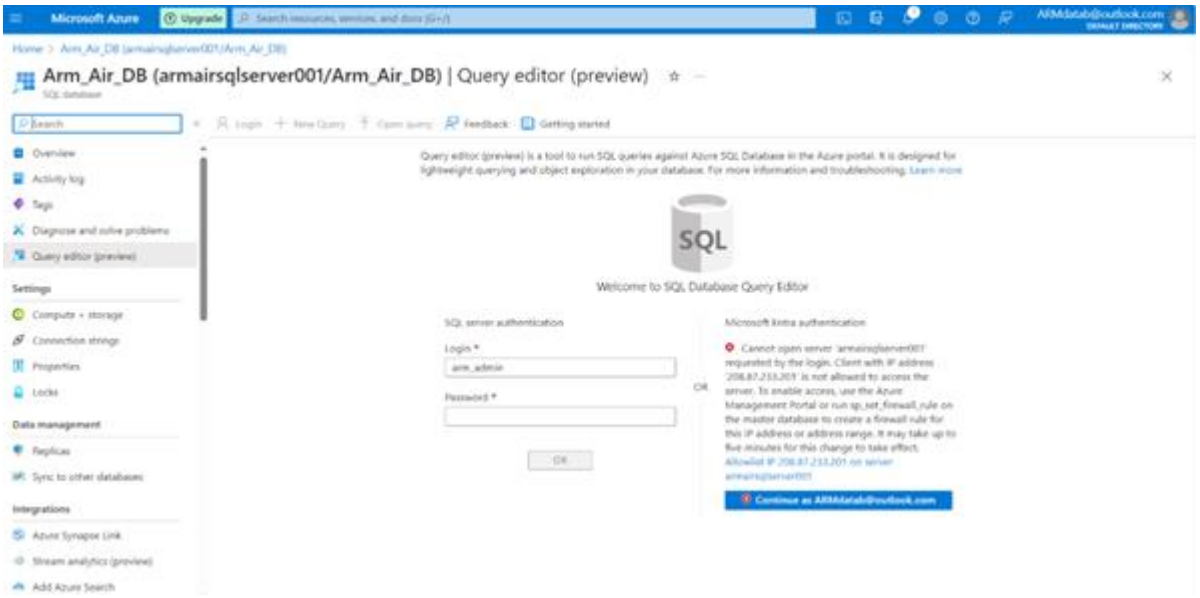


Figure 6: Azure ARM SQL Server Query Editor

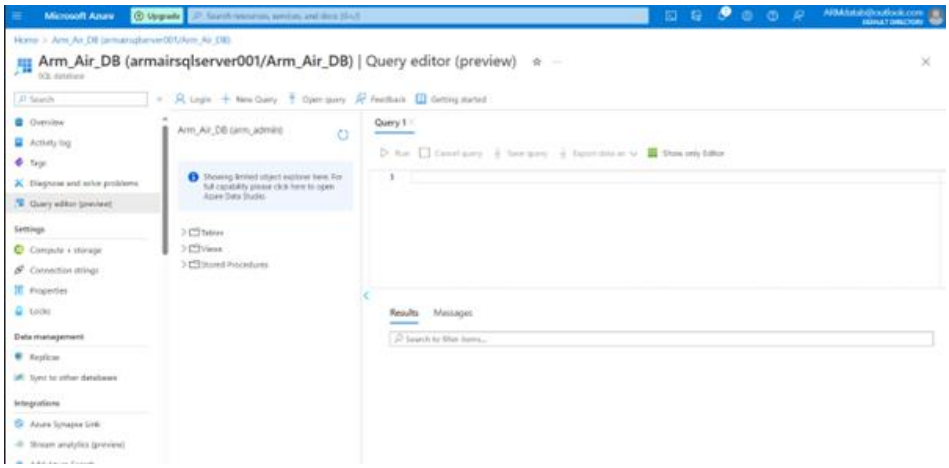


Figure 7: Azure ARM SQL Database Structure

2.2.1 Azure SQL Database Build

Based on the project requirements, front-end design and required BI metrics, a data structure was created SQL – these reflected the survey data from all 3 sites. A structured data set is required for Power BI and PowerApps.

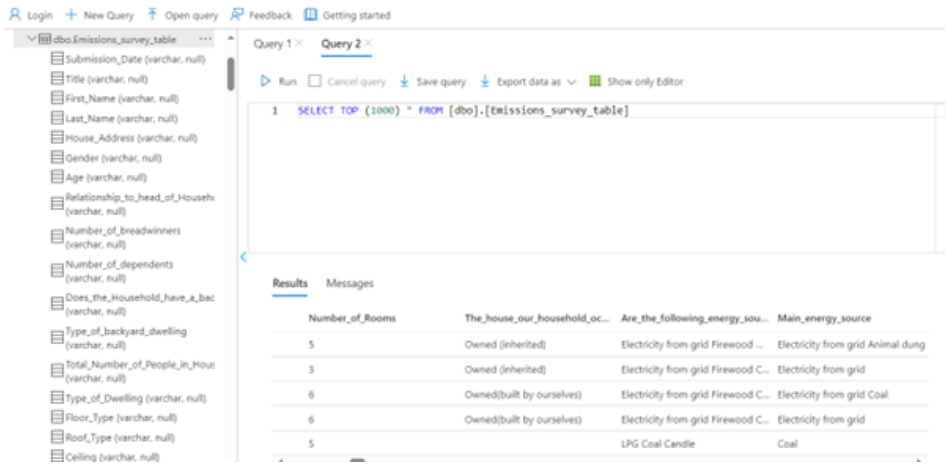


Figure 8: SQL Table Structure

In terms of security, the Azure Security Centre can be consulted to check the health of all resources. Should security concerns be noted, Azure provides recommendations on addressing these. Screenshots below show the SQL Server resource as well as the Azure Security Centre (Figure 9).

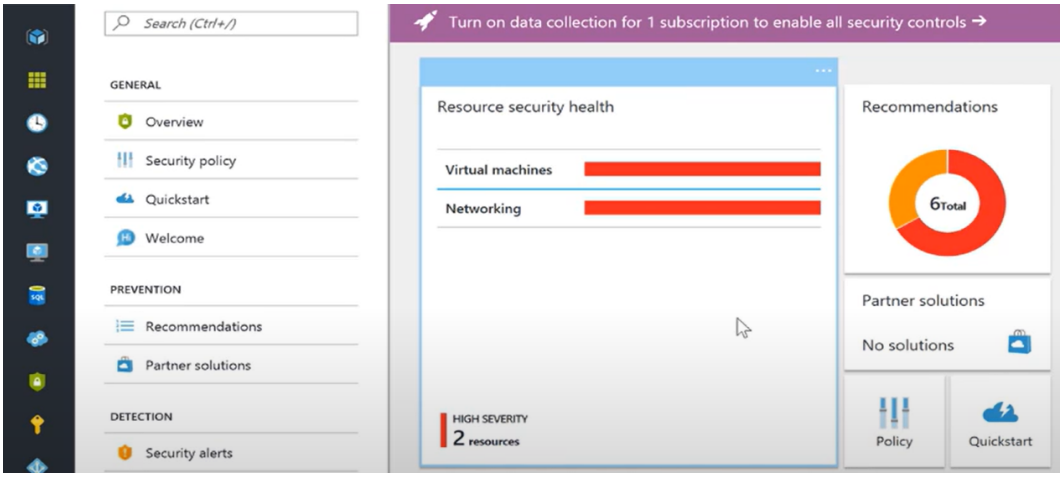


Figure 9: Azure Security Centre

2.3 Microsoft Power Platform Build

The Microsoft Power Platform is a suite of apps, services, and connectors, as well as a data platform, that provides a rapid development environment to build custom apps. It features an intuitive visual design and drag-and-drop functionality that allows teams to rapidly develop Apps and Workflow tools for their businesses.

It comprises the following elements:

- Power BI – unified self-service and enterprise analytics solution that lets you visualize your data and share insights across the organization or embed them in your app. It can be used to quick unlock business insights.

- Powerapps – provides a low-code approach to rapidly build apps for any device
- Power Automate – no code automation platform that allows for rapid automation initiatives.

ARM has developed the system in Power Platform. Below are the PowerApp front end flow as well as the Power BI Dashboard and Interactive Maps for the AQO Project.

Figure 10 illustrates the landing page. Users have the option to select the Overall Dashboard or the Dashboards relating to a specific site.

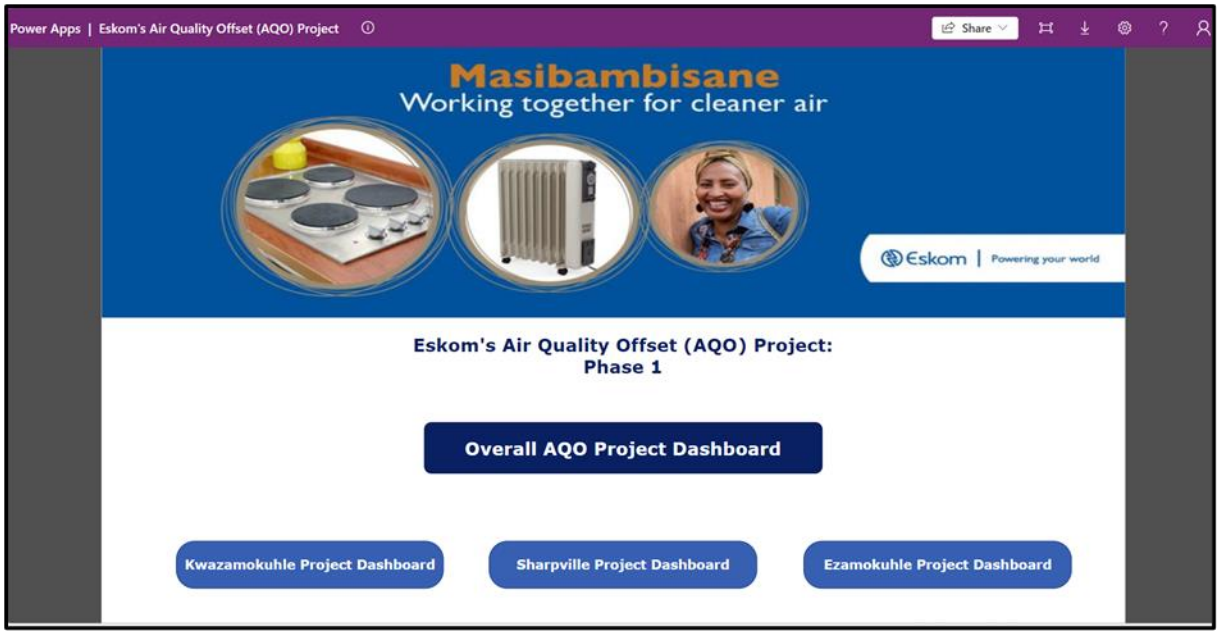


Figure 10: Landing Page of Application

Once a selection is made, the user has the option to select the dashboard, interactive maps or the project repository (Figure 11).

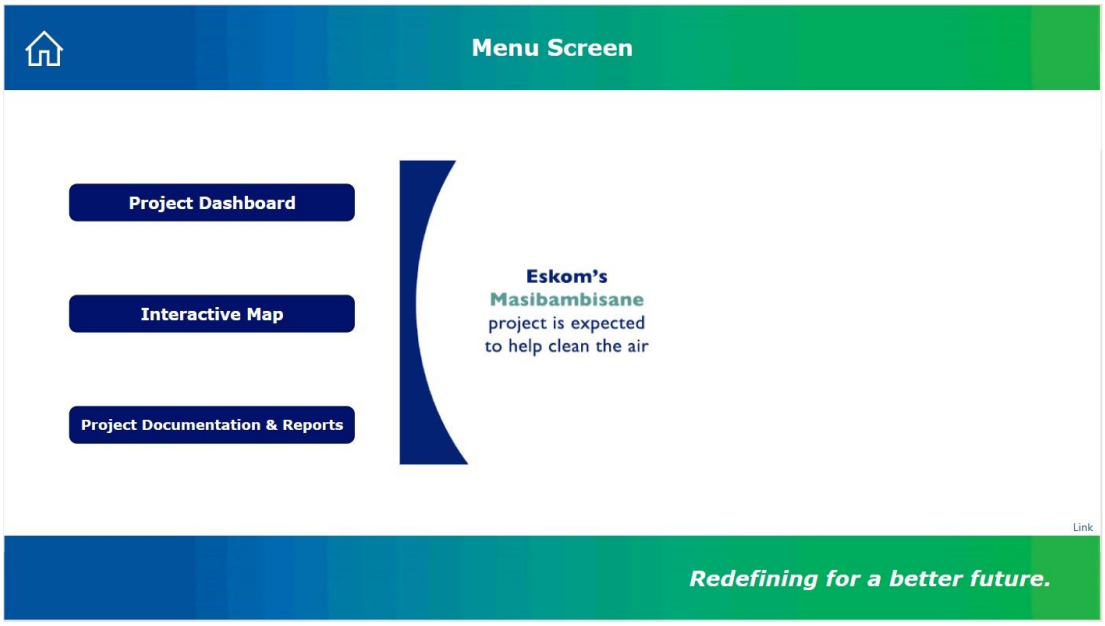


Figure 11: Menu Screen Options

When the Overall AQO Project Dashboard is selected, the user has an overview of the rolled-up key metrics (Figure 12).

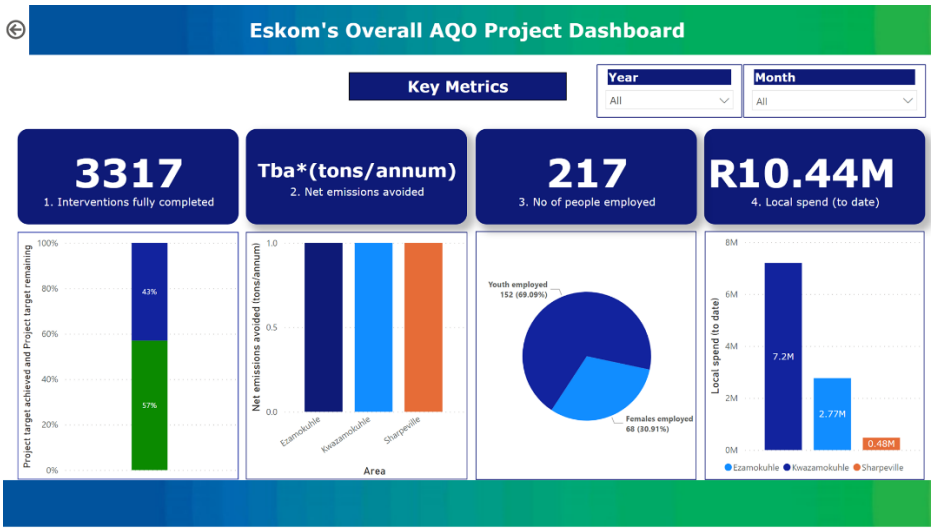


Figure 12: Overall AQO Project Dashboard View

Similarly, the user can select site-specific metrics, as shown below (Figure 13 to Figure 15).

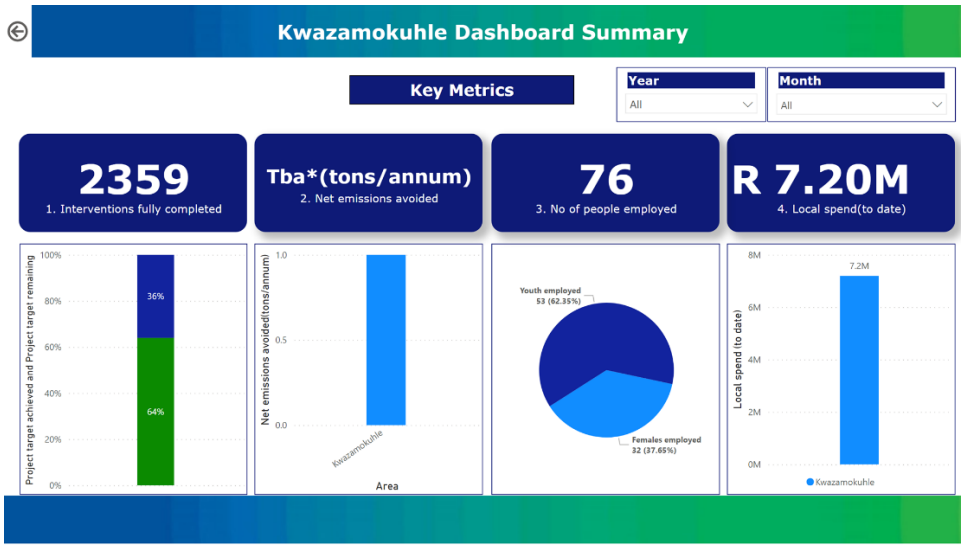


Figure 13: Kwazamokuhle Dashboard Summary

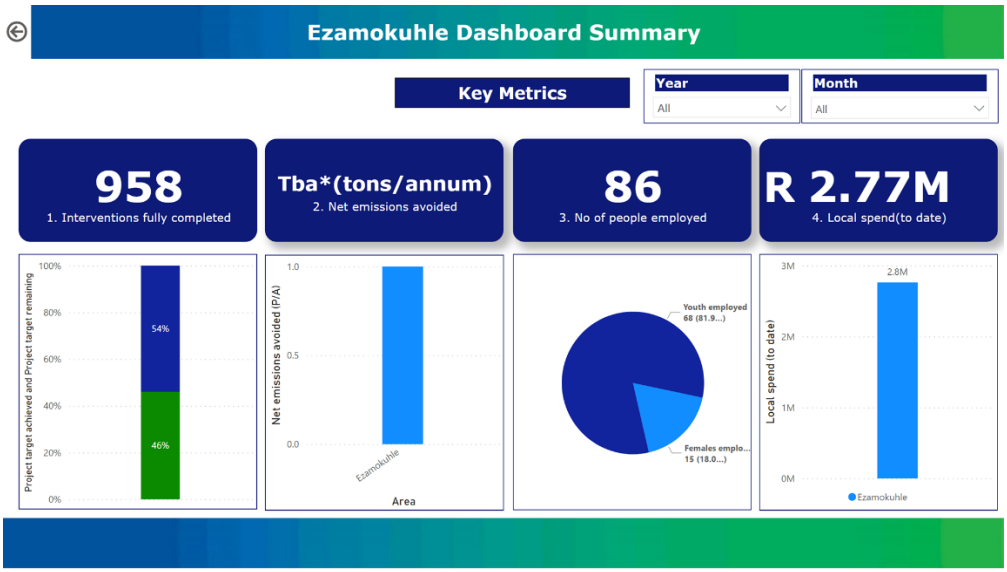


Figure 14: Ezamokuhle Dashboard Summary

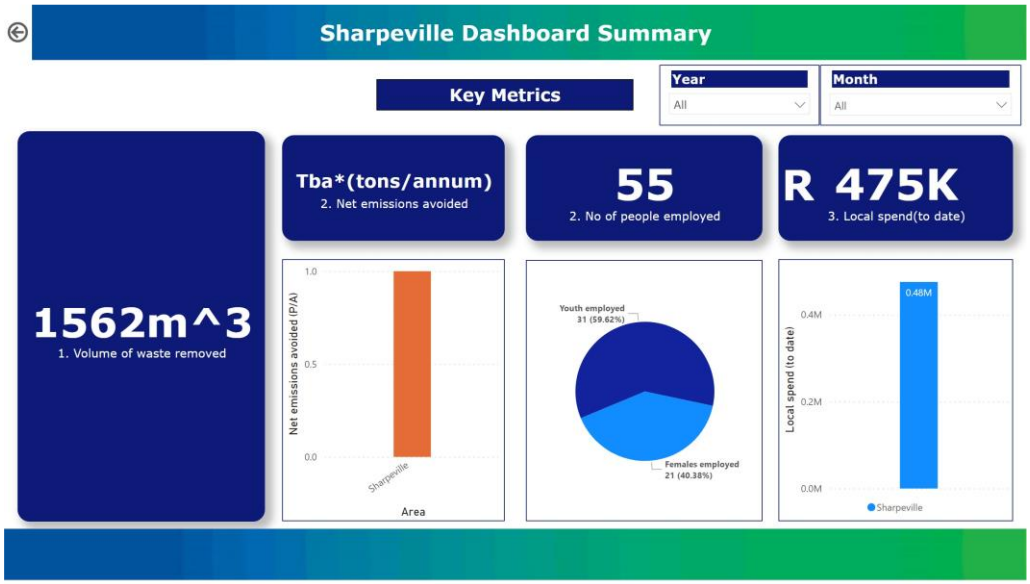


Figure 15: Sharpeville Dashboard Summary

Additionally, an interactive map has been developed to view the status of the project intervention for an area (Figure 16).

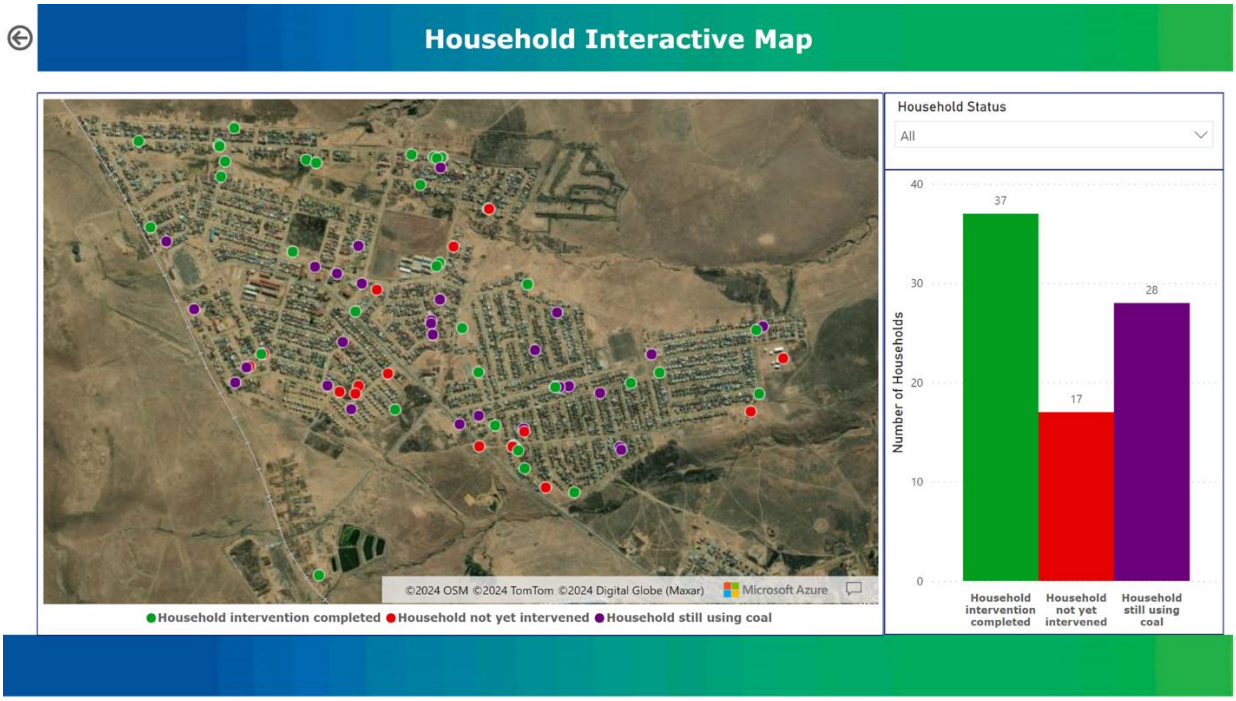


Figure 16: Household intervention status

Should the user select “Project Documentation and Reports”, the user will have the options shown below where a selection can be made from the correct folder (Figure 17 & Figure 18).

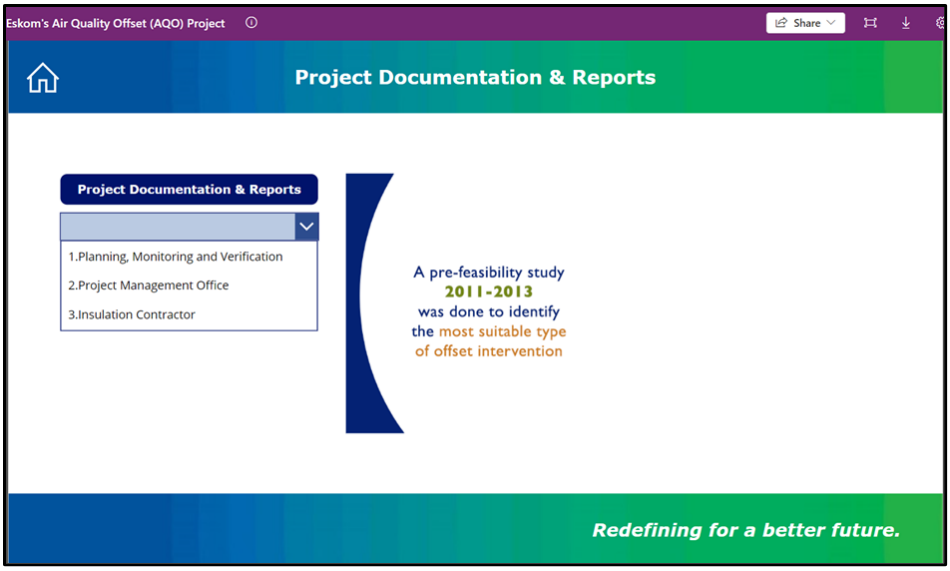


Figure 17: Project Documentation and Reports

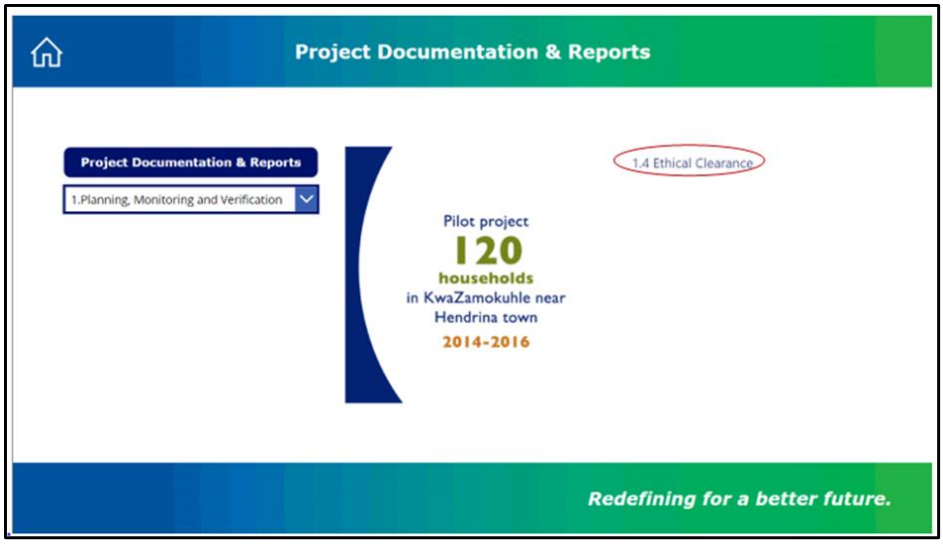


Figure 18: Illustrative example of PMV document & report repository

3. CONCLUSION

ARM developed a Management Information System (MIS) to ensure that all project data and data visualisations are centrally warehoused in a secure and highly available environment. The MIS contains the following elements: a front-end User Interface; a Business Intelligence (BI) reporting layer, and a file storage repository for all project-related reports. It is envisioned that the MIS system will be utilised as the central database & reporting platform for Eskom's upcoming Phase 2 and 3 AQO Offset Projects.

ANNEXURE 1

Microsoft Azure, formerly known as Windows Azure, is Microsoft's public cloud computing platform. It provides a broad range of cloud services, including compute, analytics, storage and networking. Users can pick and choose from these services to develop and scale new applications or run existing applications in the public cloud.

The Azure platform aims to help businesses manage challenges and meet their organizational goals. It offers tools that support all industries -- including e-commerce, finance and a variety of Fortune 500 companies -- and is compatible with open-source technologies. This gives users the flexibility to use their preferred tools and technologies. In addition, Azure offers four different forms of cloud computing: infrastructure as a service (IaaS), platform as a service (PaaS), software as a service (SaaS) and serverless functions.

Microsoft charges for Azure on a pay-as-you-go (PAYG) basis, meaning subscribers receive a bill each month that only charges them for the specific resources and services they have used.

How does Microsoft Azure work?

Once customers subscribe to Azure, they have access to all the services included in the Azure portal. Subscribers can use these services to create cloud-based resources, such as Virtual Machines (VM) and databases. Azure resources and services can then be assembled into running environments used to host workloads and store data.

In addition to the services that Microsoft offers through the Azure portal, a number of third-party vendors also make software directly available through Azure. The cost billed for third-party applications varies widely but may involve paying a subscription fee for the application, plus a usage fee for the infrastructure used to host the application.

Microsoft provides the following five different customer support options for Azure:

- Basic
- Developer
- Standard
- Professional Direct
- Enterprise (Premier)

These customer support plans vary in terms of scope and price. Basic support is available to all Azure accounts, but Microsoft charges a fee for the other support offerings. Developer support costs $29 per month, while Standard support costs $100 per month and Professional Direct support is $1,000 per month. Microsoft does not disclose the pricing for Enterprise support.

What is Microsoft Azure used for?

Because Microsoft Azure consists of widely varied resource and service offerings, its use cases are extremely diverse. Running virtual machines or containers in the cloud is one of the most popular uses for Microsoft Azure. These compute resources can host infrastructure components, such as domain name system (DNS) servers; Windows Server services, such as Internet Information Services (IIS); networking services such as firewalls; or third-party applications. Microsoft also supports the use of third-party operating systems, such as Linux.

Azure is also commonly used as a platform for hosting databases in the cloud. Microsoft offers serverless relational databases such as Azure SQL and non-relational databases such as NoSQL.

In addition, the platform is frequently used for backup and disaster recovery. Many organizations use Azure for archival storage in order to meet their long-term data retention or disaster recovery (DR) requirements.

Azure products and services

Microsoft sorts Azure cloud services into nearly two dozen categories. Each category can include numerous specific instance or service types. The most popular service categories include the following:

Compute. These services enable a user to deploy and manage VMs, containers and batch jobs, as well as support remote application access. Compute resources created within the Azure cloud can be configured

with either public IP addresses or private IP addresses, depending on whether the resource needs to be accessible to the outside world.

Mobile. These products help developers build cloud applications for mobile devices, providing notification services, support for back-end tasks, tools for building application program interfaces (APIs) and the ability to couple geospatial context with data.

Web. These services support the development and deployment of web applications. They also offer features for search, content delivery, API management, notification and reporting.

Storage. This category of services provides scalable cloud storage for structured and unstructured data. It also supports big data projects, persistent storage and archival storage.

Analytics. These services provide distributed analytics and storage, as well as features for real-time analytics, big data analytics, data lakes, machine learning, business intelligence, internet of things (IoT) data streams and data warehousing.

Networking. This group includes virtual networks, dedicated connections and gateways, as well as services for traffic management and diagnostics, load balancing, DNS hosting and network protection against distributed denial-of-service (DDoS) attacks.

Media and content delivery network (CDN). These CDN services include on-demand streaming, digital rights protection, encoding, and media playback and indexing.

Integration. These are services for server backup, site recovery and connecting private and public clouds.

Identity. These offerings ensure only authorized users can access Azure services and help protect encryption keys and other sensitive information in the cloud. Services include support for Azure Active Directory and multifactor authentication.

IoT. These services help users capture, monitor and analyze IoT data from sensors and other devices. Services include notifications, analytics, monitoring and support for coding and execution.

DevOps. This group provides project and collaboration tools, such as Azure DevOps -- formerly Visual Studio Team Services -- that facilitate DevOps software development processes. It also offers features for application diagnostics, DevOps tool integrations and test labs for build tests and experimentation.

Development. These services help application developers share code, test applications and track potential issues. Azure supports a range of application programming languages, including JavaScript, Python, .NET and Node.js. Tools in this category also include support for Azure DevOps, software development kits (SDKs) and blockchain.

Security. These products provide capabilities to identify and respond to cloud security threats, as well as manage encryption keys and other sensitive assets.

AI and machine learning. This is a wide range of services that a developer can use to infuse AI, machine learning and cognitive computing capabilities into applications and data sets.

Containers. These services help an enterprise create, register, orchestrate and manage huge volumes of containers in the Azure cloud, using common container platforms such as Docker and orchestration platforms including Kubernetes.

Databases. This category includes database as a service (DBaaS) offerings for SQL and NoSQL, as well as other database instances -- such as Azure Cosmos DB and Azure Database for PostgreSQL. It also includes Azure SQL Data Warehouse support, caching, and hybrid database integration and migration features. Azure SQL is the platform's flagship database service. It is a relational database that provides SQL functionality without the need for deploying a SQL server.

Migration. This suite of tools helps an organization estimate workload Migration costs and perform the actual migration of workloads from local data centers to the Azure cloud.

Management and governance. These services provide a range of backup, recovery, compliance, automation, scheduling and monitoring tools that can help a cloud administrator manage an Azure deployment.

Mixed reality. These services are designed to help developers create content for the Windows Mixed Reality environment.

Blockchain. The Azure Blockchain Service lets you join a blockchain consortium or create your own.

Intune. Microsoft Intune can be used to enroll user devices, thereby making it possible to push security policies and mobile apps to those devices. Mobile apps can be deployed either to groups of users or to a

collection of devices. Intune also provides tools for tracking which apps are being used. A remote wipe feature allows the organization's data to be securely removed from devices without removing a user's mobile apps in the process.

Azure for Disaster Recovery (DR) and backup

Some organizations use Azure for data backup and disaster recovery. Organizations can also use Azure as an alternative to their own data centre storage. Public clouds have proven ideal for high-volume, short-duration tasks such as data analytics. Organizations can use almost limitless storage capacity in the cloud to store vast data sets, perform analytics tasks and then dismiss data as it ages or becomes unusable -- all without procuring or deploying hardware in a local data centre. This type of utility computing has been a fundamental driver behind public cloud adoption since its inception.

Rather than invest in local servers and storage, increasing numbers of organizations choose to run some, or all, of their business applications in Azure. To ensure availability, Microsoft has Azure data centres located around the world. As of January 2020, Microsoft Azure services are available in 55 regions, spread across 140 countries. Unfortunately, not all services are available in all regions. Therefore, Azure users must ensure that workload and data storage locations comply with all prevailing compliance requirements or other legislation.

Privacy

Data security concerns and regulatory compliance requirements make privacy a major issue for cloud subscribers. To address these worries, Microsoft has created the online Trust Center, which provides detailed information about the company's security, privacy and compliance initiatives. According to the Trust Center, Microsoft will only use customer data if it is necessary to providing the agreed upon services and it will never disclose customer data to government agencies unless it is required by law.

At the same time, Azure provides numerous services such as identity and access management, firewall and other security services to help Azure users establish a secure infrastructure and monitor for intrusion in a timely manner. Security services are critical to public cloud adoption by helping users ensure the privacy of sensitive data and important workloads.

Azure pricing and costs

Similar to other public cloud providers, Azure primarily uses a PAYG pricing model that charges based on usage. However, if a single application uses multiple Azure services, each service might involve multiple pricing tiers. It's common for one service to use a subset of other services -- each adding to the total cost of the intended service.

For example, a common application running in a VM might incur one cost. The storage instance associated with the workload might incur a second cost. Networking services and reporting tools might all drive additional costs for the workload. Alternatively, services such as Azure Functions are free, but users pay for the compute and other resources needed to run the function for the duration of the function's execution -- usually to the closest second.

In addition, if a user makes a long-term commitment to certain services, such as compute instances, Microsoft offers a discounted rate. For example, Azure reserved VM instances claim to save users up to 80% on VM costs.

Even simple applications can involve many interdependent cloud services and resources. Given the many factors involved in cloud service pricing, an organization should review and manage its cloud usage to minimize costs. Azure-native tools, such as Azure Cost Management, can help monitor, visualize and optimize cloud spending.

Azure competition

Microsoft Azure is one of several major public cloud service providers operating on a large global scale. Other major clouds include Google Cloud, AWS, Oracle and IBM Cloud.

Currently, there is a lack of standardization among cloud services and capabilities. Most cloud providers offer a broad suite of similar services, but no two cloud providers offer the same service in the exact same way. Cloud providers rely on APIs and other integrations to handle provisioning and services in a programmatic manner. Because each provider uses unique APIs, the onus is on users to accommodate differences between cloud providers. Thus, to migrate a workload from one cloud to another might require significant recoding of the application or rearchitecting of the cloud environment to support the workload. This makes it difficult for a business to use more than one public cloud provider when pursuing a multi-cloud strategy. Third-party cloud management tools can reduce some of these challenges.

Microsoft Azure SQL Database

SQL Definition

Structured query language (SQL) is a programming language for storing and processing information in a relational database. A relational database stores information in tabular form, with rows and columns representing different data attributes and the various relationships between the data values.

MS Azure SQL Database

Microsoft Azure SQL Database is a managed cloud database provided as part of Microsoft Azure services. The service handles database management functions for cloud-based Microsoft SQL Server including upgrading, patching, backups, and monitoring without user involvement.

Difference between SQL Server and Azure SQL

Azure SQL Database has some additional features not available in SQL Server, such as built-in high availability, intelligence, and management. In Azure SQL database, most of the database-level features, SQL standards, and T-SQL query processing are supported.

Azure Blob Storage

Allows users to store and access unstructured data at scale. Azure Blob Storage provides storage to build powerful cloud-native and mobile apps. Blob storage supports the most popular development frameworks. It allows for petabytes of data to be stored cost-effectively and allows for the building of powerful data lakes for big data analytics.

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